ISSN 0859-600X
Volume XIII No. 1 January-March 2008

AQUACULTURE ASIA

Marine finfish aquaculture - production update

Aquaculture production, certification and trade

Genetic and reproduction technologies for Murray cod

Sahar domestication, Nepal

Ban on snakehead farming

Backyard crustacean hatcheries

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

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.

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

Printed by

Scand-Media Co., Ltd.

AQUACULTURE ASIA

Volume XIII No. 1 **ISSN 0859-600X**
January-March 2008

Bioprospecting or biopiracy?

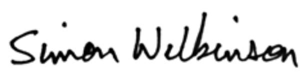
Over the last twenty years so there has been a marked interest in 'bioprospecting', the search for useful chemical compounds that are naturally produced by living organisms. Intensive screening is carried out to try and detect and isolate active substances that may be of value, notably medicines. As useful substances are few and far between this is difficult, time consuming and expensive research.

To increase the probability of success researchers often try to target their efforts. One particularly valuable source of information about the properties of plants and animals is the traditional knowledge of indigenous people. In both India and Thailand, research is underway to translate and preserve ancient writings on traditional medicine, which in turn is being used for targeted bioprospecting research by both government and commercial entities.

Organisations engaged in bioprospecting usually seek to patent their findings. This has given rise to the unfortunate phenomenon of 'biopiracy', a term originally applied for the misappropriation of legal rights over traditional knowledge, usually through patents and without compensation. There are well documented examples of biopiracy from around the world, but one such example from the Asian region concerns the Neem tree (*Azadirachta indica*), from which an anti-fungal agent was isolated and a patent awarded to the US Department of Agriculture and a pharmaceutical research firm. The medicinal properties of the tree were hardly news and the patent was eventually overturned after legal challenge by the Indian government.

Governments are now beginning to adopt a wider view of 'biopiracy' by enacting legislation claiming sovereignty over a country's biological resources and even related germplasm and genes. In theory such legislation aims to ensure the equitable sharing of the benefits from bioprospecting. In practice checks on biopiracy are implemented primarily through restrictions on access to samples necessary to conduct the research. Unfortunately, such legislation is beginning to impact on other unrelated and legitimate areas of scientific enquiry. For example, it is becoming very difficult to get permission from authorities in the region to export tissue samples for any kind of genetic research. The vast majority of genetic research has nothing to do with bioprospecting, but somehow geneticists seeking laboratory samples to conduct population or phyogenetic studies are in danger of being seen as mutineers swinging from the rigging of corporate raiders! The irony here is that while authorities are happy to allow whole fish to be exported by the tonne they will not permit small samples of same to go over the border for non-commercial scientific purposes that may be of substantial benefit either to their own nation or to the region as a whole.

The main issue in bioprospecting vs biopiracy is the equitable sharing of benefits between the investigators and the owners of biological resources or the traditional knowledge used to access them. Perhaps the region may be better served by placing more emphasis on harnessing investment in bioprospecting – with due attention to sharing of benefits - than by curtailing it. Certainly, efforts should be made to minimise the impact of anti-biopiracy legislation on unrelated research.



AQUACULTURE ASIA

Sustainable aquaculture

Genetics and biodiversity

Research and farming techniques

People in aquaculture

Asia-Pacific Marine Finfish Aquaculture Network Magazine

NACA Newsletter 51

Developing guidelines for sustainable freshwater aquaculture planning in Vietnam

Christoph Mathiesen[1], Don Griffiths[2], Dr Nguyen Cong Dan[2], Le Thi Chau Dung[2], Jacob Fjalland[2,] Ho Cong Huong[3], Do Duc Tung[3], Nguyen Thanh Hai[3], Nguyen Huu Hung[2]

1. Institute for Fisheries Management and Coastal Community Development, IFM; 2. Support to Freshwater Aquaculture, Ministry of Fisheries in Vietnam – SUFA; 3. Vietnam Institute of Fisheries Economics and Planning – VIFEP.

To promote sustainable aquaculture development, the Government of Vietnam and the Danish International Development Agency (DANIDA) are supporting the development of freshwater, brackishwater and marine aquaculture in Vietnam through the Fisheries Sector Programme Support (FSPS). A key objective of FSPS is to strengthen the capacity of local authorities to carry out multidisciplinary planning and to implement long enduring and adjustable plans. Supporting this, the FSPS component, Support to Freshwater Aquaculture (SUFA) funded a consultancy in the fall of 2004 to pilot freshwater aquaculture planning in Can Loc district.

Can Loc district of Ha Tinh province, 330 km south of Hanoi, has an abundance of water resources including reservoirs and rivers. The total freshwater production in the district increased from 162 to 446 tonnes between 2000 and 2003. Pond and rice-fish grow-out are the most common aquaculture systems. The major culture species include mud carp (*Cirrhinus molitorella*), common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idellus*). Higher value species, including mono-sex tilapia (*Oreochromis niloticus*), freshwater pomfret (*Colossoma* spp.), improved common carp, frog (*Rana* spp.) and soft shelled turtles (*Trionyx sinensis*) are also cultured on a limited scale.

The output from the consultancy in Can Loc is summarised here, to give readers an understanding of the challenges of sustainable aquaculture planning in Vietnam.

The requirement for external support for planning comes from the need to implement policies in a rapidly developing, but minimally controlled freshwater aquaculture sector. In the southern provinces, which provide most aquaculture production, poorly planned freshwater aquaculture development has created extensive environmental problems, uncontrolled production and difficulties in meeting quality and food safety standards (MRC Technical paper 7, 2002; FAO, 2004). Increasing fish prices and the expectation of rapid profits are attracting various groups of people with reasonable or insufficient aquaculture production skills. Unplanned and unskilled production is imposing socio-economic vulnerability upon the sector, which is at risk from rapid market fluctuations, resource scarcity and pollution problems (FAO, 2004).

Such unsustainable development can be prevented if development is carefully planned and monitored. However, to pursue the overall objective of sustainable development, it is necessary that decision makers agree on specific and measurable strategies. To define adequate and realistic actions for the implementation of a plan, a thorough understanding is required of: 1) multidisciplinary causalities behind key constraints and opportunities within the existing local freshwater aquaculture sector and 2) a clear definition of the decision makers' objectives and their tentative plans for meeting set targets.

Development of planning guidelines

An external consultant was used to facilitate the planning process in Can Loc because specific and targeted directions for implementation of planning objectives is a new experience for many provincial and district level government staff in Vietnam. Some of the challenges typically encountered by freshwater aquaculture planners working in Vietnamese provinces and districts include:

- There is little tradition of cooperation across government institutions (ministries and departments).
- Participation of the local community and farmers in aquaculture planning is limited.
- Existing aquaculture sector data needs updating and correlation, to provide both statistical and qualitative information.
- Multidisciplinary teams need to be trained for and involved in the planning process.
- Key staff lack awareness and training in Environmental Impact Assessments (EIA's).
- Planning is frequently reactive, i.e. the need for planning is only recognized after the development of environmental or socio-economic problems.
- Sustainable and feasible aquaculture planning is constrained by a lack of funding.
- There is little experience of coordinating aquaculture planning with development in other sectors.
- There is a need for specialized training of personnel in local governmental institutions to meet the demands of multi-disciplinary, participatory and scenario based planning.

The development of the planning guidelines in Can Loc district was conducted in close corporation with the local authorities and local stakeholders. Information needed to formulate the planning guidelines was collected through a series of participatory workshops, interviews, meetings, questionnaire surveys (140 households), scenario assessments, and statistical data collection at commune, district and province level. The following key principles were used throughout when conducting the planning process:

1. Peoples' participation.
2. Cross sectoral involvement of key stakeholders.
3. The use of an external facilitator throughout the planning process.
4. Establish Aquaculture Planning Steering Committee.
5. Integration of economic, social, environmental and production/technical factors.
6. Correlation of objectives at all levels of decision making (national, provincial, district, commune and farmers).
7. Detailed action plan for implementation
8. A process of continuous monitoring and adaptation of the plan.
9. Use of scenarios as a pointer for planning rather than for prediction of development (i.e. precautionary use).
10. Simple realizable district/province planning guidelines, needing only limited outside input.

1. People's participation

The primary goal of the planning process was to ensure people's participation. The planning of freshwater aquaculture includes great uncertainty as the natural systems and socio-economic structures are extremely complex and the interactions between them are seldom fully understood. And even if they are understood locally they cannot be generalized across different regions. In addition, the social and formal interaction between resource users and stakeholders, including government authorities, market agents, seed producers, extension workers, external advisers etc. may differ considerably from one district to another. The deficiencies of simplified and generalised solutions in complex social and environmental contexts necessitate the use of planning tools that provide dynamic and detailed solutions which can be adapted to local complexities.

2. Cross sector involvement of stakeholders

A multi-disciplinary approach calls for cross sectoral involvement of stakeholders. Planning at district and/or provincial level should include decision makers in government management institutions (agriculture and fisheries, planning and environmental management), local decision making authorities (Peoples' Committees), aquaculture specialists, farmers, irrigation companies, hatcheries, private aquaculture enterprises, mass organization like the Farmers' Association, the financial sector (e.g. banks), fish traders etc. Different stakeholders have varying degrees of influence, but all contribute to the planners' understanding of local constraints and the possibilities for aquaculture development as well as to the implementation of the plan.

3. The use of external facilitator

Planning for sustainable freshwater aquaculture using a multidisciplinary approach is a relatively new experience to Vietnamese decision makers at provincial or district level. The limited number of technical staff at the local levels can not be expected to possess the capacities and skills needed for this type of planning, as this capacity is only needed at certain times. Furthermore, governmental institutions have little tradition of cooperating horizontally and involving private enterprises in decision making. Being neutral, the external facilitator has the legitimacy to promote such cooperation and encourage extensive use of local institutional and economic potentials.

4. Establishing an Aquaculture Planning Steering Committee (APSC)

The APSC, which is responsible for coordinating the planning process and facilitating the data collection, is a cornerstone in the chosen planning approach and a valuable institution for building bridge between the external facilitator and the local stakeholders affected by the planning. Without the APSC, the planners have little chance of monitoring the process, implementing new ideas and ensuring institutional memory once the external facilitator leaves the process. There is a need to ensure that the stakeholders and decision makers share a common understanding of planning and are aware of their tasks, responsibilities and mutual commitments. The members of the committee should represent key stakeholders (including farmers) but must also be approved by the local government authorities to ensure political and financial support.

5. Integration of economic, social, environmental and production/ technical factors

The multi-disciplinary approach requires that planners correlate economic, social and environmental factors and point out the importance of each of these in meeting the development objectives. The planners must balance the need for information with the human and economic capacity of responsible institutions at the local level. Collection of data should relate closely with the work of analysing and incorporating new information in decision making. This may also be a new experience to local managers.

6. Correlation of objectives at all levels of decision making

The point of origin in freshwater aquaculture planning is to investigate and identify the objectives of key decision makers at all levels of society: national, provincial, district, commune and individual levels. This includes formal documents and qualitative information gathered through workshops, questionnaire, interviews, etc.

7. Detailed action plan for implementation

There is a need for a detailed action strategy for how and when to implement a plan. This strategy should be approved by all stakeholders and contain details on activities to be carried out, stakeholder involvement, responsibility and resource/budget allocation for specific activities. This principle seems straight forward. However, lack of a realistic and feasible implementation strategy is a common reason for non-successful aquaculture planning.

8. Continuous monitoring and adaptation of the plan

The aquaculture environment is dynamic and connected with other sectors (agriculture, forestry, industry, tourism, and infrastructure). Even the planning process itself influences and changes the circumstances. This calls for close monitoring and evaluation of the plan to ensure that objectives are met and targets are defined. New data emerging from a monitoring process must be handled and used to contribute to a continuous updating of the plan, and thus serve as the basic information for decision makers.

9. Use scenarios as a pointer and not as a prediction of development

Presentation of mathematical-economic scenarios can easily give the impression of order and predictability of aquaculture development. But scenarios rarely reflect the dynamic complexities of the real world. Scenarios should be used as a pointer to the direction of development and to help correlate key indicators. When used carefully, scenarios are a powerful tool that most stakeholders can understand and relate to during the planning process.

10. Ensure simple and realizable planning guidelines

Perhaps the most important aspect of this principle is to ensure that the planning guidelines and the tools can be used and implemented by district or provincial decision makers with limited financial and technical input from outside. However, the need for external support may vary considerably between regions.

The future planning

Through a continuous participatory approach in Can Loc district the consultants generated high expectations and local ownership of the planning process among most stakeholders. This raised the risk of disappointment if expectations are unmet, so there is an immediate need to follow up on the plan and implementation results with workshops and adjustments of the plan for the following year.

The capacities of local authorities and key stakeholders were improved during the process through interviews and workshop exercises which focused on combining objectives, targets and constraints in scenario based discussions. The workshop participants (including farmers and extension workers) handled these exercises with ease and with extensive use of local knowledge.

To ensure replicability, the planning guidelines produced will be tested in at least two other districts with different contextual conditions. While doing this the planners must pay particular attention to the principle of having peoples' participation throughout the process. Generally, the planning guidelines must be thought of as a dynamic tool which can be adjusted to meet the local conditions and the specific capacities of the planning team and the local aquaculture/agriculture administration.

References

FAO. 2004. Policy Research – Implications of Liberalization of Fish Trade for Developing Countries - A Case Study of Vietnam. Nguyen Thanh Tung, Nguyen Van Thanh and Michael Phillips. Project:

PR-26109, July 2004. www.nri.org/projects/fish-trade/vietnam.pdf

MRC. 2002. Freshwater aquaculture in the Lower Mekong Basin. Technical Paper No. 7, October 2002. Mekong River Commission.

Aquaculture production, certification and trade: Challenges and opportunities for the small-scale farmer in Asia

Michael Phillips[1], Rohana Subasinghe[2], Jesper Clausen[2], Koji Yamamoto[1], CV Mohan[1], A. Padiyar[2,3] and Simon Funge-Smith[2]

1. Network of Aquaculture Centres in Asia-Pacific (NACA), PO Box 1040, Kasetsart Post Office, Bangkok 10903, THAILAND; 2. Food and Agriculture Organization of the UN, Viale delle Terme di Caracalla, 00153 Rome, ITALY; 3. International Finance Cooperation, World Bank, Washington DC, USA.

Introduction

This article is focused on small-scale farmers in Asia and the challenges and opportunities they face in participating in global market chains for products from aquaculture. The purpose of focusing on small-scale farmers is to raise attention to this large and important part of the aquaculture sector, and the influence of production and market changes on the livelihoods of the many people involved.

Statistics on the small-scale aquaculture sector are poor, but it is important for rural development, employment and poverty reduction. The bulk of aquaculture production in many countries in Asia is from small-scale, family owned and operated operations, perhaps making up to 80% of the farming community in some countries. Small-scale farms may be diffused through a local area district, or highly concentrated around specific resource (e.g. water supply). The sector, whilst innovative and a highly important part of the regions aquaculture production, faces increasing constraints, particularly for export crops such as shrimp.

Aquaculture is under transformation. It is not only growing in response to the huge demand for global seafood products, and stagnation in capture fisheries, but especially for higher value internationally traded export species such as shrimp there is a trend towards a more integrated production-distribution chain with more focus on coordination between the aquaculture farmers, the processors, and the retailers and to some extent to consumers and restaurants. It is no longer enough for the farmer and organizations helping farmers to focus only on increased production, but it is now also important to understand how to link farmers to the production chain, how to produce high quality and safe products, and how to have on-farm management practices that are highly efficient, taking account of the surrounding environment and social issues related to production. A further factor is the trend towards traceability, certification, and improved farm management which are driving costs and responsibilities down the market chain to the farmer.

These global trends require changes in management of both large and small scale-farms to stay competitive. Whereas some larger farms with large product volumes and access to finance usually have the capacity to adapt, and benefit from such trends, there are still many uncertainties related to the influence of such trends on small-scale aquaculture producers and their adaptation and participation in modern aquaculture production and market chains.

Certification in aquaculture

Certification is rapidly being introduced to aquaculture, including mandatory and voluntary schemes. There are already a number of voluntary schemes emerging and the number of certification programs and labels for aquaculture products is expanding. Development and implementation of certification schemes is considered as one tool to help towards a more sustainable aquaculture production and at the same time link and inform different stakeholders in the production chain (Anon, 2007).

At the same time, the trends towards certification risk disadvantaging small-scale aquaculture farmers unless positive actions are taken to involve small-scale farmers and develop focused strategies to ensure their participation. Surprisingly, no certification scheme as yet targets the small-scale sector, but there could be significant social and economic benefits if the small-scale sector can be effectively serviced to participate in modern market chains. Some of the constraints the small-scale aquaculture sector faces related to certification include:

- Small volumes of product from individual farms and large numbers.
- Low or no market incentives as yet to become involved in certification.
- Complex marketing channels making traceability difficult.
- Limited access to market, technical and business knowledge and related infrastructure.
- Limited or inequitable access to financial services for investment in changes that may be required for certification.
- Farms may not be formally registered and may not be organized into producers groups.
- Traders-credit relations.
- May not be producing an export product, and therefore producing to least cost to sell within a less wealthy domestic market.
- Commercial/government servicing less oriented towards the small-scale farmer.
- Risk management strategies of larger traders and buyers, requiring large volumes of product, working against small-scale farmers producing small quantities of product.

The above issues need to be addressed. It is a matter of great importance to the industry and to a large number of people who depend on aquaculture as their main livelihood to engage small-scale farmers in the development of certification schemes, to ensure equitable participation. There is a need to better understand the process, standards, their applicability, and the opportunities and challenges for small-scale farmers to benefit from certification systems.

It is unlikely in the near future that many individual small-scale farms can be easily certified, but one way forward may be to promote group certification or certification of clusters of small-scale farmers, that has been used successfully in other agriculture sectors (e.g. organic products, IFOAM, undated). The nature of small-scale farmers is that they only produce small quantities of their product, making it difficult and inconvenient for larger buyers that prefer larger volumes. The need for solutions to allow small-scale farmers to participate in market chains requiring certified aquaculture products is therefore evident.

Example from India

As a part of a technical collaboration between the Marine Products Export and Development Authority (MPEDA) and NACA, on shrimp disease control and coastal management in India, a village demonstration program was conducted from 2002 onwards. The objectives of the program were:

- To reduce the risk of disease outbreaks and improve shrimp farm production
- To organize the farmers under “Self Help Groups” / “Aquaclubs” for sustainable production
- To produce better quality shrimps in socially acceptable, environmentally sound and economically viable manner.

The program was successful in improving organization of the small-scale sector and reduced risks, with nearly 800 shrimp farmers now participating, across all of India’s shrimp aquaculture producing states. Key elements of success include:

- The development of locally-appropriate “Better management practices” (BMPs) formulated with farmers, based on a science-based epidemiological study of shrimp disease risks and the International Principles for Responsible Shrimp Farming (MPEDA/NACA, 2003 and FAO/NACA/UNEP/WB/WWF, 2006)
- Support to formation of farmer clubs (so-called “Aquaclubs”) within villages, and within “clusters” of farmers. Clusters were defined as a group of inter-dependent shrimp ponds, often situated in a specified geographical locality and dependent on the same water source
- One of the most significant outcomes of this project is the reduction in disease prevalence and improved farm profitability as a result of BMP implementation in Aquaclub farms. Successful implementation of BMPs reduced disease prevalence and increased the number of planned (normal) harvests leading to better crop outcomes, improved efficiency

in use of key inputs (feed, seed) and profits. Another key to success was the development of farmer clubs, leading to a number of key benefits including:

- Regular information exchange/ sharing of knowledge on Better Management Practices among farmers within the group and increased awareness among farmers.
- Cooperation in buying high quality farm inputs (seed, feed, lime etc.) at competitive price.
- Increased interaction between farmers and input suppliers/farmed product buyers.
- Stronger bargaining power of clubs in the purchase of farm inputs and sale of harvest, in the former case leading to reduced prices for bulk purchase.
- Increased co-operation in sharing common facilities and in area improvements such as deepening of water inlets and unclogging of water supply/drainage canals.
- Collective approach to dealing with common problems including local environment protection especially protection of common water sources.
- Facilitation of farm licensing and formal registration of clubs with government. The formal registration has also recently opened opportunities for group members to access financial support from local Banks.
- Although the farmers are not yet formally certified, a farmer club and cluster management system in place provides a basis for moving forward towards voluntary certification.

Ways forward

The small-scale sector is the largest producer and the "mainstay" of Asian aquaculture. It is an innovative sector, but faced with many problems and constraints in the modern trade and market environment. The sector is socially and economically important and cannot be ignored. Fortunately, recent experiences show that there are ways to assist small-scale farmer participation in modern market chains and trade.

One important way is the organization of farmers into producer groups. Examples from India and elsewhere show organized farmers can speak with a louder voice in negotiating prices for inputs such as feed and seed and potentially also have a better platform for more organized marketing and price negotiation when selling the product. A farmer group also allows buyers and extension facilities to have a focal point and hence reach a larger number of farmers with reduced costs. The way forward then is for public and private sector investments to assist the small-scale sector adapt and participate in modern market chains for aquaculture products.

The public investments needed include:

- Development of policy that is more favorable to the small-scale sector, and at the very least based on the requirement and realities of the small-scale aquaculture farmer.
- Technical and marketing services more oriented towards small-scale aquaculture producers, as well as the small-scale traders and businesses associated with the sector.
- Facilitating access to financial and insurance services in rural aquaculture farming areas.
- Market access arrangements that support small-scale producers.
- Information services that cater to the needs of rural farmers.
- Encouraging private investment in small-scale aquaculture production and services.
- Social 'safety nets' for the most vulnerable producers and traders.
- Orientation of educational and research institutions towards supporting the small scale aquaculture sector.

Trade rules and guidelines, including certification guidelines, also need to consider carefully the needs and realities of the small-scale sector.

There are many opportunities for private investment to support millions of small-scale farmers. Private sector investments are needed in:

- Technical and marketing services for small-scale aquaculture producers.
- Information services.
- Micro-finance and financial services.
- Insurance services.
- Input packaging and delivery for small-scale farmers.

We also consider there is a business case for investment in the small-scale sector. In India, for example, an investment of $80,000 in technical servicing in 2006 led to crop improvements worth $2 million. Given that 70-80% of producers in Asia are small-scale, an investment in servicing the small-scale sector could therefore be a potential profitable one.

"Corporate social responsibility" also has a role to play in private sector involvement in small-scale farmers, particularly the larger retailers and trading businesses that are becoming increasingly powerful. These larger businesses should be encouraged to adopt more CSR initiatives in the aquaculture sector, such as

- Facilitating market access for small-scale aquaculture producers.
- Provision of technical and financial assistance to small-scale producers to comply with market requirements.
- Brand development and marketing favorable to aquaculture products from smaller producers.

Certification and quality assurance schemes are also needed that are relevant and practical for small-scale aquaculture producers. A focus on the advantages from small-scale producers should also be possible both in relation to environmental and social issues related to the production. Development of a small-scale certification scheme oriented towards "Fair trade" as applied to some agriculture products should also be explored.

Whilst many challenges clearly remain, with many questions, it is time to recognize the crucial role of small-scale aquaculture farmers in Asian aquaculture production and trade. The small-scale sector is the largest producer and the "mainstay" of Asian aquaculture. It is an innovative sector, but faced with many problems and constraints in the modern trade and market environment. It needs investment from public and private sector to compete and thrive in the modern aquaculture scene. There are many opportunities for assistance and investment. Ideas and partnership are certainly welcome!

References

Anon (2007) Aquaculture Certification: A Programme for implementing the recommendation of the Committee on Fisheries Sub-Committee on Aquaculture. Concept paper prepared for the FAO/NACA Expert Workshop on Development of Guidelines for Aquaculture Certification-27-31 March 2007. FAO and NACA, Bangkok, Thailand. www.enaca.org/certification.

FAO/NACA/UNEP/WB/WWF.2006. International Principles for Responsible Shrimp Farming. Network of Aquaculture Centres in Asia-Pacific (NACA). Bangkok, Thailand, 20pp.

IFOAM. Undated. Smallholder Group Certification – Producers. Internal Control Systems for Group Certification – Training Kit for Producers. International Federation of Organic Agriculture Movement.

MPEDA/NACA. 2003. Shrimp health management: Extension manual. Marine Products Export Development Authority (MPEDA), Cochin, India and Network of Aquaculture Centres in Asia-Pacific (NACA). Bangkok, Thailand.

The successful development of backyard hatcheries for crustaceans in Thailand

Hassanai Kongkeo, Michael B. New and Naruepon Sukumasavin

1. Technical Assistant to DG, Network of Aquaculture Centres in Asia-Pacific, 2. Chairman, Aquaculture without Frontiers, 3. Head, Technical Group, Inland Fisheries Research and Development Bureau, Department of Fisheries, Thailand.

One of the important milestones in freshwater prawn farming occurred in the late 1970s when the United Nations Development Programme decided to fund a three-year FAO-executed project, named ‘Expansion of Freshwater Prawn Farming’, in Thailand (New, 2000). This project built on the earlier work of the Thai Department of Fisheries (DOF), led by Somsak Singholka and his team at the Chacheongsao Coastal Fisheries Research and Development Centre (former Chacheongsao Fisheries Station) in Bangpakong, Chacheongsao Province. At first it was assisted by one of the pioneers of global *Macrobrachium* culture, Takuji Fujimura, together with visiting FAO project manager, Herminio Rabanal. Michael New was appointed by FAO in 1979 and he and Somsak Singholka co-managed this project until 1981, after which the Thai government continued this initiative. As a result of these efforts, farmed freshwater prawn production expanded from less than 5 t/yr before the project began (1976) to an estimated 400 t by the time it ended in 1981 (Boonyaratpalin & Vorasayan 1983). Soon afterwards (1984), the DOF was reporting to FAO that Thai production had exceeded 3,000 t/yr (FAO 1989), a very rapid expansion indeed.

This DOF-FAO project not only enabled the establishment of a significant aquaculture sector in Thailand but also benefited the development of freshwater prawn farming globally. One output was the publication of a technical manual on the topic (New & Singholka, 1985; New, 2002) that was translated into many languages. In addition, the Thai Department of Fisheries hosted ‘Giant Prawn 1980, the first international aquaculture conference ever held in Thailand (New 1982), which was attended by 159 international participants from 33 countries and 200 local farmers. Many Thai experts later advised *Macrobrachium* projects and ventures elsewhere in Asia. By 2005, the aquaculture production of *Macrobrachium rosenbergii* in Thailand had risen to 30,000 t/yr (valued at US$ 79 million) and to more than 205,000 t/yr globally (FAO, 2007). In addition, a similar quantity of a related species, *M. nipponense*, was produced in China in 2007. In total, the global farm-gate value of freshwater prawn farming had reached almost US$ 1.84 billion/yr by 2007.

Concrete tanks for nursing PL.

Though there was no seawater avaiable, the Bangkok Marine Laboratory which has now been allocated by DOF to the Bangkok Fish Market, successfully cultured to post-larvae stage *Penaeus merguiensis*, *P. semisulcatus*, *P. latissulcatus*, *Metapenaeus monoceros* and *M. intermedius* in 1972 (Cook 1973). Seawater had to be brought from offshore by boat. All gravid female shrimp were captured in the Gulf of Thailand. Experiments on pond culture of artificially bred seed were carried out at private shrimp farms in Samutsakorn Province and Bangpoo, Samutprakarn Province but the results were not satisfactory.

In 1973, the Phuket Coastal Fisheries Research and Development Centre (former Phuket Marine Fisheries Station) sucessfully bred *P. monodon* by induced spawning from broodstock caught from Andaman Sea. Postlarvae of the early batches were stocked in semi-intensive ponds in Bangkrachai, Chantaburi Province, Klongdaan, Samutprakarn Province and Klong-sahakorn, Samutsakorn Province. This brought shrimp farming the much needed technique that enabled the farmers to have better control of their crop and sustainable production, instead of reliance only on wild seed for stocking as an extensive culture system. This important research later led to the highest peak of *P. monodon* production of 304,988 mt in 2000 (Kongkeo, 2006) before substitution by *P. vannamei*.

