ISSN 0859-600X
Volume XVII No. 1 January-March 2012

AQUACULTURE ASIA

Reflections on small-scale aquaculture

Feeding strategies of fish farmers in Andhra Pradesh

Monitoring catfish pond effluent

Azolla in aquaculture

Snout otter clam

Crude palm oil

MSD
Animal Health

Advancing Aquaculture Around the World

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

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

Aquaculture Asia

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

NACA

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

Contact

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

Submit articles to:
magazine@enaca.org

Printed by
Scand-Media Co., Ltd.

AQUACULTURE ASIA

Volume XVII No. 1
January-March 2012

ISSN 0859-600X

Upgrading the network

So what do you do when your office and half the country is underwater? Probably you will spend a lot of time pondering water resource management, or more likely, water resource avoidance. In my case, I also spent a lot of time developing new software for the NACA website, to support an upgrade in our 'digital networking' capability.

While NACA's membership is comprised of governments, the day to day implementation of projects and activities is also carried out to a large extent through collaboration between research centres, institutes and universities of member states. To date, collaboration at the institutional level has largely been conducted on an ad hoc basis, with individual institutes participating in the network as projects relevant to their scope of expertise arise. Since most NACA activities are donor funded, the focus of projects is somewhat cyclical, with particular issues rising or falling in prominence as they gain public attention or fall out of favour. However, increasingly, Asia must become self-reliant for its development efforts.

One of the issues that has been under debate for some time is how NACA can strengthen its networking and collaboration mechanisms, at both the institutional level and in terms of engaging individual scientists, technicians and educators. This is not an easy thing to do in a highly distributed organisation working across 18 states and many different languages. However, one practical step we can take is to improve the range of information and networking services that are offered through the NACA website.

In the coming months NACA will begin assembling several databases to facilitate networking and collaboration, which will be added as searchable sections of the NACA website. These will include:

- A directory of collaborating NACA centres, their main areas of expertise and technical services that are available, to facilitate exchange and technical support at the institutional level.
- A personnel directory of scientists and technicians in participating centres, their research interests and skills, to facilitate finding collaborators.
- A joint training calendar of upcoming courses available across the network.
- An upgrade to the publications section of the NACA website into a full digital library service.

To build and maintain these services will require a substantial and ongoing commitment from both the NACA Secretariat and collaborating institutions. Therefore, NACA will seek to formalise relations, information exchange and service provision with participating centres through establishment of MOUs. If you personally or your organisation would like to participate, please contact the editor at simon@enaca.org.

AQUACULTURE ASIA

CONTENTS

Peter Edwards writes on

Rural Aquaculture

Reflections on small-scale aquaculture

An FAO expert workshop on Enhancing the Contribution of Small-Scale Aquaculture to Food Security, Poverty Alleviation and Socio-Economic Development