Hatchery production of crustacean postlarvae

The major extension thrust in the DOF-FAO project was the provision not only of technical advice but also of free *M. rosenbergii* postlarvae (PL) for stocking the initial grow-out operations on each farm. Freshwater prawns were distributed by road and rail all over Thailand. Large quantities of PL were produced for this purpose in a series of huge concrete tanks sited at the fisheries station in Bangpakong. However, many of its technical staff also began to produce PL successfully in other, less conventional and smaller containers, such as the 'klong pots' used for storing potable water. Before long, some of the stilted houses on the site had small production units underneath their living quarters. Even non-scientific staff learned the necessary techniques quickly. Soon, the first commercial 'backyard hatcheries' began to spring up in nearby areas of Chacheongsao Province. One of the reasons why these backyard hatcheries were to prove so successful was the ability of Thai entrepreneurs to follow changing market requirements. Unlike the massive species-specific hatcheries that were set up in the 1970s and 1980s for fish and crustacean species elsewhere, which were almost impossible to modify, many of these simple backyard hatcheries could easily and cheaply adapt themselves to produce marine shrimp PL (*P. monodon*) and seabass fingerlings (*Lates calcarifer*) according to demand.

Backyard hatcheies are generally managed with simple but efficient technology mainly by farmers with little education. The technology which was originally developed for *M. rosenbergii*, can easily be switched to *P. monodon*, *P. vannamei* or nursery of seabass and grouper fingerling if prices of existing species drop or disease problems occur. The initial investment for land, construction and equipment, as well as operation costs, is very low because of the simple techniques used. Fortunately, Thai farmers have had a long experience and tradition of aquaculture and crop production. They are also enthusiastic to learn and practise advanced technologies which have been successfully done on a research scale in government institutions or by large scale entrepreneurs. They always have new ideas for development or modification to suit with local conditions and are eager to experiment on their own. Sometime, they start to experiment on new culture techniques by themselves and learn by mistakes from the results. The present success of Thailand in shrimp and prawn industry is testimony to the persistence and ingenuity of Thai farmers in utilising applied science to its utmost potential. It is a good example of blending research work done by government with farmers' enthusiasm in adoption of new technology.

Due to the long distance of hatcheries from the sea, hypersaline water from salt farms is transported by truck and subsequently diluted to the desired salinity with disinfected freshwater. This hypersaline water is pathogen-free and virus carrier-free due to its high salinity. These hatcheries purchase *P. monodon* or *P. vannamei* nauplii from nauplii producers who are located near the open sea areas for better water quality and circulation needed in the maturation process. For *Macrobrachium*, hatchery operators use spawners both from grow-out farms and from the wild. Small hatcheries run by owners and families are more efficient than big hatcheries which are run by paid workers due to sense of belonging. The decrease in price of shrimp fry caused by the spread of these backyard hatcheries also helped to stimulate the rapid expansion of grow-out ponds.

When problems occur, production can be discontinued, even for a long periods, without undue expense. This family business is in contrast to large scale sophisticated hatcheries, in which the cost of wages, power supply, supporting facilities and other overheads still has to be borne during the closure. Periodic discontinuation of operations is, in fact, necessary for both hatchery and grow-out in order

to facilitate reconditioning, drying and disinfection of tanks, ponds, aeration and water systems.

This is similar to the success of small-scale intensive ponds which spread all over the country. More than 80% of Thai marine shrimp production come from approximately 12,500 intensive farms with total production area of 27,000 ha (Kongkeo, 1995). These small operators typically run 1-2 ponds, each ranging in size from 0.16-1.6 ha. However, during the early stage of development large scale operators are always required to pioneer research work by their own or by adaptation of new technogies from government or overseas to serve as a prototype for further development by small-scale operators. The income from operations has also provided considerable socio-economic benefits to these small-scale operators who mainly live in coastal regions. Thus local communities directly gain these benefits.

After being developed in Thailand, this technology has been transferred through assistance of FAO, NACA, UNDP, Thai Government, the private sector and feed manufacturers and successfully adapted in Indonesia, Vietnam, India, Bangladesh, and Myanmar. Some countries modified the technology by using direct seawater because they have better seawater supply sources.

There are more than 2,000 small scale hatcheries in Thailand including in Chacheongsao, Chonburi and Phuket provinces where they generate significant production of more than 80 billion (90% of total) marine shrimp postlarvae per year. They have had sustainable production and survived the many shrimp crises that have occurred during the past 20 years. Unfortunately, they are now suffering from competition with SPF postlarvae supplies by large scale hatcheries which have introduced high technologies such as SPF and disease resistant strains, biosecure systems, raceways etc from overseas. To cover their high investment costs, these large scale hatcheries are under pressure to increase their margin by selling postlarvae direclty to grow out farms instead of selling nauplii to backyard hatcheries as they had formerly done. Tracebility of broodstock and certification, an issue usually raised by developed countries, are also problems for these backyard hatcheries because they purchase nauplii from external suppliers. Although nauplii producers can issue PCR negative certificates, it is difficult for them to sort out the source of origin for particular backyard hatcheries. Producers usually mix nauplii from various sources for easy distribution and economic reasons.

The Thai DOF has tried very hard to solve the problems of small scale operators. A farm registration system and CoC and GAP certification systems have been implemented since 2003. At the moment, 98 and 727 hatcheries, including some backyard hatcheries, have been certified with CoC and GAP standards, respectively. Furthermore, the use of the “Movement Document” and traceability system at grow-out farm level have been recently implemented and are expected to be functioning properly and to cover the hatchery level in the next few years. As the fact that overseas SPF technology assuring the organism is free of specific disease only in its specific environement, its popularity may decrease if there is more evidence of disease infection similar to cases in Indonesia. At that time, the opportunity of the backyard hatcheries may again resurface, if they are all certified and operate under a traceability system.

References

Boonyaratpalin, M. & Vorasayan, P., 1983. Brief note on the state of the art of Macrobrachium culture in Thailand. NACA Working Paper WP/83/7. NACA, Bangkok, Thailand.

Cook, H.L., 1973. FAO Report to the Government of Thailand on Shrimp Farm Development. FAO Report No TA 314, FAO Rome.

FAO, 1989. Aquaculture production 1984-1986. FAO Fisheries Circular, 815. FAO, Rome.

Kongkeo, H., 1995. How Thailand madeit to the top, pp 25-31 in Aquaculture Session in INFOFISH International 1/95

Kongkeo, H., 2006. Responsible Shrimp Farming: A critical Overview. Presentation in WAS’06 Conference, Florence, Italy

New, M.B. (ed.), 1982. Giant prawn farming. Developments in Aquaculture and Fisheries Science, 10. Elsevier, Amsterdam, Netherlands.

New, M.B., 2000. History and global status of freshwater prawn farming. pp. 1-11 In: M.B. New & W.C. Valenti (eds), Freshwater Prawn Culture. Blackwell Science, Oxford, England.

New, M.B., 2002. Farming freshwater prawns: a manual for the culture of the giant river prawn (*Macrobrachium rosenbergii*). FAO Fisheries Technical Paper, 428. FAO, Rome, Italy. [Also published in Mandarin, with Arabic, French, Malayalam and Spanish versions in preparation]

New, M.B. & Singholka, S., 1985. Freshwater prawn farming: a manual for the culture of *Macrobrachium rosenbergii*. FAO Fisheries Technical Paper, 225, Rev 1. FAO, Rome, Italy. [Also published in Farsi, French, Hindi, Spanish & Vietnamese]

Alternate carp species for diversification in freshwater aquaculture in India

K. N. Mohanta[1], S. Subramanian[1], N. Komarpant[1] and S. Saurabh[2]

[1]ICAR Research Complex for Goa, Ela, Old Goa, Goa, 403 402; Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar, 751 002, India.

Indian fisheries has made great strides during last five decades with the production levels increasing from 750,000 tonnes of fish in 1950-51 to 6.4 million tons in 2005-2006, of which the contribution from the inland sector is around 3.3 million tons (51.6 % of the total) compared to 3.10 million tons (48.4 %) from the marine sector. The contribution of fisheries to the gross domestic product (GDP) and agriculture GDP has been estimated to be 1.2 and 4.2 %, respectively. India ranks second in world inland fish production, next to China. The growth rate of inland and marine sector at present is 6.6 and 2.2%, respectively. The anticipated growth rate during the tenth five-year plan (2002-2007) for inland and marine fisheries are 8.0% and 2.5 %, respectively.

Indian freshwater aquaculture has evolved itself from the stage of a domestic activity in the Eastern States of West Bengal and Orissa to that of industry and has become an important component of Indian fisheries contributing about one third of total fish production of the country and share about 95% of the total aquaculture production. The mean national fish production levels from tanks and ponds have increased significantly from 600 kg/ha during the 1970's to 2,200 kg/ha in the 1990s. In some areas such as the states of Andhra Pradesh, West Bengal, Punjab and Haryana yield has increased even to 8,000-10,000 kg/ha. Demonstrations on intensive composite carp culture practices had shown a maximum production of 15,000 kg/ha at Central Institute of Freshwater Aquaculture, Bhubaneswar (Jana and Jena, 2004).

Carps are the backbone of Indian freshwater aquaculture, comprising around 85% of the total freshwater production. Carp culture in India is largely limited to six species; the three Indian 'major carps' catla, rohu and mrigal; and three exotic or 'Chinese carps', grass carp, silver carp and common carp. Again, Indian major carps contribute the lion's share of freshwater aquaculture production, around 80% by volume. Among Indian major carp production, the contribution of rohu alone is about 35%.

India is regarded as a 'carp country' due to its rich diversity of carps in its freshwater ecosystems. About 2,070 species of carps (family Cyprinidae) are available in Indian waters. Though many of the carp species like minor barbs and minnows are not economical from the commercial culture point of view, the country is blessed with at least 15-20 varieties of minor and medium carps that have a high potential for freshwater aquaculture, which has yet to be exploited. These carp species can be considered as alternatives to the major cultured carp species, for diversification in freshwater aquaculture. The systematic classification, geographical distribution, biology, age at sexual maturity, breeding behaviour, consumer preference, present culture status, problems and prospects of culture along with the suggestions for conservation of these species are detailed below.

Labeo calbasu

Commonly called 'kalbasu', or 'black rohu' in some areas, it is a carp of medium economic significance, though some authors categorized it as major carp. It belongs to the sub-family Cyprininae. *Labeo calbasu* is widely distributed in India. It is a highly preferred food fish. It is also considered as a game fish. It can be domesticated in tanks and is suitable for composite fish culture with other carp species. It thrives well in tanks, lakes and other forms of stagnant water bodies. It is an 'illiophage', predominantly herbivorous, feeding on the bottom. Kalbasu competes with mrigal, frimbritus and bata in culture environments. Its feed mainly consists of organic detritus, diatoms and green algae along with zooplankton. Kalbasu has comparatively few inter-muscular bones than the major carps. It is a seasonal breeder and spawns once per year in lotic environments during the monsoon. It can be induced to breed by hypophysation. The relative fecundity of Kalbasu is highest among all major carps, ranging from 90,000 in first year group to over 500,000 in seventh year class. It can reach a maximum length of around 100 cm, but grows to around 20cm and 800 g in the first year. Sexual dimorphism is more prominent during breeding season. Like major carps, the male develops roughness on the pectoral fin and a sandy texture on scales and milt oozes with slight pressure on abdomen. In the case of females, the pectoral fins and scales are found to be smooth, abdomen bulges and the vent appears reddish and protrudes outside. Using induced breeding techniques, Kalbasu can be bred twice or three times in a breeding season. The average diameter of the matured egg is 1.5 mm. The incubation period is around 15 hours. The growth rate of females is slightly better than males. *L. calbasu* is being cultivated along with Indian major carps in eastern India.

Labeo fimbritus

A 'medium carp', which grows to a medium size. It is commonly called the "fringe-lipped peninsular carp", and is widely distributed throughout central and peninsular India. It is suitable for cultivation in confined waters. It is a bottom dweller, preferring the sandy bottom of the river, but often wanders in the column water in search of food. It is mainly available in the Krishna, Godavari, Tungabhadra, Mahanadi, Narmada, Cauvery and Tapti river systems. It is the basis of a major fishery in the Narmada river system, where is popularly called the 'rohu of the Narmada river' by consumers. This species is a herbivorous bottom feeder, consuming mainly vegetable debris, decaying organic matter, algae (Chlorophyceae and Myxophyceae) and macro-vegetation in adult stages and the planktonic crustaceaens, protozoa, rotifer, copepod and Bacillariophyceae in fry and fingerling stages. In adult fish, the lip is thick, continuous and fringed with a thin cartilaginous layer on the inner side of both jaws. Like other carps, sex is easily recognized during breeding season. It matures in the second year of life and breeds during the monsoon season. The female generally attains first maturity at 40-50 cm length. It is a highly fecund fish and the fecundity varies from 100,000 (in the first year age group) to 500,000 (in seventh year age group). In nature, it can grow over 60 cm and 3.15 kg. But in ponds it can grow to around 23 cm and 450 g in the first year and 31 cm in the second year, so it is a relatively slow growing fish. It can be cultured with other major carps in pond. The eggs of the fish are non-adhesive, demersal, transparent and round. The diameter of a fully swollen egg is reported to vary from 3.5-6.0 mm. Although the fish has high potential for composite culture along with other carps, so far it is not being cultured commercially in India.

Labeo bata

A minor carp commonly known as 'Bata'. It is distributed throughout northern India. It is also found in the Cauvery, Krishna, Godavari river systems of peninsular south India and the freshwater bodies of West Bengal, Orissa, Uttar Pradesh, Bihar and Assam. They are also available in the upper stretches of the Ganga, Yamuna and Bramhaputra rivers. *L. bata* is considered an esteemed food fish and cultured along with other major carps in India. It is found in tanks, rivers, reservoirs, jheels, beels and moats. Until now the major source of seed for culture of this species has been wild collection from river, reservoir, and wet bundhs. It attains a length of 20-25 cm in pond and 40-60 cm in large tanks and reservoirs. It is also a slow growing fish, reaching 20-22.5 cm length in 9-10 months, and the growth rate of this species decreases markedly after two years in age. *L. bata* is herbivorous, adults are bottom dwellers but frequently move in all zones of the water column for feeding and breeding purposes. It generally matures in two years but under favourable conditions it can mature in the first year. Fully matured fish are found in May-June. The average length of the matured fish in both sexes is around 20 cm and 100-125 g in weight. They are also highly fecund ranging from 300,000 to 450,000 eggs per kg body weight. *L. bata* breeds early in the monsoon and its spawning season is very short. In nature it spawns once in a year but by induced breeding it can be made to spawn 2-3 times in a year. The diameter of the fully swollen egg is 3.0-3.5 mm. Although it is a tasty fish, the fine inter-muscular bones dampen its preference among consumers. It is relatively susceptible to even slight adverse water quality when compared to major carps and cannot withstand long distance transportation even under normal oxygen packing. It is widely cultured in bheries in the Sunderban areas of West Bengal.

Labeo gonius

A medium carp, popularly called 'kuria labeo; or "gonius", it is is distributed in Bengal, Orissa, Assam, Uttar Pradesh, Bihar, Rajsthan, Madhya Pradesh and Punjab in the major freshwater rivers, reservoirs, lakes, jheels and tanks. It is the slowest growing among the potentially cultivable carps. The average size at maturity is around 300-500 g. The maximum reported size of *L. gonius* reported is 150 cm (Day, 1878), however around 50 cm is more typical of commercial catches. In one year it can reach 40 cm and 750 g. It is also a high fecund fish like rohu, ranging from 245,000 (800-900 g fish) to 540,000 (1.5- 1.6 kg fish). Eggs are demersal, non-adhesive, transparent and round. The diameter of a fully swollen egg ranges from 2.8 – 4.5 mm. The size on first maturity varies from 14–23 cm in males and 18–30 cm in females in different freshwater ecosystems. The males attain maturity earlier then females both in terms of age and size. In nature, the usual maturity age is three years; however pond reared fish can mature even in one year. Peak maturity is found in May-June. All ova are shed during single spawning act. It can be induced to breed with pituitary injection. *L. gonius* is a herbivorous bottom feeder and in composite fish culture it competes with mrigal, calbasu, fimbriatus and bata. Excepting for Assam, it is not considered as an important culture fishery in India. In Assam, as mrigal is not consumed due to some religious belief, *L. gonius* is cultured instead as a bottom feeding substitute in composite fish culture.

Labeo kontius

Commonly known as 'pig mouth carp', *L. kontius* is a valuable component of capture fisheries in the Cauvery River system, found specifically in the middle and lower stretches of the river. Although it is found in certain areas of South India, it is not available in the Gangetic belt. It is predominantly herbivorous and can be domesticated for pond culture. It has a peculiar feeding habit, in that the adult and fingerling being bottom and column feeders, while the spawn and fry stages feed in the surface realm. The fish is found to be very active and hardy. It can jump up in the air in their attempt to negotiate the barriers found in the river and move upstream. It breeds once per year during the monsoon season in June–August. Breeding occurs during both day and night. The information regarding the fecundity of this species is lacking. Fertilized eggs are demersal, non–adhensive, round and transparent with pale–blue colour. The fully swollen eggs are 3.5 – 4.3 mm in diameter. It is a slow growing fish, which can grow up to 23 –30 cm in length and 350 g in weight at the end of the first year in ponds. It becomes sexually mature at

30-35 cm length. It is currently being cultivated in ponds of South India particularly in Tamilnadu and Karnataka.

Labeo dero

It is a minor carp and forms a commercially important food fish in upland waters in Northern India. This fish is commonly known as "Kursa Bata". Flesh of this fish is well flavoured and highly esteemed as food. It is widely distributed all along the Himalayan rivers particularly in the Sutlej, Beas, Ravi, Baner, Tawi and Jhelum. It is mainly restricted in the upper reaches of the river. The fish prefer to come down to lower stretches of the river to avoid the cold during winter months. It is distributed mainly in the States of Arunachal Pradesh, Punjab and Jammu and Kashmir. It is also observed in the Mahanadi river system in Orissa. It is a herbivorous fish, feeding on soft aquatic vegetation and periphyton. It also feeds by licking off algal growth from rocks and hard surfaces. It is highly fecund ranging from 67, 288 (330 g fish) to 700,000 (1.35 kg fish). It breeds early during the monsoon over a very short breeding period. It is relatively slow-growing, reaching a maximum size of 1.5 kg in weight and 50 cm in length. The fertilized eggs are non–adhesive, demersal and 2.9 – 3.2 mm in diameter. Culture and seed production of this fish is not being realized in India till now.

Labeo dussumieri

L. dussumieri is a medium carp, and the only member of the *Labeo* genus that is found indigenously in south India particularly in Kerala. It is an endangered species. The fish is variously known as 'Malabar Labeo', 'Thooli' and 'Pullan'. It is restricted to Kerala in the Pampa, Manimala and Meenachil rivers. It can grow up to 35 cm. Fecundity is low compared to the other carp species, ranging from 65,000 to 240,000 for a fish of 35-45 cm. Very few attempts have been made to study the biology, feeding habit, breeding and culture aspects of this species.

Labeo boggut

A minor carp, commonly known as 'Boggut Labeo'. It is the most slender fish among the genus *Labeo*. It is distributed in Northern India and the Cauvery River system. A fairly large quantity of this species is also available in Panna weekly market of Madhya Pradesh. It is abundantly available in Kathiawar Island watershed of Gujarat. This species is also available in the Krishna and Tungabhadra watersheds. The sexual maturity of the fish occurs at 14-15 cm length. It is a monsoon breeder. Ripe females are observed in June-July. Not much work has been carried out on the breeding habit of this fish.

Cirrhinus reba

A minor carp commonly known as 'Reba carp'. It is a widely distributed in India, found in the Gangetic regions in North and Cauvery River systems in South, although it is not available in the Malabar River systems. It is a bottom feeder and prefers to stay in deep water. It is predominantly a plankton feeder in young stages and takes on a herbivorous habit in adult stages. The fish attains sexual maturity after one year at 22-25 cm in length. Induced breeding through hypophysation has been attempted on the species. Although the breeding season extends from May to October, the peak breeding occurs in June-August. The fecundity of the fish is 287 egg/kg body weight. The initial growth rate of the fish is very fast, even greater than catla, though fish does not grow beyond 30 cm in ponds. No attempts have been made for commercial scientific culture of this species in India.

Cirrhinus cirrhosa

A medium carp commonly known as 'white carp'. It is widely distributed in southern Indian rivers. Cauvery is called the 'river of white carp'. It is also available in the Krishna, Godavari, Narmada and Pench river systems. It is a very active fish and can swiftly swim against the current. It is a bottom feeder. The young fish feeds on zooplankton whereas the adult prefers phytoplankton. It matures in the first year at a size of 20-25 cm. The breeding season is from July-September. It does not breed in confinement but can be domesticated in ponds. The fecundity of the fish is 150,000-200,000/kg fish. The eggs are spherical, non-adhesive and demersal. Although the fish is a tasty one, the flesh contains more bones. In India, no attempt has been made for commercial seed production and culture of this species.

*Barbonymus gonionotus**

A medium carp, and exotic to India, having been introduced to India in 1972 to control aquatic weeds. It is commonly called 'silver barb', 'Thai barb', 'Java carp', 'tawes' and 'Raj punti'. The fish is an omnivore, but prefers to eat soft weeds like *Hydrilla*, *Najas*, *Ceratophyllum*, etc. It is a column feeder and can compete with rohu in composite fish culture. Sexual maturity is attained in 8-10 months in females and 6-8 months in males. The fish can grow 700-800 g/year in a culture pond. The initial growth rate of the fish is as fast as Indian major carps. The marketable size of this fish is over 300 g. Females generally grow faster than males. It is an auto-breeder and breeds in confinement. It can also be induced bred using synthetic hormone and pituitary extract. The fecundity of this fish is 300,000-500,000 egg/kg body weight. The size of the egg is small (0.98 mm). Although the fish was introduced in the 1970s, the culture potentiality of this species was only realized during the late 1990s. The fish is now already being cultured in West Bengal, Assam and other northeastern states. It is a highly preferred fish and fetches the same market price as that of Indian major carps.

Puntius sarana

A minor carp that is an esteemed food in eastern region of the country. It is commonly known as "sarana" or "sar-punti". It is distributed in the Gangetic river system. It is an omnivore and eats submerged vegetation and molluscs. One peculiar feature of this species is that the rate of feeding is maximum during the peak breeding season of the fish. The fish sexually matures at the end of first year at 17-25 cm in size. It is a pre-monsoon breeder and spawns only once a year. The fecundity of the species ranges from 60,000 to 225,000 depending on the size of the fish. The fish doest not grow beyond 30 cm length and 800-900 g weight. It is exclusively freshwater and cannot withstand even very low-saline water. It dies immediately in any adverse physiological condition of soil or water. It is also easily susceptible to protozoan diseases.

** = Puntius gonionotus.*

*Hypselobarbus pulchellus***

An endangered medium carp of peninsular India, commonly called 'peninsular carp'. It is distributed in the peninsular rivers including the Krishna, Godavari and Tungabhadra. It is a herbivorous fish and changes its feeding habits depending up on the availability of food. It feeds on soft vegetation preferably *Vallisneria*. The fish attains sexual maturity at the end of first year when it grows to about 17-25 cm. It is a post-monsoon breeder and the breeding season is from July to November. It is reported that it can grow up to 6 kg in nature. Some attempts have been made to culture this species at the Peninsula Aquaculture Division of Central Institute of Freshwater Aquaculture, Hessarghata, Bangalore.

Thynnichthys sandkhol

It is a medium carp and resembles as silver carp. It is commonly called as "sandkhol carp". It is distributed in the Krishna, Godavari, Tungabhdra and Mahanadi River systems in India. It is a column-cum-surface feeder and a planktophagus fish. The fish attains sexual maturity in first year at 30 cm in length and 500 g in weight. It is a monsoon breeder and breeds once per year and does not breed in confinement. The fecundity of the fish is about 125,000/kg body weight. The initial growth rate of the fish is fast and it can grow to 0.9-1.4 kg in 9-12 months. Although a potential culture species, no attempt has been made to breed and culture on a commercial scale.

Prospects of culturing the alternate carp species:

- Except for *Cirrhinus reba* and *Puntius sarana*, all other species described are hardy in nature.
- Many of the minor and medium carps fetch better prices than the Indian major carps in different parts of the country.
- They are high fecund fish.
- The initial growth rate of many minor and medium carps is fast, being advantageous in short duration culture in seasonal water bodies.
- The marketable size of the fish is small (100-300 g) compared to 700-800 g in major carps.
- Many have prolonged breeding seasons.
- Compatible to Indian major carps for composite fish culture.
- Suitable for integrated fish culture systems (rice-fish, poultry-fish, pig-fish, cattle-fish, etc.).
- Can be cultured in low water depth, as they are hardy.
- Two crops/year can be easily harvested.
- Suitable for high stocking density culture.
- They can be cultured in pens and cages.
- Most of them are omnivores/herbivores and can easily digest the plant protein source. Therefore, the different plant based agro-industry by-products, which are rich in protein and are abundantly available in our country, can be used for low-cost feed formulation of these species.
- Can be easily domesticated to the pond environment.
- They are easily adaptable to artificial feed.
- Some of the species like *B. gonionotus* may be cultured in inland-saline areas of the country, as it can tolerate up to 8 ppt saline water.
- As they are suitable for short duration culture, farmer can get his returns in a shorter duration as compared to Indian major carps.

Problems in culturing the alternate carp species:

- Most of these carps grow slow after 4-5 months of culture and are not economical for long duration culture.
- Most the minor and medium carps lay eggs that are small in size and are transparent, posing some problem for commercial seed production.
- Although the fecundity of the fish is high, the survival rate of larvae is low under natural conditions.

Suggestions for culture expansion of alternate carp species:

- Exploratory survey are required to know the present status of these carp species in different freshwater systems of the country.
- Recording of catch statistics of these fishes is required as a priority.
- Detailed study on the biology and breeding behaviours of those species on which such information is lacking should be taken up.
- Seed production technology must be standardized to provide sufficient seeds to the farmers desirous of culturing these species on commercial scale.
- Standardization of culture techniques of these valued species is essential for encouraging farmers to take up culture of hitherto new but economically important species.
- Research on low-cost feed formulation for these species needs immediate attention, as no attempts has been made so far.
- Farmers should be encouraged to take up the culture of small and medium carp in the form of monoculture or composite fish culture.
- Horizontal expansion for the culture of these species are required, covering both season and perennial water bodies which are unutilized at present.
- More research and development is required to improve the growth of fish through hybridization or genetic improvement.

** = *Puntius pulchellus.*

Conservation measures for alternate carp species:

Some of these alternate species are endangered and some are vulnerable to extinction. To conserve these valued carp species, it is important to ensure the following measures:

- Regulation of mesh size to prevent the catching of brooders and young ones during the breeding and larval rearing stages of fish.
- Declaration of sanctuaries in the area where these species are endemic.
- Artificial recruitment may be made to revive the carp species in the areas where these fishes are less available and the catch is declining.
- Prevention of entry of industrial pollutants in the areas where these fish inhabits.
- Public awareness is required to save these fish from extinction.
- Conservation of gametes through gene banking is important for adopting future strategies of replenishment and stock enhancement of these valued carp species.

References

Ayyappan, S. and Biradar, S., 2004. Enhancing global competition. The Hindu Survey of Indian Agriculture, 2004, pp. 97-99.

Ayyappan, S. and Jena, J.K., 2006. On a fast track of development. The Hindu Survey of Indian Agriculture, 2006, pp. 143-147.

Chondar, S. L., 1999. Biology of Finfish and Shellfish. 514 pp.

Day, F., 1994. The Fishes of India, Volume I, Jagmander Book Agency, New Delhi, 778 pp.

Day, F., 1994. The Fishes of India, Volume II, Jagmander Book Agency, New Delhi, 205 pp.

Genetic and reproduction technologies for enhanced aquaculture and fisheries management of Murray cod

Hui King Ho[1], Meaghan Rourke[2], William Bravington[1], Helen McPartlan[2] and Brett A. Ingram[1*]

*1. Department of Primary Industries Victoria, Private Bag 20, Alexandra. Vic 3714. Australia; 2. Department of Primary Industries Victoria, Mickelham Road, Attwood. Vic 3049. Australia; *Corresponding author: Dr Brett A. Ingram, of Primary Industries Victoria, Private Bag 20, Alexandra. Vic 3714. Australia.*

Email. Brett.ingram@dpi.vic.gov.au

Introduction

Fish consumption forms an important aspect in the traditional diet of many communities, particular in Asia. However, increasing consumption of seafood combined with the increasing world population has lead to a substantial rise in demands for aquatic food resources. Today, around three quarters of the world's fish stocks monitored by FAO are fully exploited, overexploited or depleted. The maximum wild capture fishery potential from the world's oceans has probably been reached and there is world-wide over-fishing of inland fishery resources. (FAO 2007). One possibility for alleviating pressure on wild fisheries is through aquaculture (food fish and aquatic plants) which continues to grow rapidly globally (average 8.8% per annum since 1970), more so than for capture fisheries (1.2%) and terrestrial farmed meat production (2.8%) (FAO 2007). Aquaculture is providing an alternative supply pathway by producing both staple fish species and high-value seafood from sustainable production systems and is alleviating pressure on wild fisheries.

In recent decades there has been a revolution in application of genomics and gene-related biotechnology in agriculture and aquaculture (eg. Foresti 2000, Hew and Fletcher 2001, Melamed et al. 2002). Biotechnology research aims to increase production and reduce costs, especially through the manipulation of the genes and chromosomes of cultivated species. Equally biotechnology is also applied to wild fisheries resources to improve their management, for example DNA is being used to differentiate populations and to manage captive breeding programs for stock enhancement/replenishment.

In Australia, through a major project funded by the State Government of Victoria, a biotechnology approach for enhancing aquaculture and fisheries management is being applied to Murray cod (*Maccullochella peelii peelii*) (Percichthyidae) (Ingram et al. 2005b, Rourke et al. 2007a, Ingram 2007). The challenge of this project is to apply advanced genetic and reproduction technologies to this high-value inland species to increase production efficiencies and manage wild populations. With gains in production performance, reliability and profitability, the next five to 10 years could see the expansion of Murray cod farming sector in Australia and internationally. Application of these technologies will also provide extra benefits for the management of native finfish biodiversity, particularly for species such as Murray cod which are declining in the wild and yet continue to be managed for multiple purposes (ie. commercial, recreation, conservation). This article outlines progress made in the project.

Murray cod, Australia's largest indigenous freshwater fish, is an iconic species with significant commercial, recreational, conservation and cultural value (Figure 1). However, over-fishing, habitat loss and modification within the cod's natural range in

Figure1.Large Murray cod angled from the Murray River.

the Murray-Darling Basin (MDB) have seen numbers reduced since the early 1900's. The MDB consist of a network of streams, rivers and water bodies with a catchment area of over million square kilometres, approximately 14% of the land surface of the Australian mainland. Nationally, Murray cod is listed as "Vulnerable" under Australian legislation (Environment Protection and Biodiversity Conservation Act 1999), which is designed to protect its conservation status. Since the 1980's, over 11 million hatchery-reared juveniles have been released into the wild to enhance recreational fisheries and for conservation purposes. Murray cod has excellent aquaculture prospects and small quantities are already being sold into domestic and international markets (Ingram et al. 2005a, Ingram and De Silva 2004). Some aquaculture attributes of Murray cod include, established hatchery production of fry, readily accepts artificial food, hardiness to physical handling, fast growth rates, can tolerate high stocking densities and has a high demand within the Asian community.

Project aims

The project aims to develop and apply genetic and reproduction technologies to boost the profitability and sustainability of the newly emerging Murray cod aquaculture industry in Australia. The selective breeding of Murray cod will involve using genetic markers (microsatellites) to identify broodfish that possess favourable production traits of commercial importance (ie. rapid growth, robustness, disease resistance, skin colour, fat content etc.). These broodfish will then be used to breed new elite strains of Murray cod suited to aquaculture.

The project will also investigate the use of controlled reproduction technologies, (ie. out-of-season spawning, chromosome-set manipulation, hybridisation and cryopreservation) to improve stock management and to enhance the performance and value of selectively bred strains of Murray cod. These technologies will allow production of sterile seedstock that will provide for biosecurity and protection of intellectual property (IP) invested in selective breeding.

Microsatellite markers and genetic tools developed for the selective breeding program will also be used to study the genetic diversity of wild Murray cod populations across the MDB. This work will assist in the protection and management of these populations, and will be used to develop genetically sound stock enhancement practices to support recreational fishing.

The project is being undertaken by scientists at the Department of Primary Industries (DPI), Victoria, Australia at the Attwood and Snobs Creek centres and forms part of the Our Rural Landscape (ORL) Initiative program. The Attwood group is conducting animal genetics and genomics research for the dairy, beef, sheep and abalone industries. It has built up an impressive collection of genetic material, as well as expertise in molecular genetics and bioinformatics. The Snobs Creek group has a long history of fisheries and aquaculture research, and has played a key role in the development of captive breeding and production techniques for Murray cod and other native fish species.

Developing biotechnology capabilities by government and industry will provide clear triple bottom line benefits which are;

1. Economic; through the development of the Murray cod aquaculture industry and sustaining Murray cod recreational fisheries;
2. Environmental; from using microsatellite markers to help understand biodiversity in Murray cod populations, and;
3. Social; through enhanced genetic management of wild populations for conservation and recreation.

Project progress

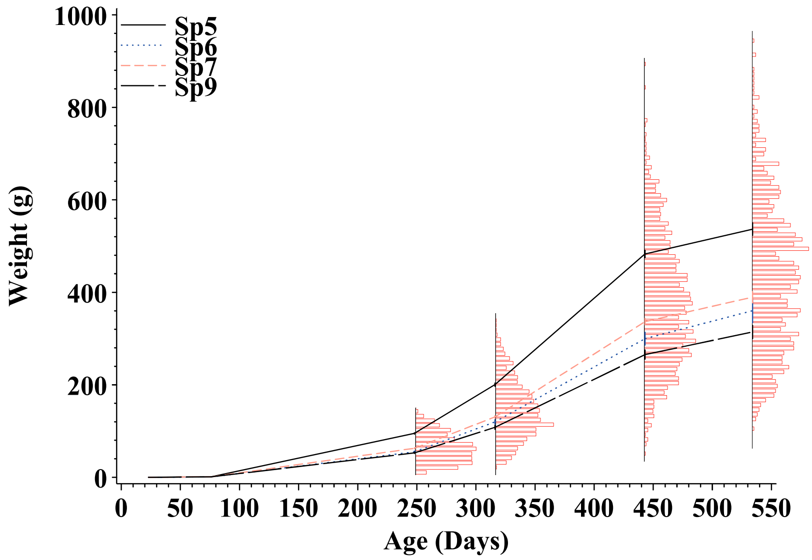
Selective breeding

Currently, approximately 4,600 fish from 40 genetically diverse families (1st generation stock) of Murray cod, obtained from two government hatcheries and three private hatcheries over two different breeding seasons, have been established in custom built recirculating aquaculture systems to create the founder population. An additional 20 families will be obtained during the current breeding season to boost diversity of the founder population. These fish, once mature will provide a genepool from which new broodstock possessing traits of interest will be used to breed new domesticated strains of Murray cod selected for high performance (growth etc.) in aquaculture. Some fish are now reaching maturity and will be ready to spawn for the first time in 2008.

An industry survey of fish farmers and fish retailers indicated that important traits of interest for the aquaculture of Murray cod included fast growth, hardiness (eg. stress resistance and disease resistance) and survival during production, while at market, fish size, skin colour and flesh texture (amongst others) were important. Retailers prefer larger fish (>2 kg), and lighter coloured fish, typical of those caught from the wild, over darker coloured fish. This information will be used to guide the selective breeding program for Murray cod.

In order to link the microsatellite markers to the aquaculture traits of interest, fish from four families of known parentage were combined at three weeks of age and communally-reared. At eight months of age these fish were implanted with microchips (Trovan Pty Ltd, Australia) to identify individuals, and a tissue sample was collected from each fish for DNA analysis. Subsequent measurement of these fish showed that a number of important traits were quite variable within and between families. Fish from one family in particular (Sp5) grew faster (Figure 2) and more survived than in the other three families. At 14 months of age, weight ranged from 57g to 886g. Researchers also observed considerable differences in fish condition and skin colour (Figure 3).

Figure 2. Growth of four families of Murray cod reared communally (lines = mean values), and frequency distribution of weight at four sampling dates (bars).



We have successfully amplified 103 microsatellites in Murray cod, of which 101 were polymorphic and two were monomorphic (Rourke et al. 2007b). Excluding the monomorphic loci, the number of alleles per locus ranged from two to 19 alleles per locus (mean seven alleles per locus). The expected heterozygosities ranged from 0.066 to 0.95 (mean 0.64), and most loci were in Hardy-Weinberg equilibrium. These new loci have been used for the identification of quantitative trait loci to improve the productivity of cultured Murray cod, and to assess wild and hatchery stock structure of Murray cod for management purposes. A genetic map for Murray cod is currently being developed and analysed for the four communally reared Murray cod families. So far, 20 linkage groups, with between two and seven markers per group, have been identified. Cross-amplification of the loci developed for Murray cod was tested on 19 other species of fish. Within the Percichthyidae, 79-94% of loci crossed-amplified in three other *Maccullochella* species and 18-38% four *Macquaria* species (Rourke et al. 2007). These results make this set of microsatellite markers an extremely useful resource for future genetic studies of percichthyids.

A subset of microsatellite markers have been successfully linked to a number of important aquaculture traits, including growth (weight at measurement and specific growth rate), skin colour, fish condition and carcass fat content (Figure 1). However, analyses performed on the surviving fish found no evidence of any of the DNA markers being inherited with the “survival” trait. Nevertheless, this information can now be used to select broodstock with these traits to produce new, high performing strains of fish for the aquaculture industry.

Reproduction

Research into the controlled reproduction of Murray cod is being conducted on a group of mature broodfish held in a recirculating aquaculture system under an artificial photo-thermal regime. These fish were successfully induced to spawn outside their normal breeding season by manipulating the temperature and light regimes in the recirculating aquaculture system and hormone-induction of ovulation (Figure 4). In 2004, when the first spawning trials were conducted, 90% of fish injected with hormone (HCG) ovulated and were stripped, but hatch rates averaged 3%, and were substantially lower than hatch rates observed in natural pond spawnings at DPI, Snobs Creek (mean 50%). However by the third year of trials hatch rates of up to 67% were obtained. Controlled breeding of this species will increase the flexibility of the selective breeding program and enable greater control over fish mating and seedstock production.

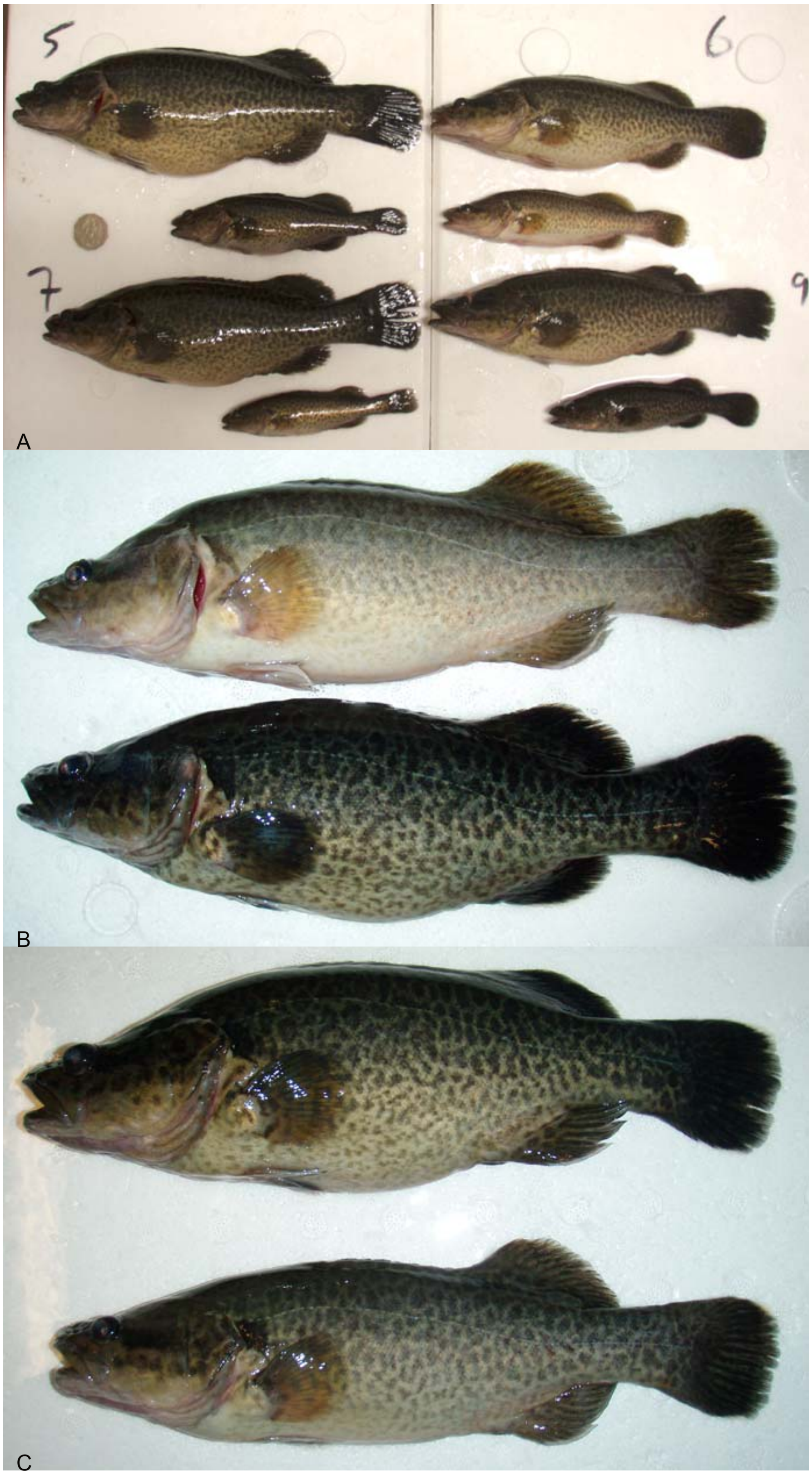
Triploid fish (fish with three sets of chromosomes) are desirable in aquaculture because they are generally sterile. Since no energy is spent in the development of gonads, these fish exhibit faster muscle growth. Triploidy is also used as a means of genetic containment by reduction of unwanted reproduction. Triploidy was induced in Murray cod by shocking eggs shortly after fertilisation. Eggs in some shock treatments failed to hatch while in other treatments hatch rates ranged from <1% to >100% of control (non-shocked) hatch rates. Heat and cold shocks failed to induce triploidy, whereas some pressure shocks induced various levels of triploidy (up to 100% in some replicates) (Figure 5). Further experiments are now being conducted to refine techniques.

Hybrid fish are used in aquaculture to increase growth (hybrid vigour), transfer or combine desirable traits between species and reduce unwanted reproduction through production of sterile offspring. Hybridisation was successfully induced in both direct and reciprocal crosses between Murray cod and trout cod (*Maccullochella macquariensis*). Murray cod x trout cod hybrids, though rare, occur naturally in the wild where both species occur sympatrically. A small number of hybrids are currently being reared to evaluate their aquaculture performance (eg. growth and environmental tolerance) and ultimately to determine their fertility.

In collaboration with the Monash Institute of Medical Research (Melbourne), we are investigating options for cryopreserving sperm in liquid nitrogen as a means of cost-effectively storing genetic material for conservation and selective breeding programs (Figure 6). Trials have identified cryoprotectant composition and freezing methods for Murray cod sperm that provide high levels of sperm motility post-thawing. In fertilisation trials, we have achieved hatch rates up of to 65% of the hatch rates for eggs fertilised with fresh sperm.

Genetic analyses of captive Murray cod broodstock and their offspring have provided insights into the previously unknown breeding habits of this species. Murray cod are generally believed to form monogamous pairs and breed once a year. In captivity, broodstock are allowed to spawn naturally in ponds and during the breeding season nesting boxes located

Figure 3. Variation communally reared Murray cod in size. (A) growth variation within and between four families. (B) Skin colour. (C) Condition (fattiness).



in the broodstock ponds are regularly checked for spawnings. However, parentage analysis of captive-spawned offspring has revealed that broodstock are occasionally polygynous with up to 17% of spawnings involving three parents (mostly 1 male and 2 females). Some fish (both male and female) spawned twice in a single season, and larger males contributed more to spawnings than smaller males. These results have substantial implications for genetic management of captive broodstock used in stock enhancement programs.

Early detection of sex is important in evaluating reproduction technologies that affect or manipulate sex. However, outside the breeding season Murray cod cannot be accurately sexed without applying invasive techniques whilst juveniles cannot be sexed at all. We found that testing for the presence of vitellogenin (yolk protein) in blood plasma, was a reliable method for non-destructively identifying maturing and mature female Murray cod.

Population genetics

In order to determine the genetic structure of contemporary wild Murray cod, tissue samples (finclips and fish scales) were obtained from 700 fish from 19 river catchments across MDB. A historical collection of Murray cod scales of 361 fish collected from six southern river catchments between 1948 and 1953 were compared against contemporary samples (post 1995) to identify temporal changes in the genetic structure of Murray cod in the southern part of the MDB, and to identify potential impacts of stock enhancement programs, which commenced in the early 1980's.

Genetic analysis of contemporary fish samples revealed up six populations across the MDB. Fish from two river catchments (Lachlan and Macquarie-Bogan) each represent a discrete genetic cluster, while fish from three others (Border, Namoi and Gwydir) show a slightly lower degree of differentiation and evidence of restricted gene flow. Fish from other MDB catchments are apparently one large panmictic population (Figure 7). These results indicate that the populations in rivers flowing into the Murray River are highly connected, while those terminating in swamps and wetlands, (Lachlan and Macquarie-Bogan), are historically isolated.

Results of this study suggest that stock enhancement practices have had a mixed effect on the Murray cod populations in the MDB. Temporal comparisons between the historical and contemporary samples from five southern catchments showed limited genetic differentiation, indicating no change in either genetic diversity or structure in these catchments over the past half century, despite the commencement of stock enhancement in the 1980's. This is probably due to broodstock being obtained primarily within these southern catchments, which represent a single panmictic population and continual replacement of broodstock in breeding programs with fresh stock from the wild. On the other hand, there is evidence that stocked fish have interbred with local populations in two catchments (Macquarie-Bogan and Gwydir), while one distinctive population (Lachlan) has retained its genetic uniqueness despite extensive stocking of fish into large impoundments within these catchments. These manmade barriers may have prevented stocked fish from mixing with native strains in the rivers downstream.

This is important information for the long-term management of the genetic diversity of wild populations of Murray cod. The data has shown that some populations are unique and need to be managed accordingly. We are now using these data to develop a model to evaluate the effects of different breeding and stocking practices on the genetic diversity of wild populations. This model will assist fisheries managers to implement genetically sound stock enhancement programs.

Conclusions and future work

Murray cod aquaculture is a new and developing industry that exhibits efficient and profitable use of natural resources (water and fish). This project has established an excellent foundation for establishing a selective breeding program for the species (family lines and tools for selection). While no selec-

Figure 4. Hand-stripping Murray cod eggs.

Figure 5. Application of hydrostatic pressure to induce triploidy in Murray cod eggs.

Figure 6. Straws of Murray cod sperm being frozen in liquid nitrogen.

tive breeding took place in the current project, due to the limited timeframe, the results from this work are the first stage of such a program. Now that a genetically diverse founder population of broodstock has been established and microsatellite markers have been linked to favourable aquaculture traits, a "proof-of-concept" project will be undertaken to evaluate the performance of selectively bred strains of Murray cod. In addition, discussions with potential industry partners to commercialise the breeding program have already commenced.

Information from this project will assist fisheries managers in assuring the future of wild stocks, ensuring sustainability of aquatic resources and maintenance of biodiversity. The existence of unique populations of Murray cod and are now being recognised and being incorporated into management plans for the species by some fisheries agencies. The microsatellite markers developed for Murray cod are now being used by other researchers in population genetics studies of percichthyid species for conservation purposes.

Another achievement of this project has been the development of new capabilities in fisheries and aquaculture genetics and genomics within the DPI. These capabilities will be applied to other aquatic species for aquaculture (eg. selective breeding of blue mussels, *Mytilus* spp.), sustainable fisheries management (development of genetically sound stock enhancement practices for native species) and aquatic species conservation (eg. genetic structure of stocked populations of the endangered trout cod).

References

FAO (2007). The State of World Fisheries and Aquaculture 2006. FAO Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations, Rome.

Foresti, F. (2000). Biotechnology and fish culture. Hydrobiologia, 420, 45-47.

Hew, C.L. & Fletcher, G.L. (2001). The role of aquatic biotechnology in aquaculture. Aquaculture, 197, 191-204.

Ingram, B.A. (2007). Genetic and reproduction technologies for enhanced production of Murray cod Our Rural Landscape. Sustainable development through innovation. Technical Note 17. Department of Primary Industries, Melbourne. 4 pp.

Ingram, B.A. & De Silva, S.S. eds. (2004). Development of Intensive Commercial Aquaculture Production Technology for Murray cod. Final Report to the Fisheries Research and Development Corporation (Project No. 1999/328). Primary Industries Research Victoria, DPI, Alexandra, Victoria, Australia. 202 pp.

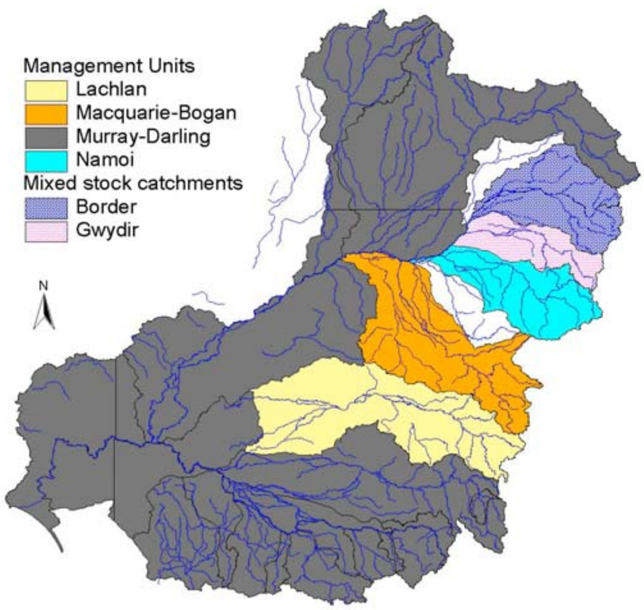
Ingram, B.A., De Silva, S.S. & Gooley, G.J. (2005a). The Australian Murray cod - A new candidate for intensive production systems. World Aquaculture, 36, 37-43 and 69.

Ingram, B.A., Rourke, M.L., Lade, J., Taylor, A.C. & Boyd, P. (2005b). Application of genetic and reproduction technologies to Murray cod for aquaculture and conservation In Management of Murray cod in the Murray-Darling Basin. Statement, recommendations and supporting papers (Workshop held in Canberra, 3-4 June 2004) (Lintermans, M. & Phillips, B. eds.), pp. 107-109. Murray-Darling Basin Commission, Canberra.

Melamed, P., Gong, Z.Y., Fletcher, G. & Hew, C.L. (2002). The potential impact of modern biotechnology on fish aquaculture. Aquaculture, 204, 255-269.

Rourke, M., McPartlan, H. & Ingram, B.A. (2007a). Genetic technologies for the management of natural Murray cod populations Our Rural

Figure 7. Potentially unique populations (management units) of Murray cod in the Murray-Darling basin.



Landscape. Sustainable development through innovation. Technical Note 20. Department of Primary Industries, Melbourne. 4 pp.

Rourke, M., Nheu, J., Mountford, H., Lade, L., Ingram, B. & McPartlan, H. (2007b). Isolation and characterisation of 102 new microsatellite loci in Murray cod *Maccullochella peelii peelii* (Percichthyidae), and assessment of cross-amplification in thirteen Australian native and six introduced freshwater species. Molecular Ecology Notes, 7, 1258-1264.

Effluent and disease management in traditional practices of shrimp farming: A case study on the west coast of Sabah, Malaysia

Norasma Dacho* and Saleem Mustafa

Borneo Marine Research Institute, University Malaysia Sabah, 88999 Kota Kinabalu, Sabah, Malaysia. Email: norasmadacho@gmail.com.

Introduction

Similar to other aquaculture activities, the production process of shrimp farming is not without environmental implications. To a global context, the adverse environmental impact of unplanned and uncontrolled expansion of shrimp farming has prompted widespread criticisms (Naylor et al. 1998). Disease problems and environmental issues in shrimp farming have caused worries about the sustainability of traditional farming practices (Otoshi et al., 2005). Persistent disease and environmental threats originating from traditional practices have also caused concern in Sabah. A thorough assessment of the farming practices will provide a basis for recommendations for the most viable way of producing shrimp consistent with sustainability criteria. This has been attempted in the present study.

Materials and methods

In the process of data collection, this case study used method based on social science approach - technical site observations and interviews. Social science research offered a way of better understanding people who were engaged in the fisheries activities and the social dimensions needed for inclusion in the management process (Kaplan and McCay, 2004).

The farms were located on the west coast of Sabah, in Tuaran, Kota Belud, Kudat, Kuala Penyu and Beaufort. Three field visits were made to each of the shrimp farms during August-December 2005. This was followed by two more visits in August 2006 for reliability checks and to validate observations made earlier. These farms were chosen because of their willingness to cooperate unconditionally. The samples in this study were farm managers and farm technicians, working directly at the farms. Semi-structured interviews were performed on site, face to face, using a printed form as guidance. Questions were asked about farm management practices for disease and effluent management.

The observations were obtrusive; the farm managers were informed in advanced that site observation and interview would take place. Observation focused on obtaining direct and generally indisputable verification of obvious behaviour which can also be used to measure subjective experiences such as attitudes (Singleton and Straits, 2005). The Department of Fisheries, Sabah record showed as of August 2005 that there were 21 active shrimp farms on the west coast of Sabah. Ten shrimp farms were included and taken as purposive and convenient samples, representing about 50% of the total shrimp farms in that area.

The aim in a qualitative research is to describe the process and events involved rather than their distribution and therefore, sampling is purposive and does not attempt to be statistically representative (Rice and Ezzy, 2001). Questions and observations were designed so as to elicit this information. In such studies it is a general distribution of processes that is considered necessary.

Even though the shrimp farms are accessible by road, most of them are scattered and it took between two to three hours to reach some of the farms. In such a situation, this convenience or purposive sampling could be appropriate (Singleton and Straits, 2005). Due to limited time and resources, the number of shrimp farms included in this study was considered sufficient to achieve the objective of the study. The decision to select study sites was based on: 1) availability of funding, 2) allocation of time, 3) willingness of participants, and 4) accessibility.

Results and discussion

Results of this study are presented in a qualitative manner. The observed variables and questions asked are discussed to explore the qualitative dimension of traditional practices. This case study revealed that the nature of its operation is purely for commercial purposes. The size of shrimp farms varied from 7 acres to 100 aces.

Results showed that generally most farm managers are aware of the importance of environmental issues and disease prevention. All farms claimed to have stocked with post-larvae that have tested negative for White Spot Syndrome Virus (WSSV). In terms of disease experience, four farms reported to have been affected by WSSV, one farm experienced *Vibrio* disease in the ponds and six farms are free of any shrimp disease (Table 1). The results of this case study are synthesized and grouped into two components.

Disease management

Questions and observations regarding disease management were focused on how farm managers treated the waste water, sludge, and dead shrimp from ponds that have been affected with disease and post-harvest processes. Regardless of their experience with disease, all farm managers reported that dead shrimp of commercial value were sold and smaller shrimps were disposed off. Direct disposal of dead or diseased shrimp is not a good practice because it can spread disease to other crustaceans and neighbouring farms. Technical site observations revealed that such practices were common among shrimp farmers. Horizontal transmission of WSSV through water and feeding of infected shrimps and movement of infected live animals have been known to be a probable route for the spread of the disease (Mohan et al., 1997; Bondad-Reantaso et al. 2005). Farmers should be made aware that disposing dead or infected shrimp without treatment is not environment-friendly and of the environmental implications of their practices and their impact on shrimp aquaculture itself.

Different procedures were applied for treatment of waste water and effluent. Some farmers released waste water without treatment, others discharging it into nearby mangrove and estuary. One farm had tilapias and milkfish in the settlement pond as biological filter and two farms kept discharge water in settlement ponds for some time before releasing it to the open water. Farm managers related the importance of water quality, the use of certified disease-free post-larvae, seed selection techniques, use of vitamins and probiotics, and good nutritional management as steps in health management and specifically in reducing the chances of disease outbreak. It was encouraging to note that even with certified disease free post larvae, half of the farms observed still go through post-larvae selection technique.

This case study indicated that farms with disease experience exhibited some peculiarities. Since some of the farms are situated in the same area, it is likely that untreated water could have been pumped into culture pond or reservoir ponds. Disease outbreaks could very much be associated with the lack of responsible farm operations, especially waste disposal.

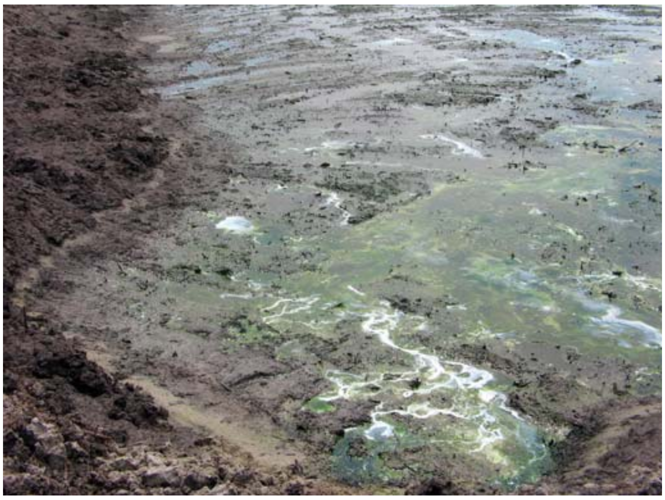
Six out of ten of the shrimp farms surveyed were neighbours and shared the water source but results of interviews indicated that not all managers informed their neighbours when faced with disease problems. This practice could have negative impacts on the ecosystem and the water source they are sharing. WSSV could affect pond rapidly with mass mortalities and readily transmitted disease from diseased shrimp to healthy susceptible shrimp via contaminated water (Rajan et al. 2000). Not informing the authorities and nearby shrimp farms could give shrimp farming an irresponsible and generally bad reputation, and contribute to self-pollution that escalates disease problems.

It was observed that the use of pet dogs for security and preventing intruders is very common in all shrimp farms. One shrimp farm employed contract security guard on contract basis but only at the entrance gate. Pet dogs were observed wondering freely around the shrimp ponds and workers quarters. This should not happen because dogs could also be a disease carrier, particularly when they wonder from one shrimp farm to another. Investing resources to employ more contract security personnel could add to the operation cost but will be a worthy investment. Visitors and vehicles that enter the farms are not subjected to any sanitary measures, which showed a lack of biosecurity and poor health management standard.

Managers reported that the use of probiotic base products and vitamins are helpful for health management and to reducing disease risk by fortifying natural defences of the stock. There is are growing evidence that show the effectiveness of probiotics in inhibiting a wide range of fish pathogens and disease problems in shrimp farming (Moriarty, 1999; Rengpipat et al., 2000; Irianto and Austin, 2002). This is a good indication that shows some farm managers are accepting new approaches to health management.

Certified disease free post-larvae and pond preparation were recognized as two of the most important steps in disease prevention. All the farms indicated that ponds were properly dried and green water was prepared before stocking the post-larvae. Several measures had been applied in health management to reduce disease which included post-larvae selection, specific pathogen free brooders,

Sludge area.


Black thick soil formed as sludge.


Outflow water canal.

closed systems, recirculation systems, probiotic application and some form of biosecurity (Donovan, 1997; Kongkeo, 1997; Moriarty, 1999; Kautsky et al., 2000; Irianto and Austin, 2002; Mustafa, 2004).

Training needs in health management were assessed to find out their technical capabilities in disease and effluent management. Only four farm managers were reported to have obtained formal training in disease management. Two of them attended training conducted by the Department of Fisheries Malaysia and the other two attended training organized By Charoen Pokphand (CP) group in Thailand. Other farm managers reported that they gained knowledge through their own experience working in different farms without attending any formal training at all. It was reported that there is shortage of local experts and qualified personnel to assist them with shrimp disease. Farm managers are very concerned about disease threats and voiced their interest in attending courses for health management if


Farm technician explaining feeding schedule.


Site observation.

Table 1: Farm Size, Disease Experience and Effluent Treatment

Farm size	Disease experience	Effluent treatment
7 acres	None	Closed system, solid waste recycled into fertilizer.
7 acres	None	No treatment of waste water, sludge is left to dry at pond bottom.
19 acres	White spot disease	Water is treated and kept in treatment pond before discharge. Sludge is recycled, used as fertilizer.
11 acres	None	No treatment of waste water, sludge is left to dry at pond bottom.
30 acres	White spot disease	Discharge of water to nearby mangrove, drying of pond sludge.
30 acres	None	No treatment of waste water, sludge is left to dry at pond bottom.
40 acres	White spot disease	Discharge of water to nearby estuary, sludge is kept in specific area in the farm.
50 acres	None	No treatment of waste water, sludge is flushed, ploughed and left to dry at pond bottom.
60 acres	None	Use of settlement pond, treatment of water before discharge, sludge is kept in specified area, used as fertilizer after two years.
100 acres	White spot disease	Water is treated, kept in settlement pond with tilapias and milkfish as bio-filters, sludge is kept in specified area.

arranged locally and free of cost. It is worth mentioning that training for shrimp health management is available locally but participation is generally subsidized, not entirely free.

This case study showed that technical consultation and professional services for effluent and health management are needed. Lack of widespread use of new techniques is due to hesitation of the farm enterprise to invest resources in acquisition of higher technology. Economic loses due to disease and environmental problems can be mitigated by investing in new technology, fine tuning traditional practices, and embracing new concepts (Mustafa, 2004).

Some farm managers reiterated that disease outbreaks could be reduced by proper water management throughout the farming period, regular monitoring of feeding, and the external appearance of the shrimp in the ponds. This shows that some farmers are receptive to change the traditional practices to contemporary disease management. However, concerns are high for those shrimp farms that lack biosecurity measures and choose to release untreated water from infected ponds, sale or dispose diseased or dead shrimp, and not willing to invest in training and consultation of professionals in shrimp health management.

Feeding tray.

Effluent management

To reduce negative impacts of effluents and enhance nutrients in the ponds, some farm managers indicated the used of effective microorganism product. As summarized in Table 1, it was noted that three out of the ten farms in this survey were recycling the sludge and using it as fertilizer. Three farms had allocated specific areas to contain the sludge. Farm managers dry the pond for a period of one to two months. One farm used tractors to plough and turnover the sludge at the pond bottom while the rest carry out disinfecting, drying and flushing methods to ensure the dark smelly pond bottom is cleaned and made suitable for aquaculture.

In spite of portraying some level of environmental awareness, some managers still discharged waste water directly without proper treatment. Not all farms have settling or reservoir pond for sedimentation and treatment. For those who treated effluents, they managed it by constructing settlement ponds, drying and reapplying of sludge, and discharging in mangrove areas. Recycling of sludge and providing settlement ponds are some of the approaches recommended to mitigate shrimp pond effluents (Donovan, 1997; Boyd and Tucker, 1998; Teichert-Coddington et al., 1999; Paez-Osuna, 2001). Some of the practices of effluent management observed in this study are not totally environment-friendly.

Monitoring feeding efficiency.

The variety of responses to effluent treatment and weather or not the farmers have disease experience showed a lack the conviction with farming commitments to adhere to better management practices and lacking willingness to invest in biosecurity measures. Although there is no one effluent treatment is suitable for all conditions, some level of awareness and basic concept of effluent management is necessary for a farm to reduce risks of diseases and maintain equilibrium with environment-friendly systems. This case study revealed that there is no significant relationship between disease experience and sludge

Pumping water to reservoir pond.

management. Disease experience has not made farm managers to be more cautious in effluent treatment. Some are learning from past experience while others continued their unsustainable practices, the latter category of farm managers often react to disease when it breaks out.

Conclusion

The findings of this study showed that not all traditional practices in effluent treatment and disease management conform to modern requirements. Disease management in traditional practices does not include the prescription in favour of prevention of infection and stress reduction; it shows their continued dependence on methods that have betrayed their expectations in the past. Currently, technical management and farm design are inadequate for comprehensive effluent and infectious disease exclusion. Shifting of paradigms and investments are needed to benefit from the current techniques. In the absence of such reforms the traditional practices of shrimp farming will remain unsustainable. Despite growing awareness of new methods, the reluctance of farm enterprise to invest more capital makes knowledge-based modernization difficult.

Drawing on these findings, some procedures can be suggested for introducing contemporary measures in disease and effluent management: i) working with farmers based on an institutional approach to implement a biosecurity model shrimp farm that envisages environmental and health management criteria, ii) offering technical services and resources formulated as Standard Operation Procedures for sustainable shrimp farming, iii) dissemination and communication of the benefits of good management practices in shrimp farming by doing it right the first time, iv) introducing stringent effluent management guidelines, and v) mandatory shrimp-pathogen free testing by accredited laboratories.

Organic fertiliser.

References

Bondad-Reantaso, M. G., Subasinghe, R. P., Arthur, J. R., Ogawa, K., Chinabut, S., Adlard, Tan, Z. and Shariff, M. 2005. Disease and health management in Asian aquaculture. Veterinary Parasitology 132: 249- 272.

Boyd, C. E. and Tucker, C. S. 1998. Pond Aquaculture Water Quality Management. Kluwer Academic Publishers, Boston, Massachusetts.

Donovan, D. J., 1997. Environmental code of conduct for Australian prawn farmers. Australian Prawn Farmers Association, Bribie Island, Queensland, Australia.

Irianto, A. and Austin, B. 2002. Probiotics in aquaculture. Journal of Fish Diseases 25 (11): 633-642.

Kaplan, I. M. and McCay, B. J. 2004. Co-operative research, Co-management and the social dimension of fisheries science and management. Marine Policy 28: 257-258.

Kautsky, N., Ronnback, P., Tedengren, M. and Troell, M. 2000. Ecosystem perspectives on management of disease in shrimp pond farming. Aquaculture 191: 145- 161.

Kongkeo, H. 1997. Comparison of intensive shrimp farming systems in Indonesia, Philippines, Taiwan and Thailand. Aquaculture Research 28: 789 -796.

Mohan, C. V., Sudha, P. M., Shankar, K. M. and Hedge, A. 1997. Vertical transmission of white spot baculovirus in shrimps – A possibility? Current Science 73 (2): 109-110.

Moriarty, D. J. W. 1999. Disease control in shrimp aquaculture with probiotic bacteria: In Bell. C.R., Brylinsky. M., Johnson-Green, P. (eds). Microbial Interactions. Aquaculture Proceedings of the 8th International Symposium on Microbial Ecology 1–5.

Farmworkers preparing fertiliser.

Mustafa, S. and Van, J. L. 2004. A new method in production of organic shrimp using 'cell salts'. Austasia Aquaculture 18:58-62.

Naylor, R. L., Goldburg, R.J., Mooney, H., Beveridge, M. C. M., Clay, J., Folke, C., Kautsky, N., Lubchenco, J., Primavera, J. and Williams, M. 1998. Nature's subsidies to shrimp and salmon farming. Science 282 (5390): 883 – 884.

Otoshi, C. A., Arce S. M., Moss, S. M. 2003. Growth and reproductive performance of broodstock shrimp reared in a biosecure recirculating aquaculture system versus a flow-through pond. Aquaculture Engineering 29: 93 – 107.

Paez-Osuna, F. 2001. The environmental impact of shrimp aquaculture: causes, effects, and mitigating alternatives. Environmental Management 28 (1): 131 - 140.

Rajan, P. R, Ramasamy, P., Purushothaman, V. and Brenan, G. P. 2000. White Spot Baculovirus syndrome, in the Indian shrimp *Penaeus monodon* and *P. indicus*. Aquaculture 184: 31-44.

Rengpipat, S., Rukpratanporn, S., Piyatiratitivorakul, S., and Menavesta, P. 2000. Immunity enhancement in black tiger shrimp (*Penaeus monodon*) by a probiont bacterium (*Bacillus* S 11) Aquaculture 191: 271-288.

Rice, P. L. and Ezzy, D. 2001. Qualitative Research Methods: A health focus. Oxford University Press, Victoria, Australia.

Singleton, R. A. Jr. and Straits, B. C. 2005. Approaches to Social Research. Fourth Edition. Oxford University Press Incorporation. New York, USA.

Teichert-Coddington, D. R., Rouse D. B., Potts A., Boyd, C. E. 1999. Treatment of harvest discharge from intensive shrimp ponds by settling. Aquacultural Engineering 19:147 - 161.

Status of sahar (*Tor putitora*) domestication and its development in the Himalayan Region of Nepal

Ash Kumar Rai

Golden mahseer.

Sahar (*Tor* spp.), a mahseer, is the second largest riverine fish species indigenous to Nepal, after the catfish *Bagarius yerrellii*. It is a well-known food and sport fish in the Himalayan waters, and an inhabitant of the fast flowing large rivers, lakes and reservoirs of Nepal. Sahar is omnivorous. It has high economic value, typically selling for NRs 250-350 per kg (US$ 3.50-4.90) which is 3-5 times higher than cultured carp fish. It can survive water temperatures ranging from 7-38°C. The species is migratory, over long distances, and also occurs in the South Asia region. Sahar is much sought after as a sport fish in India (Kulkarni 1970; Chaturvedi 1976).

The culture technology for sahar has not been commercialized as yet; however artificial propagation techniques have been developed successfully in Nepal following many years of research. Two species of sahar are available in Nepal of which *Tor putitora* is the most common whereas *Tor tor* is rare. The Trishuli River system and lakes of Pokhara valley are notable sources of *T. putitora* (Gurung and Pradhan 1994). Sahar growth is slower in first year and increases from second year onwards. Sahar is a partial breeder and breeds from March to November (Gurung et al. 2001). Brood fish should be maintained properly particularly for breeding purposes to get successful results.

Studies on management, propagation and conservation of sahar were initiated in different countries after the 1970s (Pathani 1981; Shrestha 1997). In the early sixties *Tor* spp. constituted one of the major species of commercial fisheries in the lakes of Pokhara valley (Shrestha and Gurung 1990) but now its catches are negligible (Swar and Gurung 1988; Wagle and Bista 1999).

The deteriorating environmental conditions of the water bodies as well as high fishing pressure using destructive gears such as electro-fishing, poisoning and dynamiting have contributed to this decline (Das and Joshi 1994; Shrestha 1994). Artificial propagation and culture technologies will help to conserve as well as maintain the declining population. They will also help to increase fish production, increase per capita animal fish protein consumption, provide more job opportunities and increase income of the people living in the rural areas as well as increase national fish production.

Distribution

Mahseer is a sport fish (McDonald 1948) that inhibits the mid hills and inner terai (Shrestha 1997), distributed in India, Bangladesh, Pakistan, Sri Lanka, Afghanistan, Burma and Nepal. *T. putitora* is distributed in most trans-Himalayan countries ranging from Afghanistan to Myanmar (McDonald 1948; Day 1958; Desai 1994). *T. putitora* and *T. tor* inhabit torrential waters and mid-hill lakes (Shrestha 1981; 1991) and can attain up to 45 kg in weight (Shrestha 1997) though fishers have recently caught *T. putitora* of 120 kg in the western Modi River. Shrestha (1995) has reported that *T. putitora* is found at an altitude 70-1891 metres.

Domestication

Development of seed production technology of sahar is essential to maintain and enhance its population abundance in natural water resources and to explore the possibility of high value commercial fish farming systems. Visualizing this objective wild brood fish of sahar were collected from the lakes (Phewa and Begnas) and rivers (Tadi River at Gadkhar and Devighat near Trisuli River) and have been reared in earthen ponds for domestication at the Pokhara and Trishuli Fisheries Research Stations, since 1989, with studies into its spawning behavior (FRC 2001). The brood fish were fed 2-3% body weight of a 35% crude protein content pellet made locally. Females spawned on and off in the past but not regularly each year. At the beginning breeding activity was carried out using mature wild brood fish in August-September. But at present the brood fish are domesticated and spawn regularly. The F2 generation is now being used as brood fish, which breed naturally in earthen ponds.

Growth of sahar

Growth of sahar in captivity is less than in nature (Shrestha 1997). Sahar of 1.3 g size reached 29 g within 7 months at 12-21°C in earthen pond at Godawari at an altitude 1800 m (Rai et al. 2001) whilst 0.5 g size reached 90-160 g within 12 months in earthen pond at above 18.5°C at Tarahara at an altitude of 74 m. Transparency in the ponds was maintained around 30cm Secchi depth through fertilization. Supplementary feed was provided at the rate of 2-3% body weight of fish per day. The dissolved oxygen remained above 7.7 mg/l and pH between 8.0-8.4. The growth of sahar increased substantially from May onwards when water temperature reached above 18.5°C at Tarahara but above 22°C its growth was at Godawari, where water temperature ranged from 12-21°C (Rai et al. 2001). Hatchlings of 18 mg average weight reared in fiberglass pools from September 1992 to July 1993 reached an average of 1541 mg within 10 months and the growth was higher during June and July. The growth rate data of sahar increased with water temperature indicating that it is preferable for sahar to grow in warmer place than in colder place (FRC 1993) and southern terai region of Nepal shows potential to commercially grow sahar in the future.

Feeding habits and supplementary feed for sahar

Gut analysis of sahar showed that it feeds on small fish, insects, molluscs, insect larvae and vegetable matter. Sahar has variously been described as subsisting on vegetable matter (Dubey 1985), a herbi-omnivore (Kausal et al. 1980), carnivorous (Malhotra 1982), intermediate (McDonald 1948), and omnivore that feeds on insects, molluscs, micro-vegetation and algae (Negi 1994). Shrestha (1997) reported that adult sahar feed on gastropods, plant debris and algae whereas fingerlings feed mainly on algae. A study conducted on diet development for sahar showed promising results when fed a mixture of plant and animal protein sources (Bista and Yamada 1996). This study carried out for 210 days based on diets of 30% and 40% protein content; to about 6 g size growth was significantly higher ($P<0.05$) until 90 days when fed with 30% protein content diet, but after 90 days the larger fish growth was reversed and was significantly higher ($P<0.05$) on the 40% protein diet (Table 1). The diets contained 38% protein showed higher growth than the diets of 42% protein (Table 2). However 35% protein content diet showed comparable growth. Also fish growth gave best results when feed contained methionine, and mixing with methionine also allowed feed to be made containing a higher proportion of plant proteins, with equivalent results to using a higher proportion of animal protein in the feed (Bista and Yamada 1996). Samoon (1994) and Juyal (1994) also studied on food conversion efficiency by feeding with commercial fishmeal and supplementary feeding.

Table 1. Feed composition with different protein content diets fed to Sahar.

Ingredients	Crude protein (%)	
	30	40
Soybean	50	30
Shrimp	12	50
Wheat	16	8
Corn	10	5
Oil cake	10	5
Mineral mix.	1	1
Vitamin mix.	1	1
Total	100	100
Source: FRC, Pokhara		

Spawning behavior of sahar

Characteristics of brood fish during spawning period: Sahar mainly breeds during the monsoon season. Mature males developed fine tubercles at the end of the snout, on the head, opercula and pelvic fins but not in females (Shrestha 1990; FRC 1993). During the spawning period the male brood fish started to chase females making a loop in the spawning areas, where gravel had been made available.

Spawning: Many authors have reported on the breeding activities of *Tor* spp. (Tripathi 1978; Masuda and Bastola 1984; Shrestha 1994; Kulkarni 1980; Joshi 1994; Chaturavedi 1976; Desai 1993; Gurung et al. 2001). Sahar *T. putitora* spawn is a partial spawner and spawns during March/April in the first cycle and again in August/October as a second cycle of spawning (FRC 1993; 2000). Shrestha et al. (1990) and FRC (1996; 1997) have reported of successfully inducing sahar to spawn using hormone during July to October. *T. putitora* is reported lay eggs in sheltered rock pools three times a year from January to September in Punjab (McDonald 1948). In Nepal, the first breeding attempt was carried out in the 1960s in FRC, Pokhara by stripping matured wild sahar but the regular attempt of its spawning has been underway since 1982. Later on Shrestha et al. (1990), Morimoto et al. (1995), and Baidhya et al. (2000) have reported the successful spawning of *T. putitora* using different methods. In the beginning mature wild brood fish were collected from the lakes Phewa and Begnas and spawned during August to October while fish from the Trisuli and Tadi rivers spawned during upward migration in March to May, the first spawning period (FRC 2001). Eggs were fertilized using milt taken from males in the field and brought into the station for incubation. Later brood fish were raised in earthen ponds where they were fed with artificial feed and used for hormone-induced spawning (LRH-A, pituitary gland and ovaprime). Shrestha et al. (1990) reported the successful spawning of hormone induced sahar reared in captivity with supplementary feeding. Sahar raised fed with artificial feed in cages and spawned artificially by stripping eggs at water temperatures between 25-28°C after injection of pituitary hormone extracted from common carp (Table 3).

Continued on page 30.

Table 2. Feed composition fed to Sahar and compared their growth rates.

Ingredients	Crude protein (CP) composition (%)		
	35	38	42
Fish meal		55	27.5
Shrimp meal	20	10	10
Wheat flour	12	15	10
Corn flour	10	5	13.5
Soybean cake	35	6	30
Cod liver oil		5	5
Rice bran	12		
Oil cake	9		
Vitamin mix	1	2	2
Mineral mix	1	2	2
Total	100	100	100
Source: FRC Pokhara			

Schering-Plough Global Aquaculture

Vaccination benefits highlighted as Schering-Plough reinforces commitment to Asian aquaculture

A series of key aquaculture events and presentations have confirmed Schering-Plough's ever growing presence and support in S.E. Asia. Aquaculture is continuing to develop at a pace in the region where the demand for Tilapia is especially strong. As producers look to establish long-term and sustainable operations, the focus on health management becomes crucial. Whilst the returns are attractive, endemic disease is a factor in Asia as much as anywhere else. Schering-Plough's strategy is to work across all the major stakeholder groups with education and technical awareness programmes.

The company has a longstanding relationship with The World Aquaculture Society (WAS) which hosted this autumn's key event, the WAS Asia – Pacific conference in Hanoi, Vietnam. The programme was very well attended and attracted a wide group of local and visiting delegates. Amongst the key speakers was Schering-Plough's leading immunology and fish vaccine expert, Professor Patrick Smith who presented a highly informative paper which summarised the global successes of fish vaccine programmes.

Professor Smith highlighted how vaccine programmes are now impacting five key areas of world aquaculture. Sighting firstly pathology, he explained how the introduction of vaccine programmes had greatly reduced disease threat and burden across a wide spectrum of species. Welfare, an issue of increasing global focus correspondingly benefits from improved tools for disease prevention. Moving to the environment he confirmed the clear advantages of introducing vaccines to replace the number of chemicals and antimicrobials that have historically been required in disease control. The link between vaccination and nutrition, another key area in modern aquaculture, was highlighted with Professor Smith explaining that through improved health and well formulated diets farmed fish now have the ability to grow and convert to a level nearer their genetic potential. The fifth of these critical factors was that the benefits from the other key areas provided a range of significant commercial benefits ranging from improved cost of production through to the capability to build and sustain fish farming operations with control and confidence.

In addition to its exhibition stand which was continually busy, Schering-Plough hosted a number of private customer consultation sessions which enabled producers to discuss their production and health programmes one-to-one with the company's technical and sales experts. "We have had very good feedback on these sessions at previous events," explains Robin Wardle, Director of marketing and technical services with the company. "The opportunity to understand the issues that are currently facing operations in the area allows us to develop a dialogue on suitable vaccination strategies. WAS Hanoi was particularly successful in this respect and we have made firm commitments to follow up with specific visits to assist in establishing the most effective vaccination programmes to suit individual operations," he confirmed.

Vaccination for Streptococcosis in Tilapia is one specific area where preventive programmes are delivering significant protection around the world. Schering-Plough Regional Technical Manager, Aries Madethen presented a technical paper reporting on recent trials conducted in Latin America and Asia using the company's AquaVac Garvetil* and AquaVac Garvetil* Oral vaccines as part of the company's Total Protection Strategy, a tailored programme to prevent disease through appropriate vaccination.

The trials demonstrate that AquaVac Garvetil, and AquaVac Garvetil Oral vaccines are safe and highly effective for use in Tilapia. They also demonstrated significant improvements in survival when the fish are exposed to a natural challenge. Added benefits in increased feed efficiency and the quality of production were also identified.

This theme continued at Tilapia 2007 in Kuala Lumpur, Malaysia later in August where producers again registered an increasing interest in developing vaccination programmes. Robin Wardle sees Schering-Plough's involvement increasing, "Our commitment is to continue to develop relationships with producers in the region and in addition to supplying vaccines we look to build and support long-term health programmes to help take their businesses forward."

Producers or vets looking to establish AquaVac vaccine programmes or seeking further information on Schering-Plough Aquaculture products should contact Schering-Plough Aquaculture offices on +44 1799 528 167, log on to http://www.spaquaculture.com/ or e-mail spaquaculture@spcorp.com.

Schering-Plough is a global science-based health care company with leading prescription, consumer and animal health products. Through internal research and collaborations with partners, Schering-Plough discovers, develops, manufactures and markets advanced drug therapies to meet important medical needs. Schering-Plough's vision is to earn the trust of the physicians, patients and customers served by its approximately 33,500 people around the world. The company is based in Kenilworth, N.J., and its Web site is www.schering-plough.com.

** AquaVac and Garvetil are worldwide trademarks of Schering-Plough Ltd. or any affiliated company.*

Status of sahar domestication

Continued from page 27.

Breeding was carried out continuously but achieved success partially at FRC Trisuli (FRC 1996; 1998/'99). However since 2000, F2 sahar have been spawning naturally without use of hormonal injections and without post-spawning mortality. Male sahar mature after 2 years and release milt year round but females reach maturity after 3-5 years cultured in earthen ponds feeding with 30-40% protein content diet. Based on few years data compilation on breeding activities of *T. putitora*, it can spawn up to nine months per year from March to November without using hormonal injection at preferable water temperature between 19.5-33.0°C (Gurung et al. 2001), whereas Chaturavedi (1976) has reported that a water temperature between 21.5-23.5°C is preferable with more than 9.5 mg/l of dissolved oxygen for sahar spawning. McDonald (1948) reported that mahseer spawn three times in a season, Desai (1994) noted mahseer breed from July to March and Pathani (1983) reported sahar spawn at least four times based on four types developmental stages of eggs. Mahseer is a partial spawning and release low number of eggs during single spawning event explained by many authors (Joshi 1994; Shrestha 1997; Shrestha et al. 1990), however it needs to examined more frequently to avoid over maturation of eggs. Shrestha et al. (1990) also stripped sahar three times but the third time obtained very few eggs and a very low fertilization rate, suggesting that the first spawning is best and the number of eggs and fertilization rate declines thereafter (Table 3).

Fertilization and incubation: The stripped eggs are fertilized using milt taken from the male immediately by dry method. The fertilized eggs washed in 1% salt solution for disinfection and then washed 3-4 times with fresh water. The fertilized swollen eggs, after hardening, ARE poured on screen-trays (33 cm × 33 cm size) for incubation and loaded trays are tied tightly in a stack and placed in a glass-fiber Atkin's incubation apparatus for incubation, supplying spring water regularly at the rate of 1.5-2 l/minute. The water temperature and dissolved oxygen recorded were 20-22°C and 4-5 mg/l, respectively and hatch within 90-125 hours (Table 4). The hatching time is dependent on the water temperature (Shrestha et al. 1990; FRC 1998/'99; Baidhya et al. 2000; FRC 2001). It takes about 48-72 hours to hatch at 26.5-31.0°C (FRC 1994; 1995). F2 generation sahar broods are successfully bred from March to November at water temperature ranging from 19.0-30.0°C (Gurung et al. 2001). However, frequent brood fish checking is necessary preferably biweekly to avoid over-ripening.

Nursing and rearing: The yolk sac is absorbed within 3-4 days after hatching and then the larvae need natural food or special artificial feed. Rotifer is an excellent natural food for many marine and fresh water fish larvae (Fontain and Revera 1980).

Importance and prospect of sahar culture industry: Sahar is very important native riverine sport fish. The development of its breeding technology leads a very positive development with the mass production of fingerlings, which can be stocked in the natural water bodies to maintain or increase its population as well as to support aquaculture industry. Sahar is very popular and has a very high demand and sells for a higher price than other cultured carp species. The study has shown that sahar culture is suitable in warmer areas particularly in southern part of Nepal, though the mid-hill region is suitable a breeding area and for egg development with its cool temperatures.

Trans-Himalayan cold water fish hatchery: Among the trans-Himalayan fish, sahar (*Tor* spp.), Katle (*Neolissocheilus hexagonolepis*) and asla (*Schizothorax* spp. and *Schizothoraichthys* spp.) are very important and economically high value fish, which are under study at FRCs, Trishuli and Pokhara. These economically high value fish species have high demand in the whole South Asia region. Successful spawning of these species in captive condition has been achieved although it needs further more detail studies to standardize the technique. There are other economically high value indigenous fish species, which also deserve study and to develop technology for culture practices. In order to carry out studies and develop technology, facilities and human resources and the required infrastructure development are essential. The basic facilities for trans-Himalayan fish spawning have

Table 3. Sahar (*Tor putitora*) fed with artificial feed and spawned using pituitary gland.

Brood fish		Feed fed for brood fish		Pituitary gland injection time		
Male (kg)	Female (kg)	Ingredients	Composition (%)	1600 hrs	2200 hrs	1000 hrs
0.8	1.8	Rice bran	40			
0.6	2.0	Wheat flour	20			
		Corn flour	20			
		Oil cake	20			
Female (kg)						
1.8				1.08 mg (10%)	8.64 mg (80%)	1.08 mg (10%)
2.0				1.20 mg (10%)	9.60 mg (80%)	1.20 mg (10%)
Male (kg)						
0.8					4.80 mg (100%)	
0.60					3.40 mg (100%)	
Date	Time	Stripping	Released eggs (no.)	Fertilized (no.)	Survival (%)	
2/8/1988	17:00	1st	4,500	4,479	99.5	
3/8/1988	10:30	2nd	2,000	1,945	97.3	
3/8/1988	16:00	3rd	100	30	30	

Source: Shrestha et al. 1990

Table 4. Breeding record of Sahar (*Tor putitora*).

Description	2000		2001	
	21 April	22 April	12 March	3 April
Water temp. (°C)	22.0	22.0	20	21
No. of Female	3	2	1	1
Average female weight (kg)	7.5	6.6	3.4	2.2
Average. total length (cm)	80.0	75.0	74	69
No. of male	3	1	2	2
Average male weight (kg)	7.5	6.0	4.0	5.5
Time of stripping	10:00	16:00	10:30	10:45
Total weight of eggs (g)	950	550	62	82
Total no. of eggs	88350	50600	3348	13202
Egg size (mm)	2.7	2.4	2.9	2.0
Dissolved oxygen (mg/L)	4 -5	4 -5	4-5	4-5
Fertility (%)	93-96	90-95	85	80
Incubation period (hours)	90-115	90-110	120-125	120-125
Total no. of hatchlings	57143	36836	2,500	8,800
Mean hatchibility (%)	>90	>80	73.9	66.6
Size of hatchlings (mm)	7.0 -8.0	7.0 -8.0	7-8	7-8

been well developed at the Pokhara and Trishuli Fisheries Research Centres and the fish hatchery at Kaligandaki, which serve the lakes/reservoirs in Pokhara and for rivers in Trisuli and Kaligadaki, respectively.

Among the trans-Himalayan fish species, sahar, katle and asla have been domesticated and are maintained with parental stock up to the F2 generation, which are very convenient for breeding. Therefore FRC Pokhara has the potential to be developed as a Trans-Himalayan Cold Water Fish Hatchery Centre in for the South-Asian region. The center will aim to study of trans-Himalayan cold water fish species on a regional basis with the coordination and exchange and maximum involvement of different specialists in different subjects of the region and to develop a complete technology package to enhance the culture industry in suitable places, particularly in mid-hill region, and to provide job opportunities as well as to increase the economic status in that region. The program will support and conserve the diminishing stocks of economically high value trans-Himalayan fish species.

Conclusion

Sahar is a very important sport and high value riverine native fish species, which is highly preferred in the market. To increase its yield and conserve the declining population in natural environment, breeding techniques should be standardized for mass seed production as well as should develop proper artificial feed for different stages. Breeding studies have been carried out regularly for a decade but there is still need to standardize the technique for mass seed production due to its complex or partial spawning pattern.

References

Azadi, M.A., M. Shafi, M.A., Islam 1991. Studies on the age and growth of mahseer *Tor tor* (Ham.) from the Kaptal Lake Bangladesh. Journal of Zoology 19:47-54.

Baidhya, A.P. and G.P. Lamsal 1996. Breeding of mahseer *Tor putitora* in natural and artificial condition. Annual Technical Report. NARC, FRC, Pokhara, Nepal. 13-116.

Baidya, A. K., T.K. Gurung and B. Shrestha 2000. Study on the propagation of sahar (*Tor putitora*) in relation to hormones and nutrition management. Annual Technical Report (1999-2000). NARC, FRC, Pokhara, Kaski, Nepal. 44-49.

Baidya, A. P. and B. K. Shrestha 1997. On the propagation and mass production of mahseer, *Tor putitora*. Annual Technical Report. NARC, FRC, Pokhara, Nepal. 56-58.

Bista, J. D. and O. Yamada 1996. Feed development for rearing mahseer. Annual Technical Report. NARC, FRC , Pokhara, Kaski, Nepal. 28-32.

Bista, J. D. and R. K. Shrestha 2000. Quantification of Dietary protein requirement of sahar (*Tor putitora*). NARC, FRC , Pokhara, Kaski, Nepal. 50-53.

Chaturvedi, S.K. 1976. Spawning histology of tor mahaseer *Tor tor* (Ham.). J. Bombay Nat. Hist. Soc. 73(1):63-73.

Das, P. and K. D. Joshi 1994. Mahaseer conservation – present and future, P. Nautiyal (com. & ed.) Mahaseer the Game Fish, D3-D9.

Day, F. 1958. The fishes of India: Being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma and Ceylon. Vol (text), London. William Dawson and Sons Ltd. London. 564 pp.

Desai, V.R. 1993. Studies on fishery and bilogy of *Tor tor* (Ham.) from River Narmada. Proc. Indian Nat. Soc. Acad 39:228-248.

Desai, V.R. 1994. Ecostatus of mahseer in river Narmada (Madhya Pradesh). In Mahseer the game fish Natural History, Status and conservation practices in India and Nepal, ed (P. Nautiyal), Rachna, Garhwal UP, India.

Dubey, G. P. 1985. Conservation of dying King mahaseer the mighty game fish and its future role in reservoir fisheries. Punjab Fisheries Bulletin. Vol. IX No. 182.

Fontaine, C.T. and D.B. Revera. 1980. The mass culture of rotifer, *Brachionus plicatitis* for use as food stuff in aquaculture. World Maricult. Soc. 11:211-218.

FRC, 1993. Breeding techniques of sahar, katle and asla. Annual Technical Report (July 16 1992 to July 15 1993). NARC, FRC, Trisuli, Nuwakot, Nepal. 29-33.

FRC, 1993. Feeding trials on sahar, katle and asla. Annual Technical Report (July 16 1992 to July 15 1993). NARC, FRC, Trisuli, Nuwakot, Nepal. 34-46.

FRC, 1993. Study of local fish katle and mahaseer in Raceway system. Annual Technical Report. NARC, FRC, Pokhara, Nepal. 26-28.

FRC, 1994. Breeding of mahseer and study of the possibility for mass production. Annual Technical Report. NARC, FRC, Pokhara, Nepal. 37-40.

FRC, 1995. Breeding of mahseer in natural and artificial condition. Annual Technical Report. NARC, FRC, Pokhara, Nepal. 16-19.

FRC, 1996. Growth and survival of golden mahseer. Annual Technical Report (1995/'96). NARC, FRC, Trisuli, Nuwakot, Nepal. 6-11.

FRC, 1997. Growth and survival of golden mahseer. Annual Technical Report (1995/'96). NARC, FRC, Trisuli, Nuwakot, Nepal. 6-11.

FRC, 1998/'99. Spawning bahavior of sahar *Tor putitora*. Annual Technical Report. NARC, FRC, Trisuli, Nuwakot, Nepal. 16-20.

FRC, 2000. Domestication and spawning behavior of sahar *Tor putitora*. Annual Technical Report. NARC, FRC, Trisuli, Nuwakot, Nepal. 16-20.

FRC, 2001. Domestication and spawning behabior of sahar *Tor putitora*. Annual Technical Report (2000/'01). NARC, FRC, Trisuli, Nuwakot, Nepal. 21-26.

Gurung, T. B. and G.B.N. Pradhan 1994. Genetical resources of sahar (*Tor putitora*, Ham.) in Nepal. Fisheries Dev. Division, Dept. of Agriculture, MOA, Nepal.

Gurung, T.B., A.K. Rai, P.L. Joshi, A. Nepal, A. Baidhya, J. Bista and S.R. Basnet. 2001. Breeding of pond reared golden mahseer (*Tor putitora*) in Pokhara, Nepal. Coldwater Fish Species in the Trans-Himalayan Region, (10-14 July, 2001), Kathmandu, Nepal.

Joshi, C.B. 1994. Conservation of *Tor putitora*. Hatchery Practices D15-D25. In Mahseer the game fish Natural History, Status and conservation practices in India and Nepal ed (P. Nautiyal) Rachna, Garhwal UP, India.

Juyal, C.P. 19994. Food conservation efficiency of Himalayan mahaseer, P. Nantiyal. Mahaseer-The game fish. Rachna, Srinagr, India: D91-D97.

Kaushal, D.K., M.D. Pirolker and Y.R. Rao 1980. Observation on the food habits of *T. putitora* (Ham.) from Gobindasagar reservoir, Himanchal Pradesh. J. Inland Fish. soc. India. 12(1).

Kulkarni, C.V. 1970 Spawning habits, eggs and early development of Deccan Mahaseer *Tor khudree* (Sykes). J. Bombay Nat. Hist. Soc. 67 (3): 510-521.

Kulkarni, C.V. 1980. Eggs and early development of *Tor tor* mahseer. J. Bam. Nat. Hist. Soc. 77:70-75.

Malhotra, A. 1982: Bionomics of hill stream cyprinids. Food parasites and length weight relationship of Garhwal Mahseer *Tor tor* (Ham.). Proc. Indian Aced. Sci. (Anim. Sci) 92(6):493-499.

Masuda, K. and K.R. Bastola 1984. Breeding of sahar *Tor putitora* using naturally matured broods in Tadi river central Nepal. A report submitted to the Fisheries Development Division, HMG/ Nepal.

McDonald A. St. J. 1948. Circumventing the mahseer and other sporting fish in India and Burma. The Bombay Nat. Hist. Soc. 114(6):306.

Morimoto, N., Sakai. K. and Basnyet S. R. 1995. Basic Research Study of Mahaseer (*Tor putitora*) in Pokhara Fisheries Center, Nepal.

Negi, S. S. 1994. Himalayan fishes and fisheries, carps or cyprinoids, 106.

Pathani, S.S. 1981. Fecundity of mahseer *Tor putitora*. Proceeding of India, Academy of Sciences 90:253-260.

Pathani, S.S. 1983. On the age and growth of Mahaseer *Tor tor* (Ham.) by opercular bone. Ind. J. Zool. 2(1):13- 19.

Rai, A.K., R.M. Mulmi, M.K. Shrestha, K. Bajracharya, N.K. Roy, S. Rai and R.P. Shrestha 2001. Growth study of sahar (*Tor putitora*) and Freshwater Prawn (*Macrobrachium rosenbergii*). Annual Technical Report, Fisheries Research Division, Godawari, Nepal. 62-67 pp.

Samoon, M.H. 1994. Cultural feasibility of Deccan mahaseer, Tor khudree (SYKES), P. Nautiyal. Mahaseer-The game fish, Rachna, Srinagar, India:D79-D84.

Shrestha, T.K. 1981. Fishing with open Wale Catch Boat in Narayani River System. J.Nat.Hist.Mus. 5(1-4):99-104.

Shrestha, B. C., A. K. Rai, T. B. Gurung and K. Mori 1990. Successful artificial induced spawning of Himalayan Mahaseer (*Tor putitora*, Ham.) in Pokhara Valley, Nepal. The second Asian fish. Forum. Asian Fish. Soc. 573-575.

Shrestha, B.C. and T.B. Gurung 1990. Declining fishing of sahar (*Tor* spp.) from lake Begnas, Pokhara Nepal. Paper presented in National Conference on Science and Technology 25-29 April, b1988, Kathmandu, Nepal. 1-8.

Shrestha, T.K. 1990. Behavior of mahseer *Tor putitora* in nature and captivity. J. Freshwater Biology 2(3):209-219.

Shrestha, J. 1991. Cold water Fish and Fisheries of Nepal. Fish and Fisheries at higher altitudes, Asia. FAO. Fisheries Technical Report 385.

Shrestha, T. K. 1994. Development of Mahaseer culture towards ranching, P. Nautiyal (com. & ed.) Mahaseer the Game Fish, D26-D41.

Shrestha, J. 1995: Enumeration of the Fishes of Nepal. HMG/Govt. of the Netherlands, Biodiversity Profiles Project, Technical Publication No 10, 64 pp.

Shrestha, T. K. 1997. Prospects of propagating the Mahaseer in Phewa Lake of the Pokhara Valley, The Mahaseer, 70-71.

Shrestha, T.K. 1997. The mahseer in the rivers of Nepal distributed by dams and ranching strategies. RK Printers, Teku, Kathmandu, Nepal. 259 pp.

Swar D.B. and T.B. Gurung 1988. Introduction and cage culture of exotic carps and their impact on fish harvested in lake Begnas, Nepal. Hydrobiologia 166:277-287.

Tripathi, Y.R. 1978. Artificial breeding of *Tor putitora* (Ham.) J. Inland Fish. Soc. India 9:161.

Wagle, S.K. and J.D. Bista 1999. Catch efforts and capture fishery in lakes of Pokhara valley. Status and management perspective. Paper presented in the 3rd National workshop on livestock and fisheries held at Lumle on 21-23 June, 1999.

Comparative advantage analysis of shrimp production in Asia

Yuan Xinhua
Freshwater Fisheries Research Center, CAFS, No. 9 West Shanshui Road, Wuxi, Jiangsu, China. E-mail: yuanxh@ffrc.cn.

This article emanates from Yuan Xianhua's PhD thesis submitted to Nanjing University, PR China, and deals with trading aspects of the shrimp sector with special reference to Asia. Shrimp has proved to be the largest trade commodity of aquatic products. In 2003, the total trade value of frozen shrimp and PUD shrimp was US$ 9.15 billion, and was about 14.8% of total aquatic products trade. The export market price of shrimp from China was the lowest and that from Thailand the highest. Based on the available data market occupation ratio (MOR), the revealed comparative advantage (RCA) and normalized trade balance (NTB) for shrimp in the Asian countries were calculated. Thailand had the largest MOR (21.9%) of the world shrimp market, followed by Indonesia, India, and China of 8.8%, 7.5% and 4.9%, respectively. Among the Asian major shrimp producers, Bangladesh, China, India, Indonesia, Philippines, Thailand and Viet Nam have higher NTB (above 0.70). The RCA for Thailand, China, Indonesia and Philippines have significantly decreased, whilst India and Viet Nam has retained the same level and for Bangladesh the RCA increased since 1998.

Shrimp is a fisheries commodity of great importance in the international aquatic product trade, particularly to Asia and some South American nations. Shrimp products are a universally popular food commodity consumed through out the globe and rarely restricted by gender, age and religion etc. The USA anti-dumping case against Asian countries has brought about much public and governmental attention on the shrimp production sector and its international trade.

In order to analyze the status of Asian shrimp production, and to promote sustainability of its trade, comparative advantage and competitiveness analysis was undertaken. It is hoped that such an analysis will be useful in understanding the current situation of the shrimp industry and its development, and will be helpful in making the shrimp production more efficient and viable.

General information

Asia has favorable natural resources for shrimp production, with the coasts of the Pacific and Indian oceans providing adequate coastal resources. The climate of Asian countries is tropical or subtropical. These favorable natural conditions are suitable for shrimp production and development. Shrimp production includes production from capture and aquaculture and Asian countries take advantage of both. Asia is the most important shrimp producing region of the world, particularly South-East Asia. In 2003, the cultured shrimp from Asia accounted for 85% of the total world cultured shrimp production.

Total shrimp production in the last decades has increased dramatically; the production has increased from 2.63 million tonnes in 1990 to 5.329 million tonnes in 2003. The top five shrimp producing countries of the world are all Asian, ie. China, India, Indonesia, Thailand and Viet Nam (Table 1). China had the highest share (36.5%) of world shrimp production in 2003.

Table 1. The world's top 10 countries, in order, in shrimp production in 2003.

Country	Total production		Composition of total production			
			Capture		Aquaculture	
	Tonnes (x10^3)	%	Tonnes (x10^3)	%	Tonnes (x10^3)	%
China	1945	36.5	1452	74.7	493	25.3
India	517	9.7	404	78.1	113	21.9
Indonesia	457	8.6	266	58.2	191	41.8
Thailand	381	7.2	83	21.8	298	78.2
Viet Nam	310	5.8	78	25.2	232	74.8
USA	147	2.8	142	96.9	5	3.1
Greenland	142	2.7	142	100	0	0.0
Canada	121	2.3	121	100	0	0.0
Brazil	117	2.2	26	22.9	90	77.1
Mexico	100	1.9	54	54.1	46	45.9
Other	1092	20.3	755	69.14	337	30.86
Total	5329	100	3524	-	1805	-

Source: FAO, FishStat Plus (http://www.fao.org/figis)

Table 2. Top 10 country of shrimp aquaculture production of the world in 2003.

Country	Aquaculture production (1,000 tonnes)	% of total world aquaculture production
China	493	27.3
Thailand	298	16.5
Viet Nam	232	12.8
Indonesia	191	10.6
India	113	6.3
Brazil	90	5.0
Ecuador	57	3.2
Bangladesh	57	3.1
Mexico	46	2.5
Philippines	37	2.1
Other	191	10.6
Total	1805	100.0

Source: FAO, FishStat Plus (http://www.fao.org/figis)

Since 1990, the capture shrimp production has decreased year by year, whilst that from aquaculture is increasing at an accelerated rate, and cultured shrimp production now leads in world shrimp supply. In 2003, the top five countries for cultured shrimp were Asian, i.e. China, Thailand, Viet Nam, Indonesia and India. The production from the top five countries took a share of 73.5% of the world cultured shrimp production (Table 2).

Shrimp trade of the world

Among all fisheries products traded, shrimp was the most important commodity. In the last 20 years, the shrimp trade accounted for over 20% of the total fisheries product trade. In 2003, the total shrimp imports of the world were 1.955 million MT, valued at US$12 billion. Shrimp has proved to be the largest trade commodity of aquatic products. In 2003, the total trade value of frozen shrimp and PUD shrimp was US$ 9.15 billion, and was about 14.8% of total aquatic products trade. The trade value of prepared and chilled shrimp was US$ 2.396 billion, and US$ 0.457 billion for other shrimp products.

In recent years, the trade of shrimp products has developed very rapidly. Developed countries, such as USA, Japan and European countries are the major importers of shrimp products. Developing countries, especially Asian countries, act as the main shrimp supplier of the world. In 2003, the importation of shrimp to USA reached 500 000 tonnes, approximately 27.8% of the world's imports, and were followed by Japan, Spain, Demark and France. Approximately 61.6% of the imported shrimp was consumed by people living in the developed countries, such as US, Japan and Europe (Table 3).

With continued increasing demand on shrimp products, the shrimp trade has also become highly competitive, and more countries are being engaged in shrimp production. Since 1990, Asian countries have become the major supplier of shrimp exports to the developed countries. Thailand and China were the major exporting countries, followed by India, Viet Nam and Indonesia. (Table 4).

Market occupation ratio (MOR)

The market occupation ratio can be represented by the percentage of shrimp exports from one country to that of the world. Table 5 shows the shrimp market occupation ratio of Asian major shrimp producers from 1990-2003. Comparing the average market occupation ratio in 1990-2003; the result show that Thailand had the largest market occupation ratio (21.9%) of the world shrimp market, followed by Indonesia, India, and China of 8.8%, 7.5% and 4.9%, respectively. Since 1990, Thailand has lead shrimp exportation to the world.

Market price

The market price of exportation was calculated by dividing the total exportation value with the total exportation amount of each country. In 1990-2003, China has the lowest average price (US$ 4.95) for shrimp exports, while Thailand has the highest (US$ 9.54). The export price fluctuated during the last 14 years. In 1994 to 2000, the price was higher, and after 2000, the market price was decreased for all countries.

Revealed comparative advantage (RCA)

Revealed comparative advantage (RCA) is based on observed trade patterns. An increase in the value of RCA means an increase in a country's competitiveness in a commodity. It can be computed by the formula below:

$RCA_{ik}=(X_{ik}/X_i) / (W_k/W)$

Where RCAik represents k commodity in country i has the revealed comparative advantage, X_{ik} is exports of commodity j by country i. X_i is the total exports by country i, W_k is the world total exports of commodity k, W is the world total exports of all commodities. If RCA_{ik} >1, it shows that the exports by the country is focused on few commodities, and it has a comparative advantage on that commodity; RCA_{ik} <1, indicates that the country has wide trade commodities range, and it has no comparative advantage on the particular commodity.

Table 3. Top 5 countries, in order, of world shrimp importation in 1999-2003.

1999		2000		2001		2002		2003	
Country	%	Country	%	Country	%	Country	%	Country	%
USA	25.8	USA	23.1	USA	23.5	USA	23.7	USA	27.8
Japan	22.8	Japan	20.2	Japan	16.8	Japan	16.2	Japan	13.0
Spain	8.5	Spain	9.3	Spain	7.5	Spain	6.9	Spain	9.7
France	5.3	Denmark	5.1	Canada	5.5	Denmark	5.9	Denmark	5.8
Canada	4.8	Canada	4.9	Denmark	4.8	China	4.8	France	5.3

Table 4. Top 5 countries of shrimp exporters of the world in 1999-2003 (MT).

1999		2000		2001		2002		2003	
Country	Export	Country	Export	Country	Export	Country	Export	Country	Export
Thailand	240551	Thailand	249638	Thailand	255600	Thailand	211659	Thailand	234044
India	127640	India	128827	India	140565	India	169854	China	188464
Ecaudor	94605	Indonesia	104793	Indonesia	115372	China	132626	India	174842
Indonesia	90733	China	93881	China	105999	Vietnam	114883	Vietnam	124865
China	66496	Denmark	92807	Denmark	87825	Indonesia	112054	Indonesia	122651
Source: FAO, Fish Stat Plus									

Table 5. MOR of Asia major shrimp production countries (1990-2003) (%).

Year	Bangladesh	China	India	Indonesia	Malaysia	Philippines	Thailand	Viet Nam
1990	2.2	10.0	4.9	9.4	1.7	3.2	14.4	1.6
1991	1.9	6.9	6.3	9.9	1.9	3.7	17.9	2.3
1992	1.8	7.7	5.9	9.3	1.7	2.8	20.5	2.8
1993	2.2	4.9	7.3	10.0	1.5	2.8	23.2	3.3
1994	2.8	3.9	8.3	9.5	1.5	2.6	25.7	3.4
1995	2.8	3.4	6.8	8.9	1.5	2.1	26.6	2.9
1996	2.9	2.2	7.5	8.8	1.4	1.6	25.5	2.7
1997	2.4	2.7	7.9	8.6	1.6	1.3	24.7	3.9
1998	2.5	2.3	7.7	8.7	0.9	1.3	23.4	4.6
1999	2.5	2.5	8.3	8.0	0.9	1.5	24.3	5.1
2000	2.9	3.5	8.5	8.9	0.9	1.4	25.4	6.2
2001	3.2	4.4	7.8	8.6	1.1	1.2	21.5	7.5
2002	2.6	6.1	9.1	7.9	2.0	1.6	17.3	9.2
2003	2.7	8.1	8.2	7.2	1.1	1.2	15.8	9.7
Average	2.5	4.9	7.5	8.8	1.4	2.0	21.9	4.7

Source: Calculated through the data from FAO, Fish stat plus

In table 7, the RCA of shrimp in major Asia shrimp production was calculated. Thailand, China, Indonesia and Philippines have significantly decreasing RCAs, whilst India, Viet Nam has retained the same level of RCA.
For Bangladesh the RCA increased since 1998. Malaysia has the lowest RCA among Asian countries, with an average of 1.14. The decreasing RCA in Thailand and China showed a significant losing of comparative advantage for shrimp products, and could be related to a major shift in the species cultured.

Normalized trade balance (NTB)

Normalized trade balance also known as net exportation ratio, shows the difference between exports and imports, and indicates the comparative advantage in production. It can be calculated by:

NTB=X-M/(X+M)

Where X represents the export of the product and M represents the imports of the commodity. The value of NTB is between -1 and +1, if NTB is -1, it means the country only imports the commodity; In the view of exportation, when NTB is near +1, it has high international competitiveness in the product.

Among the Asian major shrimp producers, Bangladesh, China, India, Indonesia, Philippines, Thailand and Viet Nam have higher NTB (above 0.70), indicative of that the country has more shrimp exports than the imports and the higher comparative advantage of shrimp production .The NTB of Bangladesh and India is about 1.00, that is these two countries only export shrimp products, and thereby have extremely high comparative advantage.

Conclusion and recommendation

By analyzing the market occupation ratio, export prices, RCA and NTB, the Asian major shrimp producing countries seem to have a higher comparative advantage in shrimp production. With rapid developments of shrimp products trade, Asian countries will become the most important producers of shrimp globally.

Each country has different performance of comparative advantage: for example Thailand Indonesia and India had higher market occupation ratio, China had the lowest exportation price; Thailand, China and Viet Nam had the higher

Table 6. The average export price of major Asia shrimp producers (1990-2003) (US$/kg).

Year	Bangladesh	China	India	Indonesia	Malaysia	Philippines	Thailand	Viet Nam
1990	5.81	5.96	5.60	7.37	4.90	8.75	8.62	3.74
1991	6.31	6.05	5.52	8.11	5.14	8.81	8.26	4.20
1992	5.90	5.74	5.80	7.94	5.61	8.78	8.65	4.35
1993	7.23	5.50	6.20	8.96	5.58	9.68	9.73	4.79
1994	8.57	5.64	7.27	10.27	6.36	10.63	10.44	5.00
1995	10.06	6.26	6.94	11.01	7.22	11.69	11.40	6.85
1996	10.21	4.74	6.51	10.03	6.47	6.61	10.72	6.31
1997	7.87	4.41	7.20	10.85	7.28	11.71	11.81	5.89
1998	10.73	3.74	6.35	6.75	5.28	7.28	9.32	6.86
1999	11.76	3.62	6.17	8.42	5.51	9.58	9.63	7.82
2000	10.85	4.00	6.98	9.05	5.37	7.43	10.81	9.75
2001	9.94	4.29	5.74	7.69	4.34	6.37	8.69	8.90
2002	7.93	4.60	5.34	7.05	4.57	7.33	8.14	8.28
2003	9.66	4.68	5.13	6.43	4.24	5.76	7.40	8.47
Average	8.77	4.95	6.20	8.57	5.56	8.60	9.54	6.52

Source: Calculated through the data from FAO, Fish stat plus

Table 7. RCA of Asia major shrimp producers, 1990-2003.

Year	Bangladesh	China	India	Indonesia	Malaysia	Philippines	Thailand	Viet Nam
1990	1.20	206.90	9.54	12.59	2.00	13.61	206.54	23.12
1991	0.93	143.39	12.45	11.94	1.96	14.92	301.45	39.39
1992	0.81	138.66	11.37	10.34	1.58	10.71	298.60	40.59
1993	0.92	72.45	12.81	10.24	1.17	9.42	293.38	41.13
1994	0.98	58.02	14.29	10.23	1.07	8.30	274.40	36.20
1995	0.96	50.55	11.38	10.11	1.05	6.30	251.62	27.26
1996	1.04	27.79	12.23	9.48	0.99	4.13	189.15	20.16
1997	0.75	31.50	12.57	8.56	1.17	2.83	150.03	23.64
1998	26.80	0.69	12.67	9.85	0.76	2.46	24.04	26.95
1999	25.41	0.73	12.72	9.26	0.59	2.25	23.41	24.83
2000	29.00	0.90	12.74	9.15	0.62	2.18	23.40	27.22
2001	32.59	1.01	11.00	9.36	0.75	0.97	87.46	0.08
2002	27.39	1.21	11.89	8.93	1.35	2.79	16.16	35.84
2003	28.47	1.38	10.98	8.87	0.85	2.36	14.74	35.94
Average	12.66	52.51	12.05	9.92	1.14	5.95	153.88	28.74

Source: WTO database and FAO, Fish stat plus

Table 8. NTB of Asia major shrimp producers in 1990-2003.

Year	Bangladesh	China	India	Indonesia	Malaysia	Philippines	Thailand	Viet Nam
1990	1.00	0.99	1.00	1.00	0.71	1.00	0.98	1.00
1991	1.00	0.96	1.00	1.00	0.67	1.00	0.98	1.00
1992	1.00	0.95	1.00	0.98	0.53	1.00	0.98	1.00
1993	1.00	0.93	1.00	1.00	0.48	1.00	0.97	1.00
1994	1.00	0.74	1.00	1.00	0.49	1.00	0.97	1.00
1995	1.00	0.74	1.00	1.00	0.46	1.00	0.95	1.00
1996	1.00	0.64	1.00	0.99	0.49	1.00	0.95	1.00
1997	1.00	0.71	1.00	0.99	0.55	1.00	0.94	1.00
1998	0.99	0.68	1.00	0.99	0.36	1.00	0.90	1.00
1999	1.00	0.60	1.00	0.98	0.42	1.00	0.91	0.99
2000	1.00	0.48	1.00	0.98	0.46	1.00	0.90	0.99
2001	1.00	0.55	1.00	0.98	0.36	0.99	0.87	0.99
2002	1.00	0.71	0.99	0.97	0.53	0.97	0.82	0.89
2003	1.00	0.74	0.99	0.97	0.24	0.98	0.84	0.83
Average	1.00	0.74	1.00	0.99	0.48	1.00	0.93	0.98

Source: FAO, Fish Stat Plus

RCA, and all major shrimp production countries had higher NTB of shrimp trade. This evidence shows the very high potential for shrimp production.

In view of the increasing demand for shrimp products and the high tariffs on exportation, the new international trade regulations need to be adjusted. These regulations have required the Asian countries to confront new challenges to produce better quality shrimp and do so efficiently. Between 1990-2003, the comparative advantage index of some major shrimp producers decreased, indicating that the competitiveness in Asia's shrimp products was weakening. This may be caused by higher export tariffs, higher product quality and higher sanitation standards, traceability system and organic production systems being put into place.

To strengthen Asia's shrimp products competitiveness, further efforts should be made to advance shrimp industrialization forward by developing leading shrimp enterprises. The better management and sustainable development of shrimp production is required and studies and monitoring of international competitiveness should be strengthened. New technology in shrimp disease prevention, new seed production systems, and environmental friendly aquaculture practices for sustainable development, and more international cooperation programs need to be encouraged to satisfy the world shrimp market.

Acknowledgement

The author would like to thank Dr. Prof. Sena de Silva, Director General of NACA, for his useful comments and revision on the manuscript.

References

Batassa, B.: Trade Liberalization and Revealed Comparative Advantage. The Manchester School of Economics and Social Studies, 1965(32):99—123.

Luo Le etc. Comparative advantage analysis of China aquatic products, Ecological Economy, 2004(4): P26- 29.

Lu Lingli, Analysis of Agro-products between China and ASEAN countries, China Rural Economy, 2004(9):20-25.

Globefish: http://www.globefish.org/.

FAO FIGIS: http://www.fao.org/figis.

Strategies to improve livelihood of the rural poor: A case study in two small reservoirs in Binh Phuoc Province, Vietnam

Ho Manh Tuan[1], Harvey Demain[2] and Amararatne Yakupitiyage[2]
1. Faculty of Aquaculture, Nha Trang University, Vietnam; 2. Asian Institute of Technology (AIT), Thailand

Status of livelihoods of people who live in the vicinity of two small reservoirs, Nong Truong 6 and Dakton of Binh Phuoc province, Vietnam, as well as fisheries and aquaculture activities, are reported here. The two reservoirs are of similar area, but the former is open access and the latter is leased out. These two different modes of management seem having significant impact on fish yield and income of farmers, though it is acknowledged that small sample size of one reservoir cannot warrant firm conclusions. It is also observed that aquaculture and fishing activities in the two reservoirs have been undertaken in a haphazard manner and no proper management strategies have been developed. It is suggested that a policy that encourages development of culture-based fisheries should be introduced as it has proven a useful approach in improving livelihood of the rural poor who live in the vicinity of reservoirs, in Vietnam and elsewhere in Asia.

Introduction

Binh Phuoc Province is located in the Southeast of Vietnam. Agriculture remains the main sector in the provincial economy and the area of agricultural land in the province has expanded steadily. In this context, the demand for water for agriculture is also increasing and there is a need to construct more reservoirs to meet water demand. At present, the total area of all water bodies in the province is estimated to be 20,000 ha (Giang et al., 1997); and it is expected to increase by two fold in ten years, mainly as a result of the development of small reservoirs.

Small reservoirs are believed to offer great potential for developing fisheries. At present, however, the fishery in general and reservoir fishery in particular is not well developed in the province. Small reservoirs are mostly managed by the Agricultural Project Management Section (APMS) of the Provincial Department of Agriculture and Rural Development. The APMS is responsible for identifying, appraising, monitoring and managing agricultural projects. APMS has no fishery specialists, and as such most of the projects that have been developed did not take into account the potentials for fishery development. As a consequence, reservoirs have been leased out to a small group of households to operate the fishery. Planning for the development of these reservoirs is still undertaken in a top-down manner and there is no participation of the local people in their management in general and in fishery management in particular. The leasing of small reservoirs is carried out by APMS without consultation with the local people who may be regarded as the primary stakeholders. The leasing is decided without consideration of the role of the reservoir in the socio-economic situation of the people and the possible impact upon the community who live in the reservoirs vicinity.

Some other reservoirs of Binh Phuoc Province belong to the local rubber companies, impounded initially to support rubber plantations. In contrast to the APMS, these reservoirs are open for use by the local community. At present, the Government of Vietnam is implementing its “Hunger eradication and poverty reduction” program, in which the fishery sector has now become an important component under the so-called SAPA (Sustainable Aquaculture for Poverty Alleviation) Project. It is believed that the fishery sector can provide an affordable source of animal protein for rural poor people and plays an important role in attaining food security at national level.

To date, the number of studies on small reservoir fishery management and development and especially the role and impact of such reservoir fisheries on rural people’s livelihoods, are rather limited in Vietnam. Most of these are confined to northern (Nguyen et al., 2001; Nguyen et al., 2005) or central Vietnam (Phan and De Silva, 2000). The present study aims to investigate the effects of small reservoirs management strategies on the livelihood of the communities living in the vicinity of these water bodies in Binh Phuoc Province, Vietnam. The findings could be useful in providing guidelines for fishery development in small reservoirs thereof.

Methodology

Two reservoirs representing two different modes of management were chosen as our study sites. The first reservoir, the Nong Truong 6 (NT6), was built in 1980 and located at Long Ha commune, Phuoc Long district with an area of approximately 30 ha. The reservoir was previously managed by the Phu Rieng Rubber Company. However, at present the ownership of this reservoir is unclear and considered open access. The second reservoir is the Dakton reservoir, which is located in Son Giang commune of the same district as the NT6. Dakton reservoir is 5 years younger than NT6, with 28 ha of surface water area. In contrast to the NT6 reservoir, Dakton reservoir was leased out to a group of farmers including 36 households, who can stock fish and harvest.

Rural Rapid Appraisal (RRA) methods and questionnaire surveys were used to collect data from the targeted villages around each reservoir. RRA methods were used to obtain general information on the study area and direct the questionnaire survey. Information in the questionnaire includes:

- Data on socio-economic aspects such as age, education level, labor force, land holding, household assets, income, labor inputs (man-day), % fish contribution to daily

Table 1. Social-economic characteristics of people living in vicinity of the NT6 and the Dakton reservoirs.

Reservoir	Area (ha)	Social-economic data							
		Age		Education			Labour force	Income	% Fish in diet
		Mean	Max	Primary	Secondary	High school			
NT6	30	43	72	16.7	73.3	10.0	2.0	18,565,750	42.33
Dakton	28	43.5	77	13.3	75.0	11.6	2.4	23,910,375	44.17

animal protein consumption and the local attitudes and opinions to reservoir fishery.

- Data relating to aquaculture activities such as facilities, level of intensification, cultured species and yield;
- Data on capture fisheries such as gear used, species caught, yield, frequency; institutional arrangements and measures for management (ownership, mechanisms), and accessibility to fishery resources (regulation or rules, mode of payment, amount of payment, type of gear, and species that are allowed to catch).

Questionnaires were administered to two groups of households, including 60 households who are living around the NT6, and 60 households who are living around the Dakton.

The study attempted to assess the changes of poor rural people' livelihood in terms of income and employment opportunities. The income analysis was undertaken to analyze household's income from agricultural sector, fishery sector and others. The analysis of income is conducted as gross income earned by the household, without examination of expenditure. This analysis focused on the proportion of total employment opportunity derived from the fishery sector. The social assessment was undertaken in order to understand opinions and attitudes of poor rural communities about leasing of small reservoirs. SPSS and Excel software were used to analyze linear regression, one-way ANOVA, frequencies, and case summaries of collected data.

Results and discussion

Results of the social-economic survey are presented in Table 1. The present survey showed that the major proportion of populations living in vicinity of the two reservoirs under study is of middle age. The mean and maximum age of populations in the NT6 and the Dakton reservoirs were 43 and 72, and 43.5 and 77, respectively. Levels of education were relatively low, with only 8.3% and 1.7%, and 8.3% and 3.3% completed high school and colleges in the NT6 and the Dakton, respectively. The major proportion of these populations only completed secondary school, and these people are in fact immigrants from northern provinces of Vietnam. It is noted that most people who obtained higher levels of education are young and recently educated.

The local people mostly have a sufficient labor force, and, they mostly possess a relative large area of land in comparison to other places in Vietnam. All have legal ownership of their own land. In this case, the local people are well placed for obtaining bank loans.

There are five major sources of income such as crop production, livestock, off-farm employment, fishing, and aquaculture. Out of these, crop production contributes more than 50% to total income at community level. In addition, returns from labor from crop production is the highest. However, the proportion of income varies from household to household. Aquaculture and fishery contribute only about 20% to total income at community level, which is not much lower than Yen Bai and Thai Nguyen provinces with 23% and 28%, respectively (Nguyen et al., 2001), and about from 20% to 30% of households are involved in these activities.

One advantage of fishery development is that the contribution of fish to daily animal protein consumption is rather high and exceeds 40% in most families. In this context fishing in small reservoirs is only subsistent in general. Both pond and cage culture are practiced in the NT6 reservoir, the former could reach an average yield of 5.26 tonnes/ha and and that of the latter was about 34.76 kg/m^3/year (Table 2). Cultured species include grass carp, *Ctenopharyngodon idella*, common carp, *Cyprinus carpio*, silver carp, *Hypophthalmichthys molitris*, and tilapia, *Oreochromis mossambicus* and *O. niloticus*. The yield of pond culture is average as often pond culture can reach from less than 1 to more than 10 tonnes/ha/year in Vietnam (Binh, 1998). There is only one and two crops in each pond culture and cage culture cycle, respectively. Only pond culture occurred in the areas adjacent to the Dakton reservoir, with higher pond yield (6.52 tonnes/ha before leasing and 9.03 tonnes/ha at present), and also only one crop in each culture cycle.

With regard to the attitude towards importance of fishery in the two reservoirs, over 50% of households think that the reservoir fishery is not important to their livelihood, while less than 5% of households said that it is very important. In fact, all the reservoirs belonging to the Phu Rieng Rubber Company are mostly characterized by inadequate clearance of trees from the reservoir area so that it is almost impossible to apply large-scale fishing practice unless the provincial government provides financial support for clearing out trees in the bed of reservoirs. However, there is much controversy with regard to clearing reservoir beds, as submerged vegetation provides suitable habitats for fish and releases nutrients thereby increasing primary productivity. Some reservoirs built by the provincial government (e.g., the Dakton reservoir) are in such an oligotrophic condition

Table 2. Aquaculture production in the two reservoirs under study.

Reservoir	System	Species	Yield (yr^{-1})	Production per cycle
NT6	Ponds	Grass carp, common carp, silver carp, tilapia	5.26 tonnes.ha^{-1}	1
	Cages	Grass carp, common carp, silver carp, tilapia	34.67 kg.m^{-3}	2
Dakton	Ponds	Grass carp, common carp, tilapia	9.03 tonnes.ha^{-1}	1

that fish yields are low. Thus, only a small number of households can obtain income from the fishery, in which no households are involved on a full-time basis.

Statistically, there is no significant difference of income and labor inputs between two periods of time (before and after leasing) (P>0.05). Therefore, the impact of leasing reservoirs on the local people's livelihood is insignificant in terms of economical aspects. The data also showed that income generated from aquaculture in leased reservoirs was higher than that in open access ones (P<0.01). This could be due to better management as well as the well-defined ownership (hence better protection if fishery resources) and better intensification in aquaculture as the data also showed that labor inputs in aquaculture and fishing are observed in Dakton reservoir (P<0.01).

The major and the only disadvantage found in the Dakton reservoir was the conflicts between the local people and leaseholders, especially when the latter are outsiders. Such a problem could be overcome through encouragement of local farmers to form communities or groups and lease the reservoirs and have ownership on the fish resource, and at the same time increase employment opportunities during off-crop season, and hence improve income. This model has been applied successfully in Yen Bai and Thai Nguyen provinces, initially through support from an ACIAR funded project. However, after the first cycle of culture, farmers are willing to have self financial support to sustain culture-based fisheries activities. It is also important to note that farmers in Yen Bai and Thai Nguyen provinces are well supported technically as well, with all technical issues such as suitable stocking density and species combination which are determined through scientific experiments, being transferred to grassroot levels through proper extension network using appropriate extension materials (De Silva et al., 2006; Nguyen & Nguyen, 2007).

The findings both from field discussions and data analysis indicate that key problem at the two reservoirs is low income from the fishery sector in general and low aquaculture and fishery income in particular. For aquaculture, there are two main reasons for the low income: low yields of cage culture and the low price of cultured fish. In fact, the local people at the NT6 reservoir cultured fish in cages based on their own experience, and got very limited technical assistance from the provincial related organizations. They also have difficulties in investment due to lack of financial assistance. Besides, the main cultured species in the local market command a low price so that it is necessary to develop market for aquatic products. It is also necessary to culture other valuable aquatic species in cages and ponds. For fishing, low fish yield can be caused by two factors - the oligotrophic condition in the case of Dakton and inadequate clearance of trees from reservoir area in the case of the NT6 reservoir.

The problems encountered in the two reservoirs reported herein are not uncommon in Vietnam and elsewhere in the Asian region. However, there is scientific evidence that livelihood of people living in vicinity of small reservoirs can be improved through development of culture-based fisheries. Farmers however, firstly need to be equipped with essential knowledge in fish culture, including selection of suitable sites, fish stocking, monitoring, harvesting and marketing. The Government of Vietnam is encouraging such development and as such the practice should be adopted.

Acknowledgements

The first author wishes to express his deep gratitude to Danish International Development Agency (DANIDA) for providing him assistance that enabled him to complete his Masters study at the Asian Institute of Technology (AIT), some data from which is presented herein. Many thanks are extended to Mr. Van Van Hanh and all staffs of Department of Agriculture and Rural Development (DARD), at Binh Phuoc province, Vietnam for their supports and provision of field and laboratory facilities, to local government and people at Long Ha and Son Giang communes for enabling him to conduct household surveys in that area. The author would like to be grateful to Mr. Nguyen Van Tu at the University of Agriculture and Forestry (UAF), HCMC, Vietnam for his critical suggestion and his assistance in providing the critical materials in order to conduct this study.

References

Binh, C.T. (1998) Development of pond culture of Thai Nile Tilapia (*Oreochromis niloticus* L.) and its marketability in Ha Noi, Vietnam. A dissertation submitted in partial fulfilment of the requirements for the degree of doctor of technical science. Asian Institute of Technology, Bangkok, Thailand.

De Silva, S.S. (1992) Reservoir fisheries of Asia: proceedings of the 2nd Asian reservoir fisheries workshop held in Hangzhou, People's Republic of China, 15-19 October 1990. Ottawa, Ont., IDRC, 1992. Xvi + 280p.: ill

De Silva, S. S., Amarasinghe, U., Nguyen T. T. T. (eds)(2006) Better-practice approaches for culture-based fisheries development in Asia. ACIAR Monograph No.120, 96pp.

Giang, T.T and et al. (1997) Quy hoach thuy san tinh Binh Phuoc den nam 2010. Planning for fishery development of Binh Phuoc province to year 2010 (unpublished document).

Nguyen, H. S., Bui, A. T., Nguyen, D. Q., Truong D. Q., Le, L. T., Abery, N.W., De Silva, S. S. (2005) Culture-based fisheries in small reservoirs in northern Vietnam: effect of stocking density and species combinations. Aquaculture Research 36, 1037-1048.

Nguyen H.S., Bui A.T., Le T.L., Nguyen T.T.T. & De Silva S.S. (2001) The culture-based fisheries in small, farmer-managed reservoirs in two provinces of northern Vietnam: an evaluation based on three production cycles. Aquaculture Research 32, 975-990.

Nguyen, D. Q., Nguyen, H. S. (2007). Quy trình nuôi cá hồ chứa nhỏ. (in Vietnamese), 30 pp

Phan P.D., De Silva S.S. (2000) The fisheries of the Ea Kao reservoir, southern Vietnam: a fisheries based on a combination of stock and recapture, and self-recruiting populations. Fisheries Management and Ecology 7, 251-264.

Peter Edwards writes on

Rural Aquaculture

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

Cambodian Government ban on snakehead farming enforced

A large number of fish species are farmed using low value or 'trash' fish, either exclusively or in part, in cages or ponds in coastal and inland areas, although the main issue is with marine trash fish globally. Use of low value freshwater fish for feed in aquaculture is not common as their sale as human food is usually more profitable than as feed for carnivorous fish although several freshwater fish species are cultured using mainly trash fish. According to the recent APFIC Regional Workshop on Low Value and 'Trash Fish' in the Asia-Pacific Region, the direct use of low value or trash fish to feed carnivorous fish is unlikely to be sustainable in the long term. The challenges for aquaculture are to make better use of the existing low value fish and trash fish resources and to seek alternatives to direct feeding of trash fish in aquaculture. It was also pointed out that there is a need to recognize that change will have significant implications for the people involved, especially for the poor involved in harvest, and use of trash fish.

Farming giant snakehead (*Channa micropeltes*) in cages in Cambodia was a rather significant exception to the use of low value freshwater fish as feed but the practice has recently been banned by the Ministry of Agriculture, Forestry and Fisheries (MAF) of the Government on the recommendation of the Fisheries Administration. A visit to Cambodia in September last year provided an opportunity to see how effective the ban has been and how it has affected local aquaculture, and especially its impact on poor fishers. Poor fishers were observed raising snakehead in small-scale cages based on wild seed and feed they caught to supplement their income in 2001 during a consultancy I carried out for ACIAR to review feeds and feeding strategies in Mekong river countries. Earlier observations on cage farming in the Tonle Sap river and the Great lake of Cambodia 17 years ago during 1991 when working on the Review of the Fishery Sector in the Lower Mekong Basin provide further insight into this ongoing saga.

Cage culture in Cambodia

Cages are the most important culture system in Cambodia with over 80% of national production from aquaculture. Cage culture is dominated by and was probably also initially developed by ethnic Vietnamese fishers who started to migrate up the Mekong river into Cambodia decades and possibly over a century ago. However, cage culture in the country continues to evolve.

General view of Chnok Trou floating village on the Great Lake, 2006.

Constructing a cage for silver striped catfish at Chnok Trou on the Great Lake, 2006.

Cage culture is mostly located along the Tonle Sap river in Kompong Chhnang and in the Great Lake where there are large numbers of floating cages in village level concentrations. The traditional cages are made out of either split bamboo supported by a wooden frame or mainly of wood, supported by floating rafts made of bundles of bamboo tied to the long axis of the cage. Dwellings are constructed on top of the larger cages or are constructed on separate floats or in boats adjacent to smaller cages. Many of the cages for raising silver striped catfish are constructed in the form of a boat to eventually allow the fish to be towed in the cage by a motorised boat to market.

The two major species are silver striped catfish (*Pangasianodon hypophthalmus*) and until recently, giant snakehead (*Channa micropeltes*). Minor species include native carps such as *Leptobarbus hoeveni* and *Barbichthys altus* and *B. gonionotus* and walking catfish, *Clarias* spp. are grown mostly in polyculture at low density with silver striped catfish. Cage culture depends on capture fisheries for seed and a significant part of the feed although rice bran and water spinach are fed to silver striped catfish and to native carps. Rice bran is the most important feed for silver striped catfish which is cooked and either manually rolled into balls or minced before feeding to fish. Fresh chopped fish or small fish are fed when they are abundant during December to March but are unavailable at other times, especially from July to October, when rice bran is fed. The two feeds are mostly fed separately.

A small-scale fisher and his cage on the Tonle Sap river, Kandal province, 2001.

Cooking rice bran on top of a cage to feed silver striped catfish at Chnok Trou on the Great lake, 2006.

Mincing cooked rice bran on top of a cage to feed silver striped catfish on the Tonle Sap river at Kompong Chhnang, 2006.

Cage culture in 1991

In 1991 two thirds of total national production from cages was silver striped catfish, with giant snakehead comprising most of the other third. Although snakehead grows quickly, a major constraint is that it feeds only on fresh fish. It was raised in small 4.5-15 cubic meter cages in Kompong Chhnang stocked from July to December at densities of 50-100 per cubic meter and harvested from February to April at 0.8-1.0 kg. Farmers were reported to like to culture the species because seed was abundant and it was profitable but the provincial Fishery Department had recently prohibited its culture even then because it encouraged fish poaching for feed during the closed fishing season from May to September as well as the use of fine-meshed illegal fishing gear such as mosquito netting.

By 1991 there appeared to have been an increase in the scale of cage culture according to a comparison of statistics for 1969 and 1990. Cage culture in 1969 appeared to be generally a secondary occupation for fishers, 95% of whom were small-scale but the practice came to be dominated by large-scale cage farmers rather than part-time fishers. Each small-scale fish farmer owned one cage which produced an average of 1.8 tonnes of fish based on a total of 3,034 fish farmers producing a total of 5,600 tonnes of fish. However, by 1990 only 736 farmers produced a similar total of 5,200 tonnes, with a marked increase in average farmer production of 7.1 tonnes which would preclude the participation of poor fishers because of the high capital and operating costs, particularly for the purchase of feed greater than they could catch themselves. Farmers interviewed in 1991 reported that the major constraint to cage farming was the availability of loans at suitable interest rates and the high rate of inflation.

Cage culture in 2001

The two principle species were still silver striped catfish and giant snakehead but while the latter still had a high farm gate price of R 3,500-3,800/kg, the price of the former had fallen from R3,000-4,000/kg in 1998/99 to R1,700-2,000/kg in 1991 because Vietnam which used to import 500 tonnes annually had stopped buying because of a recent marked increase in local cage production. Many farmers had thus changed from culturing silver striped catfish to giant snakehead in response to market prices. According to the provincial fisheries officer in Kompong Chhnang, the major cultured species had changed recently to giant snakehead at 77-83% followed by silver striped catfish at 15-20%, with 2-3% of local carps in polyculture. Snakehead cages were rectangular in shaped, ranging from 1-200 m^3 in volume, stocking densities were about 50 kg/m^3 with a net production of about 100 kg/m^3.

A large giant snakehead farmer interviewed in 2001 had a 106 cubic meter cage stocked with 3.3 tonnes of fingerlings at an initial density of 31 kg/cubic meter. Fish were fed daily with fresh small fish purchased from fishers and in 12-13 months 12-13 tonnes were harvested. With an estimated FCR of 5 this would require 60-65 tonnes of small fish as feed, a huge amount used by just a single cage farmer.

However, several small to medium-scale fishers were interviewed in the Great Lake at Chnnok Tru as well as along the Tonle Sap river in Kompong Chhnang and Kandal provinces who were each raising giant snakehead in a small cage of 5-15 cubic meters. They caught fingerlings as well as small fish as feed and some fishers also had a small cage for nursing fingerlings. Cage culture of giant snakehead was clearly benefiting some small-scale fishers but constraints were also observed. One fisher reported catching varying amounts of small fish from 5-20kg/day so on occasion needed to purchase small fish for feed as, unlike silver striped catfish, giant snakehead needs to be fed every day.

A small-scale fisher and his cage on the Tonle Sap river, Kandal province, 2001.

Conversion of a cage previously used to culture snakehead (right) to raise silver striped catfish. Traditional boat shaped cage for raising silver striped catfish (foreground), 2006.

One small-scale fisher reported that he tried to feed his caged fish daily but only fed them every 2 days if he lacked money to feed fish. A fisher in Kompong Chhnang fed them with 60-80 kg of small fish which he was able to catch each day, sufficient to feed his caged giant snakehead but he paid a larger scale cage farmer to mince his fish to feed his fish because he was too poor to afford to buy a US$60-80 mincer. One farmer in Prey Veng province reported that he sometimes fed chopped up rats to fish.

Disused snakehead cages at Chnok Trou on the Great Lake, 2006.

A small-scale fisher and his cage on the Tonle Sap river, Kandal province, 2001.

A small-scale fisher feeding Leptobarbus hoeveni with water spinach, and his children on the Tonle Sap river at Kompong Chhnang province, 2006.Their dwelling is the small boat in the rear.

Cage culture in 2006

A 2 day visit was made to the cage areas along the Tonle Sap river in Kompong Chhnang and at Chnok Trou in the Great Lake in September last year, kindly guided by Chhouk Borin of the Royal Agricultural University and Som Phirun, Vice Chief of Fisheries, Kompong Chhnang Provincial Fisheries Office. Six cage farmers were interviewed and the visit also indicated that the Government ban on snakehead farming was being effectively enforced. According to the provincial fishery officer there were 200 snakehead cage farmers in Kompong Chhnang, just before the ban was introduced.

The ban was announced by MAFF on 3 August, 2004. It was introduced, according to Nao Thouk, Director and Sam Nuov, Deputy Director of Fisheries Administration following complaints from some fishers about excessive harvesting of small fish which they perceived to be a cause of declining catches of larger fish. The major concern was that the small fish in the catch comprised important commercial species before they have had time to grow large, as well as the naturally small fish called ‘trey riel’ in Cambodian (*Cirrhinus lobatus* and *C. siamensis*) used to make fermented fish paste, a national dietary staple. According to these officials, the main concern of the Fisheries Administration is the preservation of the wild fisheries of the country as they provide about 90% of the total national fisheries production.

A translation of the ban is: “MAFF would like to announce to fish farmers that snakehead fish farming was very active recently, leading to illegal fishing of small wild fish to feed to snakehead, especially in the closed fishing season which severely affected natural aquatic resources. In order to eliminate this negative impact, all fish farmers must stop farming these species immediately, and temporarily to allow Government technical fisheries staff to study the negative impact on aquatic resources and to find alternative feeds for snakehead. MAFF would also like to recommend that farmers culture species other than snakehead to increase the fish supply, the second staple food after rice. MAFF strongly hopes that fish farmers, local authorities, and concerned officials at all levels will cooperate to prevent the farming of these species in an effective way and find alternative species for the long term conservation of aquatic resources”.

Before implementing the ban, the reasons for doing so were explained to farmers who were also persuaded to grow non-carnivorous species of fish such as silver striped catfish and indigenous carps. The ban did not come into effect until 2005 as farmers were allowed to complete the snakehead culture cycle already underway at the time of the ban and market harvested fish. Several cage farmers were interviewed who had previously cultured snakehead as it was 30-40% more profitable than silver striped catfish. None of the cage farmers interviewed knew of any farmers raising snakehead in the neighbourhood but added that it may still occur to a limited extent in remote areas deep inside the flooded forest as it is highly profitable.

By a stroke of good luck we were able to interview Sao Sambo, Deputy Inspector General of MAFFF. As we were travelling by boat along the river, a large white launch came into view which jolted my mind into realizing how useful it would be to interview someone from the Fisheries Inspection Unit. As it turned out, the vessel did not belong to the Fisheries Inspection Unit at all but was a Great Lake research survey vessel provided by the Government of Japan but the Fisheries Office was next door. The Inspector explained the main justification for the ban on snakehead farming, explaining that the fish consumes a lot of small fish which fishers even use mosquito netting to catch. As the FCR is 4-6 and many young fish of large commercial species are caught along with adults of small fish species, imagine how many kg of large fish could have been produced from 1 kg of feed fish if they had been allowed to mature in nature he asked rhetorically. Inspections are carried out often and forty farmers were caught illegally farming snakehead in 2006 and ordered to market the fish, with 50% of the sale taken by the Government as a fine.

None of the interviewed farmers was raising snakehead although three farmers used to do so because it was more profitable was a farm gate price of R 12,000/kg. Fortunately for the cage farmers, the price of silver striped catfish had recently risen from lows of R 1,800-2,500 the previous month to

R4,000/kg as it was near the end of the closed fishing season but also because the Government had introduced a ban on import of all fish and livestock produce from Vietnam to protect local farmers. A large cage farmer was interviewed with one large boat shaped silver striped catfish cage 30m long x 6m wide and 3m deep, a total of 540 cubic meters. The farmer was in the process of converting an old snakehead cage of 5m x 10m x 3m dimensions which used to hold 15 tonnes of fish to a striped catfish cage for US$3,000 compared to US$10,000 for a new cage, which indicates the amount of capital required to be a large cage farmer. This farmer appreciated the need for the ban on snakehead culture but reported that some fishers were now illegally catching large snakehead with electrofishing as they were not allowed to catch small fish to sell to snakehead farms. Previously rich cage farmers lent money to small fishers to buy fishing gear and contracted to buy back their catch but the situation was said to be worse with the number of wild fish continuing to decline as small-scale fishers were now fishing more intensively for the large fish and were catching them before they had time to breed.

Detailed view of feeding Leptobarbus hoeveni with water spinach, 2006.

Marine trash fish for feeding hybrid catfish in Kandal province, 2006.

One small-scale cage farmer/fisher reported that he never grew snakehead as he never had enough money; another similarly pointed out that only the rich could grow snakehead and not the poor. A third small-scale cage farmer/fisher who used to raise snakehead before the ban believed the introduction to be a good idea as he could never catch enough small fish to feed snakehead and did not have enough money to buy sufficient small fish to make up the feed deficit. As for the other small-scale operators, he reported that fishing was only for family subsistence as wild fish have declined over the last 20 years due to a marked increase in the number of fishers as well as poor water quality, especially in the hot season when the water in the Great Lake becomes shallow and static.

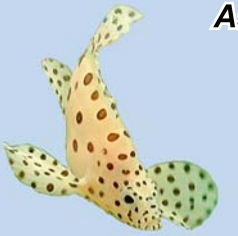
As well as increased profitability from farming silver striped catfish due to its recent increase in price, many farmers were stocking higher value native carps e.g. a small-scale farmer had stocked a monoculture of *Leptobarbus hovoeni* which is omnivorous and fetches a price of R7,000/kg. Another larger farmer was raising *Barbichthys altus* which had a farm gate price of R8,000 on commercial pellets and rice bran. A rather recent development in Cambodia is feeding marine trash fish, mainly to hybrid *Clarias* catfish in ponds, as the road from the coast is now good and ice is readily available.

Postscript

Research is planned by the Fisheries Administration to assess the impacts of the ban on the livelihoods of fishers, fish farmers and poor people, as well as on aquatic biodiversity. From the brief visit reported here, it does not appear to have adversely affected poor fishers who struggled with the need to buy sufficient small fish to feed snakehead. Furthermore, they may be able to more readily farm high value omnivorous native carps. The Fisheries Administration would also like to carry out research on alternative diets for snakehead to fresh small fish so that the temporary nature of the ban may be lifted. Preliminary results of research in progress at the Asian Institute of Technology indicates that the key to developing an alternative diet to fresh fish for snakehead is to acclimatize the fry to dry feed. This has been achieved and the fish grown subsequently grow on commercial pelleted feed.

Asia-Pacific Marine Finfish Aquaculture Network

Magazine



Marine finfish aquaculture developments at 'Indonesian Aquaculture 2007'

'Indonesia Aquaculture 2007', held at the Inna Grand Bali Beach Hotel, Sanur, Bali, 31 July – 2 August, showcased recent development in aquaculture in Indonesia. The conference theme was 'Sustainable Aquaculture and Food Safety'. Overall, the conference was a great success with a strong program of presentations on a wide variety of topics, and a trade show that proved very popular with participants. Inevitably, the conference had a strong focus on shrimp aquaculture. However, marine finfish aquaculture is also developing rapidly in Indonesia, and this article briefly highlights some of the marine finfish presentations at the conference.

As aquaculturists know, good quality product starts with good quality brood-stock and eggs. Tinggal Hermawan, Zakimin and Nur Muflich Juniyanto (BBL Batam) presented on 'Gonad maturation and spawning success of some marine fish species by feeding program improvement'. This presentation pointed out the importance of good nutrition for broodstock. BBL Batam feeds a mixture of 'trash' fish, squid, pellet mix (a mixture of chicken pellets and squid oil), plus vitamins C and E to broodstock held in cages and in tanks, including seabass, tiger and giant grouper, snappers (*Lutjanus johnii* and *L. seabae*), silver pompano and golden trevally.

Santoso Djunardi (BBPBL Lampung) also pointed out the importance of providing appropriate nutrition to broodstock. Giant grouper (*Epinephelus lanceolatus*) broodstock at BBPBL Lampung are fed fish and crabs, with added Vitamin C (150 mg / kg feed) and Vitamin E (1,000 mg / kg feed). The giant grouper are induced to spawn using injections of HCG.

Giant grouper is becoming a candidate of interest for aquaculture because of its relative hardiness and its reputed fast growth rate. Hanung Santosa and Sukadi reported on breeding success with giant grouper at BBPBL Lampung. Females (35–55 kg body weight) and males (25–35 kg) were housed in 250m^3 tanks with five fish of each sex per tank. The broodfish were implanted with LHRHa implants at 10–20 mg/kg. After implantation in January, spawning began in early May. Fish spawned in conjunction with the full moon, between 0500 and 0700. Total number of eggs spawned was 4.95 X 10^6, fertilization rate was 60–90 % and hatching rate was 80–90%. The diameter of fertilised giant grouper eggs is 906 µm, the larvae hatch 14–16 hours after fertilisation (at 28^{o}C and 32 ppt salinity), and the length of newly hatched larvae is 1.55 mm.

Interest in culture of mouse grouper (*Cromileptes altivelis*) has been limited because of its slow growth rate: around 2 years to harvest size. This issue is being addressed by research on selecting faster-growing fish. Suci Antoro, Eko Sutrisno and Arif Rahman (BBPBL Lampung) presented their results on selective breeding of F1 and F2 generation mouse grouper. The selected F1 population grew 17– 22% faster than the control (unselected) group. Heterozygosity of the selected F2 population was improved over the F1 population. The program is continuing with a comparison of the performance

of F1 and F2 selected fish, and with breeding planned for the selected F2 generation.

With quality of fingerling production still an issue in Indonesia, it was encouraging to see an increasing focus on improving fingerling quality. Wiwie Soemarjati (BBAP Situbondo) gave an interesting presentation on good hatchery practices for mouse grouper. Good hatchery practices include: sterilisation and thorough cleaning of larval rearing tanks prior to stocking, stocking with PCR-tested eggs, washing eggs in iodine solution to reduce bacterial levels, and using nutritional supplements to improve the nutritional composition of live feeds (rotifer and brine shrimp). The implementation of these procedures has improved larval survival from 3–4% to 6.5–8%, while the rate of deformity in juvenile mouse grouper has dropped from 5–7% to 1.5–2%. Growth rate also improved, with Day 60 grouper reaching 2.8 – 3.7 cm.

The nursery stage of grouper aquaculture continues to have high mortality due to canniablism, particularly with the popular tiger grouper (*Epinephelus fuscoguttatus*). In South Sulawesi, Mohd. Syaichudin, Nana, Suarni, Naomi, Hasmawati and Maqbul (BBAP Takalar) found that increased water flow, higher feeding frequency and nursery tank design improved the survival rate of tiger grouper from the usual 25–30% up to around 70%.

Although there is considerable interest in coral trout (*Plectropomus* spp.) aquaculture in Indonesia (and elsewhere), there were only a few presentations on coral trout at the conference. Ketut Suwirya and N.A. Giri presented their experiences with coral trout spawning, hatchery and grow-out at RIM Gondol. They noted that coral trout are more susceptible to parasitic infestations than other grouper species. RIM Gondol has developed a treatment regime for coral trout (*P. leopardus*) to reduce this problem, involving the regular application of formalin and a commercial product. Coral trout broodstock spawn monthly, spawning between midnight and 0200. Hatchery survival is about 1–3%. Experimental grow-out in sea cages took 9 – 10 months to reach 500 g (starting from 15 g). *P. leopardus* is relatively sensitive to environmental perturbations.

Herno Minjoyo (BBPBL Lampung) presented some results on grow-out of coral trout on different feeds. This experiment compared feeding ‘trash’ fish and a commercial pellet. Overall the results were extremely poor for the commercial pellet: only 16% survival compared with 93% for fish fed ‘trash’ fish. It was suggested that poor quality of the pellet feed (or possibly poor storage and transportation procedures) may be to blame for this result. Such results indicate the need to improve the composition, handling and storage of pellet feeds for these to replace the widespread use of ‘trash’ fish as a grow-out feed for marine finfish aquaculture.

The above gives just a sample of the marine finfish presentations and posters from ‘Indonesian Aquaculture 2007’ intended to give members of the Asia-Pacific Marine Finfish Aquaculture Network some insight into current research and development, as well as commercial, activities in Indonesia. It also highlights the strong level of technical support that is provided to the Indonesian industry by the Directorate-General of Aquaculture and the Central Research Institute for Aquaculture of the Ministry of Marine Affairs and Fisheries. Obviously, there is still a strong focus on grouper production because of the high prices and continuing strong demand from the live fish trade. However, other species are also being developed for marine fish farming, such as the golden trevally (*Gnathanodon speciosus*) and pompano (*Trachinotus blochii*). ‘Indonesian Aquaculture 2007’ was a great opportunity to see how aquaculture in Indonesia is progressing. The 2007 conference was such a success that the next conference is being planned for 2008 or 2009.

Production update – marine finfish aquaculture in the Asia-Pacific region

By Mike Rimmer
James Cook University
Address: c/- Balai Budidaya Air Payau Ujung Batee, Banda Aceh, Nanggroe Aceh Darussalam, Indonesia

Introduction

The Food and Agriculture Organisation of the United Nations (FAO) has recently released the annual update of global aquaculture production and value statistics (http://www.fao.org/fi/website/FIRetrieveAction.do?dom=topic&fid=16073). This article summarises recent changes in production trends for marine finfish aquaculture in the Asia-Pacific region based on these FAO data, which now cover the period up to 2005. Although the FAO data sets go back to 1950 (production) and 1984 (value) only the last 10 years’ data are presented here.

Please note: the data compiled by FAO are provided by the producer countries. In many cases the classification of aquaculture production is not reliable (see the FAO web site for comment on the accuracy of the data sets), so these data should be treated with some caution. To reduce potential inaccuracies I have confined this analysis to fairly broad search criteria, or to well-known species. Unless otherwise noted, data were sorted for: Countries: Continent = Asia & Oceania; Environments: Brackishwater & Mariculture.

Marine finfish

Production of marine finfish in the Asia-Pacific region increased by 11% between 2004 and 2005, from 1,031,800 to 1,143,719 tonnes (Table 1). Value increased by 9%, from USD 3.815 billion to 4.141 billion from 2004 to 2005 (Table 2). The largest producer remains China, with 659,000 tonnes of production in 2005 valued at USD 662

Figure 1. Value in USD millions (line) and production by country (columns) of milkfish (*Chanos chanos*) in the Asia-Pacific region, 1996 – 2005.

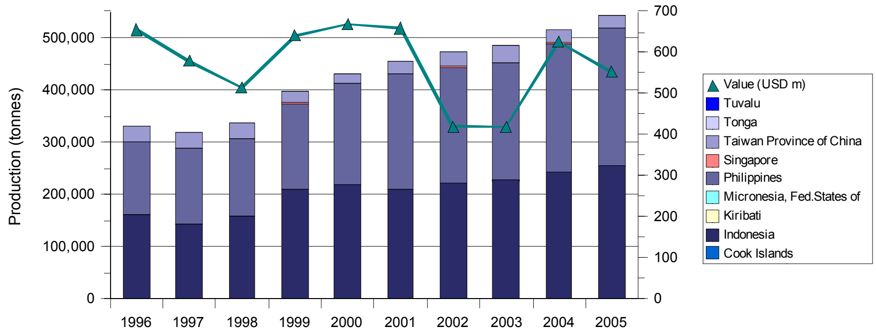


Figure 2. Value in USD millions (line) and production by country (columns) of barramundi (*Lates calcarifer*) in the Asia-Pacific region, 1996 – 2005.

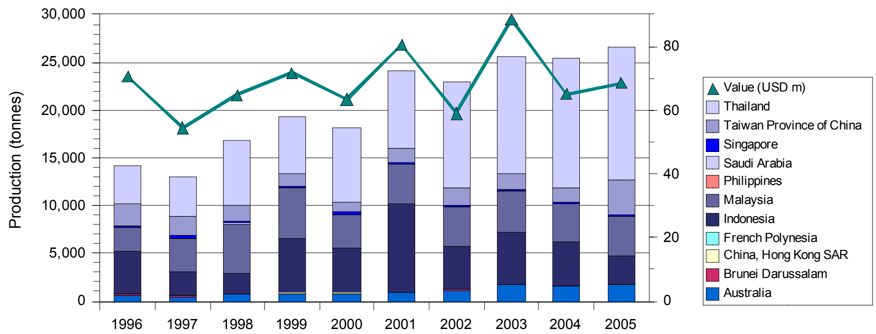
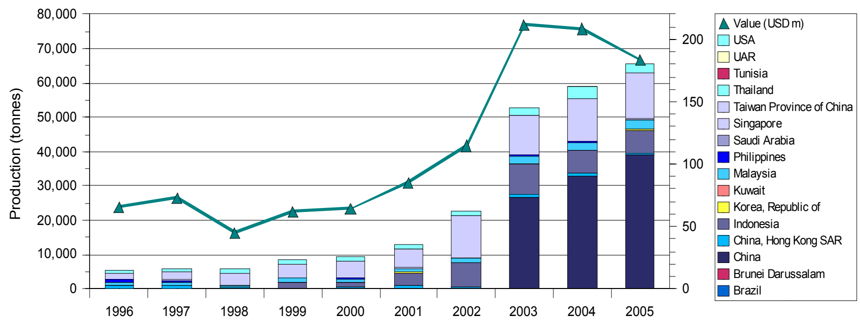


Figure 3. Global production value in USD millions (line) and production by country (columns) of groupers (Family Serranidae), 1996 – 2005.



million, followed by Japan with 256,000 tonnes, valued at more that USD 2 billion. Korea is the second-highest value producer of marine finfish, with USD 698 million from 80,522 tonnes of production.

These data suggest that production in Japan and Korea is of higher-value species than that of China. Japan produces around 22% of regional production, but the value of Japanese production is almost 50% of the regional total. The bulk of Japanese production of marine finfish (~160,000 tonnes) remains the Japanese amberjack (Seriola quinqueradiata).

Production trends in some selected species

Milkfish

Milkfish (Chanos chanos) remains a popular commodity in Indonesia and the Philippines: production of milkfish increased from 514,666 tonnes in 2004 to 542,842 tonnes in 2005 (Figure 1). However, value of production decreased from USD 627 million to USD 552 million over the same period (Figure 1), representing a decrease in price from around USD 1.20 to USD 1.00 per kilogram.

Barramundi (Asian seabass)

Barramundi production stayed relatively steady at 26,584 tonnes, up slightly from 25,399 tonnes in 2004 (Figure 2) (note that these figures exclude production listed as from freshwater, which is a relatively minor component of total production). Thailand remains the largest producer of aquacultured barramundi. Total value of production increased slightly from USD 65.08 million to USD 68.52 million (Figure 2). Average price remained steady at about USD 2.50 – 2.60 per kilogram.

Grouper

Global production of groupers increased from 59,146 to 65,362 tonnes from 2004 to 2005, an increase of 11% (Figure 3). (Note that this analysis includes countries outside the Asia-Pacific region, however the bulk of production is from Asia-Pacific countries). Despite this increase in reported production, total value of production decreased by 12%, from USD 208.5 million to USD 183.6 million over the same period (Figure 3). This may reflect increasing market saturation by farmed product, particularly by some lower-value grouper species, and consequent price decreases.

Japanese amberjack

Although there is some production of Japanese amberjack from the Republic of Korea, the bulk of production is from Japan (Figure 4). Production increased from 150,068 to 159,741 tonnes from 2004 to 2005, and value increased from USD 1.276 billion to USD 1.359 billion (Figure 4). The price of Japanese amberjack has remained steady at USD 8.50 per kilogram since 2001.

Cobia

Cobia (*Rachycentron canadum*) is an emerging species of considerable interest to farmers in the Asia-Pacific region. Presently, China and Taiwan Province of China are the only two countries in the Asia-Pacific region to report production of cobia. The apparent dramatic increase in cobia production in 2003 (Figure 5) is likely due to China

Table 1. Production of marine finfish through aquaculture (tonnes) in the Asia-Pacific region 1996 – 2005. FAO data sorted for ISSCAAP Division: Marine Finfish; Countries: Continents = Asia & Oceania; Environments: Brackishwater & Mariculture.

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Australia	2,013	2,184	1,699	1,602	2,731	4,075	4,012	7,804	9,562	7,467
Bahrain	3	<0.5	1	3	12	<0.5	3	4	8	3
Brunei Darussalam	<0.5	<0.5	<0.5	36	53	30	16	18	42	42
China	182,155	254,979	306,697	338,805	426,957	494,725	560,404	519,158	582,566	658,928
China, Hong Kong SAR	3,000	2,960	1,200	1,250	1,769	2,468	1,211	1,486	1,541	1,539
Cyprus	670	842	1,053	1,313	1,735	1,725	1,705	1,654	2,319	2,245
Fiji Islands	<0.5	-	-	-	-	-	-	-	-	-
French Polynesia	.	.	2	3	1	4	1	1	.	2
Guam	5	5	5	7	7	7	7	.	.	.
India	-	1,429	1,740	.	.	.	.	2,644	8,000	8,000
Indonesia	10,512	12,264	8,386	14,879	12,623	15,020	23,007	22,810	19,884	18,783
Israel	699	1,430	1,817	2,359	2,874	3,404	3,202	3,349	3,850	3,864
Japan	247,822	245,847	255,297	253,289	245,566	252,173	260,382	264,710	252,674	256,192
Korea, Republic of	11,384	39,121	37,323	34,382	27,052	29,297	48,073	72,393	64,195	80,522
Kuwait	90	154	150	176	346	179	179	164	100	142
Malaysia	3,367	2,706	2,266	3,092	5,645	5,165	5,570	7,369	7,704	8,451
Oman	-	-	13	-	-	-	-	352	503	168
Philippines	602	726	144	188	266	376	305	732	591	724
Qatar	1	2	<0.5	<0.5	<0.5	1	<0.5	<0.5	<0.5	<0.5
Saudi Arabia	<0.5	<0.5	31	30	42	62	45	49	41	182
Singapore	378	205	210	295	421	259	181	226	396	579
Taiwan Province of China	10,972	13,511	15,373	14,558	15,518	17,450	26,715	29,553	26,925	25,192
Thailand	1,546	1,243	1,682	1,175	1,358	1,463	1,179	2,349	3,597	2,300
Turkey	11,530	13,800	18,810	23,000	33,337	28,485	26,020	37,717	46,732	67,824
United Arab Emirates	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2,300	570	570
TOTAL	**486,749**	**593,408**	**653,899**	**690,442**	**778,313**	**856,368**	**962,217**	**976,842**	**1,031,800**	**1,143,719**

Table 2. Value of marine finfish production (USD millions) in the Asia-Pacific region 1996 – 2005. FAO data sorted for ISSCAAP Division: Marine Finfish; Countries: Asia, Oceania; Environments: Brackishwater, Mariculture.

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Australia	31.5	30.4	17.9	24.4	86.6	106.7	103.3	174.5	179.2	107.0
Bahrain	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Brunei Darussalam	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.2	0.2
China	127.5	178.5	184.0	203.3	256.2	321.6	560.4	474.0	536.5	662.1
China, Hong Kong SAR	35.7	35.0	11.3	9.4	14.6	23.0	9.5	12.8	12.6	11.3
Cyprus	6.2	7.0	7.9	8.4	8.9	7.9	8.9	9.7	17.8	16.8
Fiji Islands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
French Polynesia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Guam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
India	0.0	0.7	0.8	0.0	0.0	0.0	0.0	3.4	7.1	7.3
Indonesia	17.9	20.8	14.3	28.5	26.3	33.6	58.0	98.9	61.1	23.0
Israel	9.7	19.5	21.3	27.8	21.4	21.9	17.3	17.5	20.8	21.3
Japan	2,295.0	2,141.1	1,877.8	2,082.1	2,019.6	2,058.0	2,102.5	2,103.2	2,001.3	2,044.4
Korea, Republic of	150.3	434.7	266.6	326.0	275.8	227.5	298.0	536.8	530.9	698.1
Kuwait	0.6	0.9	0.9	1.1	2.2	1.2	1.2	1.1	0.6	0.9
Malaysia	23.6	22.8	10.7	12.2	21.7	19.2	19.5	39.2	35.4	44.4
Oman	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.7	2.3	0.9
Philippines	6.8	6.7	1.1	1.3	1.3	1.8	1.2	2.3	2.7	3.1
Qatar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Saudi Arabia	0.0	0.0	0.1	0.1	0.2	0.3	0.2	0.2	0.2	1.1
Singapore	2.8	1.7	1.6	1.9	2.5	1.6	1.1	1.9	2.7	3.5
Taiwan Province of China	56.5	72.7	78.8	84.1	91.5	96.9	107.5	144.1	141.7	137.0
Thailand	10.6	9.4	9.3	8.2	8.8	8.8	6.4	11.9	21.6	13.8
Turkey	97.4	114.5	153.2	169.1	130.9	85.4	78.1	176.5	236.1	340.5
United Arab Emirates	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	4.3	4.3
TOTAL	**2,872.0**	**3,096.5**	**2,657.5**	**2,988.1**	**2,968.8**	**3,015.6**	**3,373.4**	**3,816.8**	**3,815.2**	**4,141.0**

Figure 4. Value in USD millions (line) and production by country (columns) of Japanese amberjack (*Seriola quinqueradiata*) in the Asia-Pacific region, 1996 – 2005.

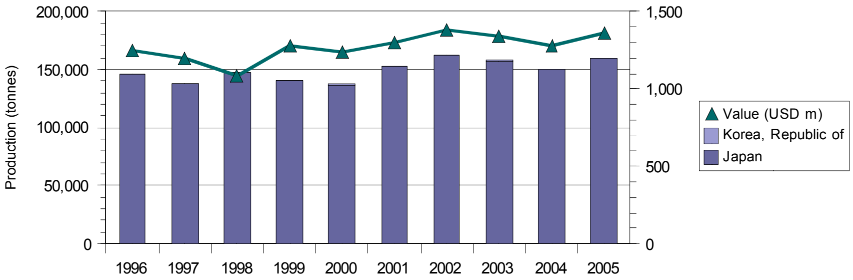
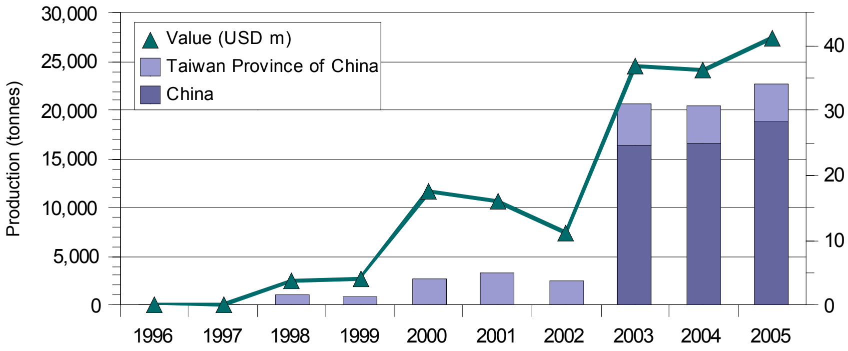


Figure 5. Value in USD millions (line) and production by country (columns) of cobia (*Rachycentron canadum*) in the Asia-Pacific region, 1996 – 2005.



beginning to report disaggregated production which had previously been reported as 'marine finfish' production. In 2004 – 2005, cobia production increased from 20,461 to 22,745 tonnes (Figure 5). Outside of the Asia-Pacific region, only Mayotte and Réunion reported small production of cobia (~ 7 tonnes in total). Total value of production increased from USD 36.2 million to USD 41.2 million (Figure 5). Price remained relatively steady at around USD 1.80 per kilogram.

Conclusion

Marine finfish aquaculture continues to expand in the Asia-Pacific region. Over the last 10 years, regional marine finfish production has grown at around 10% per annum and the 2004 – 2005 increase of 11% was in line with this general trend. The 9% increase in value in 2004 – 2005 indicates that markets generally remain relatively strong; this is substantially higher than the ten-year average value increase of 4% per annum.

Body size of rotifers (*Brachionus rotundiformis*) from estuaries in North Sulawesi

Joice Rimper[1], Richardus Kaswadji[2], Bambang Widigdo[2], Nawangsari Sugiri[2], Inneke F.M. Rumengan[1]

1. Faculty of Fisheries Sam Ratulangi University Manado North Sulawesi; Faculty of Fisheries Bogor, Institut Agriculture Bogor Indonesia.

Introduction

Rotifer has been extensively used as a live prey for marine larvae of different taxa since the 1960s, and is still considered the main supplier of nutrition for seed production in many hatcheries. The main species of cultured rotifer for finfish larval rearing world-wide, SS-morphotype of *Brachionus rotundiformis*, has been used in the research lines of many projects. However, for larvae with very small mouths, it is intended to have a greater proportion of super small rotifers by improving culture methods. Knuckey et al. (2005) have found that smaller sized diets could increase the proportion of the small group in a rotifer population, via selection pressure on the growth and size distribution of rotifers.

Studies on *B. rotundiformis* from North Sulawesi waters have been performed since 1994 with emphasis so far on the bioecological aspects and reproductive ability, but there has been no attempt to compare body size of wild rotifers from different locations in order to select the most suitable strain in terms of size and growth performance. The change of body size after culture was clarified in this study.

Materials and methods

Rotifer collections were conducted at four estuaries in North Sulawesi, Manembo-nembo and Minanga estuaries, and Wori and Tumpaan estuaries connected to Maluku and Sulawesi Sea, respectively. A clonal culture of Minanga rotifers was then developed at 20 ppt fed on two types of diet, *N. oculata* (3-5 µm in cell diameter) and a local symbiotic microalga *Prochloron* sp (2-4 µm in cell diameter) both at 3 x 106 cells/ml. The algae were cultivated in Hirata medium of sterilized diluted sea water (20 ppt) and maintained at 25ºC. A total of about 30 egg bearing females from each location and of the culture stock of each treatment were preserved with 4% formaldehyde solution for morphometric measurements.

Results and discussion

Table 1 lists the average body size of the wild and cultured rotifers. Lorica length of wild rotifers from all locations was not significantly different, but the lorica width and the anterior width are significantly different. The average of anterior width and lorica width taken from Minanga waters are higher than those of other locations (Manembo-naembo, Wori and Tumpaan). The size range of body size is relatively smaller than the other tropical SS-type rotifers (Thai, Fiji and Okinawa strains) as reported by Hagiwara et al., 1995).

Previous studies on rotifers from North Sulawesi (Rumengan *et al.*, 1998; and Yoshinaga *et al.*, 2004) have shown that the local rotifers belong to SS type rotifers of *B. rotundiformis*. The wild rotifers of present study are slightly bigger than the previous local strain, but much smaller for the cultured rotifers, as Rumengan *et al.* (1998) found that lorica length of egg bearing wild rotifers (150.7 ± 17.6 μm) was much smaller than that fed on Tetraselmis (199.2 ± 10.6μm), but similar to those fed on *N. oculata* (150.7 ± 12.9μm) and *Isochrysis* sp (151.5 ± 14.9μm). This is consistent with the finding of Knuckey *et al* (2004) that particle size of diet influences the degree of morphological plasticity in size. The present study shows that when fed on *Prochloron* sp the rotifers are getting smaller (Table 1). *Prochloron* sp used was isolated from the Ascidians, *Lissoclinum patella* from Manado Bay, North Sulawesi. This symbiont has previously been reported as 'uncultivable prokaryotic alga' since its discovery 40 years ago (Lewin and Cheng, 1989; Munchoff *et al.*, 2007), but it has been successfully maintained in culture away from their host in Laboratory of Marine Biotechnology, Sam Ratulangi University since 2005. However, in culture at 20 ppt their size reduced by 20% from their original size (10-30 μm) (unpublished data).

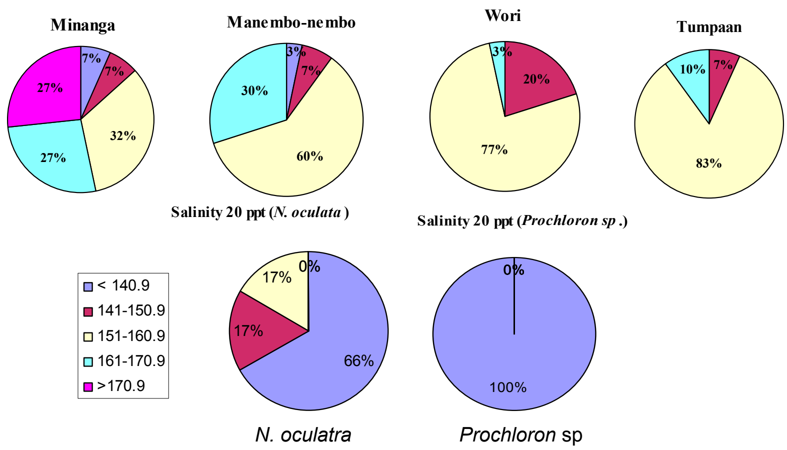
It can be seen in Fig. 1, only small portion of wild rotifer population (<20%) have body size of <141 um, but whole population of cultured rotifers are within that size range, especially those fed on *Prochloron* sp. However, it is still necessary to clarify this by long term culture and increasing the culture scale

Table 1. Body size* (μm) of wild rotifers from different locations and of cultured rotifers fed on *N.oculata* and *Prochloron* sp.

Rotifer*	Lorica Length (A)	Lorica Width (C)	Anterior Width (B)
Wild rotifers:			
Menembo-nembo	162.4 ± 8.6	119.6 ± 6.9	70.3 ± 5.2
Minanga	163.8 ± 6.9	122.6 ± 5.7	71.1± 5.3
Wori	161.8 ± 6.9	116.8 ± 6.4	69.7 ± 6.3
Tumpaan	161.3 ± 7.1	117.0 ± 6.9	69.4 ± 5.4
Cultured rotifers:			
N. oculata	127.4 ± 20.11	103.3±16.7	57.1±9.7
Prochloron sp.	108.8± 10.2	92.7±11.7	52.0±6.5

*Values are in average ± STD.

Figure 1: Lorica length of wild rotifers (upper graphs) and cultured rotifers (lower graphs) showing the proportion (%) of each size range (μm)



for mass production to meet the requirement of finfish larvae. As Knuckey *et al.*, 2004 has previously found that higher percentages of smaller rotifers suitable for first feeding larvae were obtained when rotifers were fed with ultra-small algae such as *Stichococcus* sp, but this alga is difficult to maintain in large scale culture in tropical region. Long term culture of *Prochloron* sp and their effects on rotifer growth performances in large scale remain for future studies.

References

Hagiwara, A., T. Kotani, T.W. Snell, M. Assava-Aree, and K. Hirayama: Morphology, reproduction and genetics of the tropical minute marine rotifer *Brachionus* strains. J. Exp. Mar. Biol. Ecol., 194: 25-37.

Knuckey, R.M., I. Rumengan and S. Wullur. 2004. SS-strain Rotifer Culture for Finfish Larvae with Small Mouth Gape. In: Advances in Grouper Aquaculture (M.A. Rimmer, S. McBribe and K.C. Williams, eds). ACIAR Monograph Series. p. 21-25.

Lewin, R.A dan Cheng L. 1989. *Prochloron*: A Microbial Enigma. Printed in the United States of America. pp. 115.

Munchhoff, J., E. Hirose, T. Maruyama, M. Sunairi, B.P. Burns, and B.A. Neilan, 2007. Host specificity and phylogeography of the prochlorophyte *Prochloron* sp., an obligate symbiont in didemnid acidians, Environ Microbiol. Vol 9(4): 890-9.

Rumengan, I.F.M., V. Warouw, and A.Hagiwara, 1998. Morphometry and resting egg production potential of the tropical ultra minute rotifer *Brachionus rotundiformis* (Manado strain) fed with different algae. Bull of Fac. Fisheries, Nagasaki University 79:31-36.

Yoshinaga, T., Y. Minegishi, I.F.M. Rumengan, G. Kaneko, S. Furukawa, Y. Yanagawa, K. Tsukamoto, and S. Watabe, 2004. Molecular phylogeny of the rotifers with two Indonesian *Brachionus* lineages. 2004. Coastal Marine Science, 29(1): 45-56.

NACA Newsletter

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

ISSN 0115-8503

Volume XXIII, No. 1
January-March 2008

Better management practices for catfish aquaculture in the Mekong Delta, Vietnam

A grant of AUD$455,590 has been procured for the development of better management practices (BMPs) for tra catfish (*Pangasianodon hypopthalmus*) aquaculture in the Mekong Delta of Vietnam. The grant has been provided by AusAID's Collaboration for Agriculture and Rural Development Programme.

The project will be jointly implemented over a two year period commencing in 2008, by NACA in conjunction with Fisheries Victoria on the Australian side and the Research Institute for Aquaculture No. 2 and Faculty of Fisheries, Cantho University in Vietnam. This project will further strengthen the initiatives of NACA on the development of BMPs for other important cultured commodities, such as shrimp and marine finfish carried out with other collaborators.

Catfish farming in the Mekong Delta, the bulk of which is still undertaken by relatively small-scale producers, is one of the largest and most rapidly growing freshwater aquaculture industries in the world. The sector has already reached the forecast for 2010 of a production of 1 million tonnes with export value of 1 billion US$.

Current farming practices need to be improved on many fronts and issues of environmental integrity addressed to ensure that the industry continues to develop in a sustainable manner. Issues impacting the viability and development of catfish farming in the delta include poor husbandry practices, low quality seed, excessive dependence on trash fish as a feed resource, inadequate planning in site selection, food safety and market access, and environmental degradation. These issues can be addressed through the development and adoption of Better Management Practices (BMPs), implemented through collaborative groups of small-scale farmers in conjunction with those from large-scale farmers. The project aims to develop and facilitate adoption of BMPs for the catfish farming practices that will increase the efficacy and profitability of small-scale farmers while simultaneously reducing their risk profile and environmental impact, and ensure the wider sustainability of the sector as a whole. This could also provide a model for addressing sustainability in other aquaculture commodities.

Weighing the harvest, Mekong Delta, Vietnam.

Developing better management practices for marine finfish aquaculture

A workshop on the 'Development of Better Management Practices for Marine Finfish Aquaculture in the Asia-Pacific region' was held in Lampung, Indonesia, 7–10 November 2007. The workshop was held to begin the process of developing Better Management Practices (BMPs) for the marine finfish aquaculture sector, which is growing rapidly in Asia. The rapid expansion of marine finfish aquaculture, and concerns regarding its environmental sustainability, has led to the development of several accreditation / certification schemes, and the proposed development of others. NACA and ACIAR are concerned to ensure the participation of small-scales farmers, who provide the bulk of production in Asia, in certification and market access schemes. The development of a BMPs-based approach is intended to allow small-scale farmers to adopt practices that will better support their participation in more formal accreditation / certification schemes in the future, and facilitate market access by small-scale farmers in the face of increasing consumer demands for environmental and social responsibility in aquaculture.

The four-day workshop was undertaken as part of the ACIAR-funded project 'Improved hatchery and grow-out technology for marine finfish aquaculture in the Asia-Pacific region' (FIS/2002/077). The workshop was attended by 60 participants from Australia, Cambodia, China, France, India, Indonesia, Myanmar, Norway, Philippines, Thailand and Vietnam, involving people from government, research, NGO and the private sector. There was a strong participation in the workshop by the private sector, with about half the participants coming from private industry, including representatives of farmer organizations and feed companies. Industry participants were supportive of the need to develop BMPs for marine finfish aquaculture as a way to enhance the sustainability of their industry. The workshop was also attended by representatives of environmental and other NGOs. The full report from the workshop will be available in early 2008.

The workshop was organized by NACA and the Directorate General of Aquaculture (DGA) of Indonesia in conjunction with the Australia Centre for International Agricultural Research (ACIAR).

Workshop on modeling carrying capacity for tropical finfish cage culture: Towards a consensus view

NACA and the Directorate General of Aquaculture (DGA) of Indonesia in conjunction with the Australia Centre for International Agricultural Research (ACIAR) organized the workshop on "Modeling carrying capacity for tropical finfish cage culture: Towards a consensus view" in Lampung, Indonesia from 5-6 November 2007. The objective of the workshop was to demonstrate and compare models developed for estimating carrying capacity of finfish cage culture in the Asia-Pacific region, and to develop a consensus view and recommendations to support implementation of better management practices in this important sector. Participants also considered issues with fish cage culture in inland waters in the Asia-Pacific and made recommendations with regard to use of cage culture as livelihood activity in inland lentic and lotic waters. The workshop brought stakeholder groups together to compare results, discuss issues and add value to the work that has already been done. The workshop adopted the following definition of carrying capacity:

"Carrying capacity for cage culture operations can be considered as the level of sustainable production that can be achieved in a given water body without overly perturbing environmental integrity, i.e. causing eutrophication, algal blooms, or inducing negative environmental impacts on sensitive ecosystems such as coral reefs".

The workshop participants recognized that models need to be designed to match particular environments and aquaculture problems, and these need to be at an appropriate scale (farmer-level, bay-level, provincial level). Models of carrying capacity need to be widely accessible, simple to use and affordable. It is important that models be adequately tested, ideally by the use of pilot projects, so that the results are realistic. Issues of site selection, zoning, legislative framework, farm management and socio-economics need to be considered. Dissemination activities need to incorporate all stakeholders, including farmers, decision makers and scientists.

Participants in the carrying capacity workshop.

Two modelling products are of particular relevance to the Asia Pacific region. TROPOMOD, developed under PHILMINAQ, has been developed to apply specifically to milkfish farming in the Philippines, but has application to other tropical species. CADS_TOOL (Cage Aquaculture Decision Support Tool) developed under an ACIAR project, currently includes 5 modules each representing a different modelling tool. The workshop recommended that CADS_TOOL be adopted as a prototype for the region, but recognised that it needed expansion and improvement, ideally incorporating TROPOMOD as an additional module.

The workshop was an activity under the ACIAR funded project on 'Planning tools for environmentally sustainable tropical finfish cage culture in Indonesia and northern Australia'. The workshop was attended by 25 participants from Australia, China, France, India, Indonesia, Norway, Philippines, Thailand and Vietnam. The report of the workshop will be available in early 2008.

First comprehensive genetic management plan for Asian fish species: Mahseer

The mahseer species, *Tor tambroides* and *T. douronensis*, are often referred to as empurau and semah, respectively in Sarawak, Malaysia. The two species are indigenous to the State with an aquaculture potential and of conservational value. Empurau and semah are well sought after due to high market value as well as being attractive sport fish. Many anthropogenic activities, including the recent developments in watersheds within the natural distribution of empurau and semah, as well as increased fishing pressure have led to depletion of their natural stocks. As such there is an urgent need to replenish such depleted stock as well as reducing pressure that affects the well being of natural populations of empurau and semah.

The Government of Sarawak, recognizing the importance of these two species, made an attempt to evaluate their aquaculture potential, including captive breeding using long-term pond-reared broodstock, commencing in the 1990s. However, limited success was achieved until the period 2002-2004 through an international collaboration, where researchers from Australia and Sarawak were able to breed both species using hormone induction techniques, popularly referred to as hypophysation, on long-term, pond-reared broodstock. Success in artificial propagation of empurau and semah would bring about significant developments in term of aquaculture and conservation. On the one hand, fish produced from aquaculture can be used to replenish the wild stocks – the practice often known as stock enhancement, and on the other hand, fishing for food fish will also be reduced due to the availability of cultured fish.

However, it is important to note that aquaculture and stock enhancement could be counter-productive if genetic aspects of broodstock management are not taken into account or broodstock are not properly managed. Detrimental genetic impacts of poorly or inappropriately managed fish breeding programs for both aquaculture and stock enhancement have well documented over the last two decades (Waples, 1991). When fish are removed from the natural environment and placed in a cultured environment and domesticated, random genetic drift and domestication effects (new and greatly different selective forces act upon fish in the domestic environment compared to the natural environment) alter the gene frequencies and reduce genetic variation. Domestication reduces genetic variability in fish through both selective processes and random genetic drift. Such fish once released in to the natural waters could have potential impacts on altering or diluting natural gene pools, and such events have been documented for many species. Hybridization between closely related species can have a detrimental affect on natural gene pools. Interspecific hybridization among other mahseer elsewhere has been reported. Because of the high level of morphological similarity between empurau and semah there is risk that inadvertent mixing of the two species, especially during breeding, may lead to hybridization. Therefore hybridization is an important threat to the genetic integrity of both species. In order to avoid the above mentioned potential problems, it is crucial that a genetic management plan be developed with the aim to warrant the long-term maintenance of genetic diversity of cultured stocks, as well as to minimize potential adverse effects on the genetic integrity of the wild populations through proper stock enhancement practices.

Surveys on current status of genetic variability of empurau and semah are reported herein, and the results from which are used as baseline data for development of a genetic management plan. Further, this document represents the first example in Asia of a comprehensive genetic management plan that was developed at the inception of industry development and commercialization, and that takes into account both commercial aquaculture of fish species as well as the conservation and management of wild populations.

The Guidelines for genetic management and conservation of mahseer can be downloaded from the link below. This document presents the current status on genetic diversity of empurau and semah in Sarawak, Malaysia, including taxonomic status; and a management guideline based on genetic data:

http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=63&lid=893

NACA and World Fisheries Trust sign agreement on collaboration

NACA signed a letter of agreement with the World Fisheries Trust (WFT), a NGO based in Victoria Island, Vancouver, Canada, underlining the desire to collaborate in activities that facilitate sustainable, socially and environmentally responsible aquatic resource conservation, development and management, particularly those that benefit poor and disadvantaged communities and contribute to poverty alleviation. WFT has been working on issues on aquatic resources management in the Americas and now is expected to extend into Asia and Africa.

NACA has in the past year collaborated with the WFT on activities in relation to biodiversity of aquatic resources and the agreement will now further collaboration into other areas of mutual interest. It is expected that this collaboration will also facilitate south-south dialogue on issues pertaining to aquatic resources development and management, when experiences from one region could be effectively utilized elsewhere. The collaboration initiated by the WFT will include providing financial support to NACA to document “success stories” in aquaculture pertaining to small scale farming communities, which is a also a priority and the mandate of NACA.

Fish Health Master Class

A two week master class in fish pathology, supported by the Crawford fund of the Australian Government, was formally opened by Prof Sena DeSilva, DG of NACA in Bangkok on 12th November 2007. The master class focused on training candidates in reading and interpreting slides to understand normal histology, pathological process, tissue pathology, disease case studies and artifacts. Eighteen participants from 14 countries in the region attended. The course was taught by some of the well known and respected fish pathologists from the region with resource experts including Dr Brian Jones, Dr Barbara Nowak and Ms Susan Kueh from Australia; Dr Supranee Chinabut from DOF, Thailand; Prof Miyazaki from Japan; and Dr CV Mohan from NACA. The master class was a collaborative activity between Murdoch University in Australia, AAHRI in Thailand and NACA.

Second Workshop on Application of Molecular Genetic Techniques in Inland Fisheries and Aquaculture Management

NACA and its lead centre in India, the Central Institute of Freshwater Aquaculture (CIFA), Bhubaneshwar, in conjunction with the Food and Agriculture Organisation (FAO) organised the second Training Workshop on Application of Molecular Genetic Techniques in Inland Fisheries and Aquaculture Management. The workshop was held at CIFA, India from 27 November to 05 December, 2007.

The workshop was organised particularly for scientists from south Asian member countries of NACA (Bangladesh, India, Nepal, Pakistan and Sri Lanka). The ten-day workshop covered the theory of population genetics and fish selective breeding, as well as hands-on training in common genotyping techniques, and data analysis and interpretation. Specifically, the main topics included:

- An overview of the application of molecular genetics in inland fisheries and aquaculture, and conservation of freshwater fish species.
- Principles and application of commonly used techniques such as allozyme electrophoresis, cloning, DNA sequencing, northern and southern blotting, and real time PCR.
- Hands-on training on the above techniques.
- Data analysis and interpretation.

Resource persons of the training workshop were mainly drawn from institutions in India, and included Dr. W. S. Lakra, Dr. P. K. Mukhopadhyay, Dr. K. D. Mahapatra, Dr. H. K. Barman, Dr. P. K. Meher, Dr. P. Das, Dr. S. Nandi, Dr. A. Barat, Dr. K. K. Lal of CIFA, and Dr. Basavaraju of Central Agricultural University. Dr. Thuy Nguyen, Coordinator of the Genetics and Biodiversity Program of NACA in conjunction with Dr. N. Sarangi, Director, CIFA were responsible for the overall organization. For more information about the workshop or expressions of interest in possible future workshops, contact thuy.nguyen@enaca.org.

Aquaculture without Frontiers: Temporary website relocation

Due to some technical problems the Aquaculture without Frontiers website has been temporarily relocated to the World Aquaculture Society's servers. You can access the Aquaculture without Frontiers website at http://awf.was.org/, it will be republished under its own domain name in due course.

Two new species of spiny eels described from Myanmar

The two new species of spiny eels, *Mastacembelus tinwini* and *M. pantherinus* are recently described from Myanmar waters. The former is from southerm Myanmar (in the Salween and possibly the Sittang river drainages), and the latter is from the Lake Indawgyi in northern Myanmar. Both species belong to the *M. amartus* complex, members of which have a very wide distribution, from Afghanistan to southern China and the Sunda islands, and have been previously thought to belong to a single species.

Mastacembelus tinwini is named for U Tin Win, for providing the author with study material and assisting him in the field, while *M. pantherinus* is named for its spotted pattern (from panther, the Greek name for the leopard).

According to the author, *M. tinwini* can be distinguished from other members of the genus in having "...a unique colour pattern consisting of five regular and parallel, black, longitudinal bands along the body, frequently expressed as a series of interrupted lines or broken up into individual blotches, and a white margin to the soft dorsal, anal, and caudal fins..." while *M. pantherinus* can be distinguished by "...a unique colour pattern that consists of numerous individual spots or irregular marks, sometimes forming short lines and a whitish belly devoid of any marks...".

The author states that given the high amount of variation seen in the vertebral number of the different populations of *M. armatus* throughout South and Southeast Asia, "...it can be expected that a thorough revision of this complex will result in additional species-level taxa to be resurrected from synonymy and new species to be described..."

For more information, see the paper: Britz, R (2007). Two new species of *Mastacembelus* from Myanmar (Teleostei: Synbranchiformes: Mastacembleidae). Ichthyological Exploration of Freshwaters 18, pp. 257–268.

Importance of species identification in conservation

Over the last two decades, fisheries biologist have make attempts to preserve the endangered Greenback cutthroat trout, *Oncorhynchus clarkii stomias* by rearing thousands of fish and stocking them in Colorado rivers, lakes and streams. However, it is so unfortunate to learn that a recent study using mitochondrial and nuclear genetic makers, conducted by scientists from the University of Colorado at Boulder reported that in most cases, the fish used to stock was actually the closely related Colorado River cutthroat trout, *Oncorhynchus clarkii pleuriticus*. The problem is believed to have been caused by misidentifications dating back to the stocking of trout in Colorado waters in the late 1800s and early 1900s, although it is acknowledged that management decisions by federal and state fisheries biologists over the past decades were based on the best reports available by experts at the time. Fortunately, the data is becoming more accurate over time as genetic techniques improve and the peer review process is increasingly incorporated into scientific management strategies. However, this study highlights the need for great care in undertaking the translocation of aquatic animals and for appropriate risk assessments.

For more information see the paper: Metcalf JL, Pritchard VL, Silvestri SM, Jenkins JB, Wood JS, Cowley DE, Evans RP, Shiozawa DK, Martin AP (2007) Across the great divide: genetic forensics reveals misidentification of endangered cutthroat trout populations. Molecular Ecology 2007 Aug 28.

Koh Yao Noi mangrove replanting in celebration of 80th birthday of His Majesty the King of Thailand

A special mangrove replanting programme was opened at Koh Yao Noi (KYN), an island community in Thailand's Phang Nga Bay, in honor of His Majesty the King's 80th birthday.

At the opening ceremony in Koh Yao Noi School, Khun Hassanai Kongkeo, as the representative of Chiba Environmental Education team and NACA, handed over US$1,000 cash contributed from Chiba to KYN School Director. This fund will be used for seedling production and to purchase a water pump.

The school forest replanting programme covers both mangrove and inland areas. 1,000 seedlings of *Rhizophora* and *Avicenia* mangrove and 350 seedlings of timber plants were prepared for reforestation in tidal and inland areas respectively. The original mangroves in this tidal area were heavily damaged by the tsunami of December 2004. The ceremony was attended by 27 KYN school teachers/lecturers, 409 KYN school students, 50 students from Phuket Community College, 10 District Officers, 10 representatives from KYN Communities and a NACA/Chiba representative, totaling 507 people engaged in this activity. The students have also been assigned to nurse these planted seedlings until they become strong. This reforestation programme is considered to be the most successful in the district for this special occasion.

Above: Khun Hassanai offers the donation on behalf of the Chiba Environmental Education Team and NACA to the Director of the Koh Yao Noi school. Below: Students enjoy planting mangroves!

Responsible movement of live food finfish within ASEAN: Implementation workshop

The AADCP-RPS 370-018 project "Operationalise Guidelines on Responsible Movement of Live Food Finfish within ASEAN" has been underway since January 2006. This Implementation workshop, the third in the series, was held in KU Home, Kasetsart University, Bangkok, Thailand, from Monday 8 to Friday 12 October 2007.

The project is coordinated by ASEC, AusVet and NACA and has the active participation of delegates from 10 ASEAN countries. The project has developed "Standard operating procedures (SOPs) for health certification and quarantine measures for the responsible movement of live food finfish within ASEAN". The draft SOPs have been presented at the recent ASWGFi meeting held in Singapore (June 2007) and were also considered by the Special Senior Officials' Meeting (SOM) - 28th ASEAN Ministers for Agriculture, Fisheries and Forestry (AMAF). As per the suggestion of SOM-AMAF, the title of the document has been revised to "Guidelines on development of Standard operating procedures for health certification and quarantine measures for the responsible movement of live food finfish within ASEAN".

The workshop identified specific implementation gaps for the SOPs in all ASEAN member countries and developed a framework within ASEAN for a sustainable network for communication on implementation of the LFF-SOPs and for their future adaptation for trade in other aquatic animals. It also addressed development of a work program for the implementation of the LFF-SOPs and an auditing and monitoring program.

The extension will also develop a framework for technical support within ASEAN under which more developed countries will act as partners for Cambodia, Lao PDR and Myanmar with assistance from NACA and the proposed ASEAN Network of Aquatic Animal Health Centres (ANAAHC).

Consultation on aquaculture certification guidelines

Aquaculture certification meeting was held in Avenue Hotel, Kochi India on 23rd November 2007 in partnership with FAO and hosted by Marine Products Exports Development Authority (MPEDA). This meeting was the third in a series of consultations to bring stakeholders together to prepare international guidelines for aquaculture certification. The meeting was attended by a group of experts who were participating in the 8th Asian Fisheries Forum and involved 20 people representing industry, government and NGOs.

The revised draft Guidelines for Aquaculture Certification, incorporating the comments and discussion points from earlier workshops held in Bangkok (March 2007) and Fortaleza (July 2007), were distributed to the participants and discussed in detail.

Taking into account of the outcomes of this certification meeting during the 8th Asian Fisheries Forum, and the comments, suggestions and recommendations received by many, the Secretariat has revised the draft Guidelines, and the latest version (17/12/07) is available for download from www.enaca.org/certification.

FAO and NACA welcome comments on this draft guideline document, and more generally the sharing of experiences, reports and debate on aquaculture certification. Review comments on this draft document and other information should be sent to:

certification@enaca.org.

Strengthening regional mechanisms to maximize benefits to small-holder shrimp farmer groups adopting better management practices

The first meeting of this ACIAR-funded project, schedule to run until November 2009, was held in MPEDA, Cochin, India on 21 November. The meeting was attended by project partners from India (MPEDA, CIBA, NaCSA), Vietnam (NAFIQAVED), Indonesia, Malaysia, Australia and NACA. Representatives from other BMP projects in the region (IFC, WWF, FAO), and Seafood Alliance also participated. A brief overview of all ongoing BMP projects in the region, including for shrimp and other aquaculture commodities such as catfish, was presented and discussed. The project partners recognized a need to consolidate information on aquaculture BMP activities and agreed to develop a BMP website as a platform to stay in touch and share information on activities underway in different projects and countries in the region. The website will be launched in January 2008, along with a revised shrimp e-newsletter, which will be produced quarterly. Information on linking ongoing research activities to development and implementation of BMP programmes in the region was presented. The need to actively integrate new research findings into the BMP programs and revise/modify BMPs was recognized as very important to keeping the BMPs scientifically sound. Ways to improve market access to BMP compliant small scale farmers was recognized as a key issue; including the need to raise the awareness of consumers in importing countries of both the positive and negative impacts of their purchasing decisions on the small scale farmers in producing countries. The possibilities of developing pilot studies in market access and cluster certification methodology were also discussed and agreed.


VIETNAM
INDIA
THAILAND
MOANA
NEW GENERATION OF BLACK TIGER SHRIMP
AFTER YEARS OF FOCUSED DEVELOPMENT,
THE COUNTDOWN HAS BEGUN...
...WE OFFER A NEW GENERATION OF
BLACK TIGER SHRIMP
MOANA is the leading aquaculture company in the development and supply of genetically improved and disease free seed of Black Tiger Shrimp (Penaeus monodon). MOANA's innovative approach through pedigree-based selective breeding (non-GMO) fills today's need for sustainable production and fully traceable supply of high quality seed throughout the value chain.
SUSTAINABILITY
2008
QUALITY
TRACEABILITY
MOANA (Asia) Ltd.
218/47-48, 4th Floor Geneva Building, Muang Thong Thani,
Bond St., Bangpood, Pakkred, Nonthaburi 11120 Thailand.
Tel: + 66 (0) 2361 0207 FAX: + 66 (0) 2961 0208
Website: www.moanatech.com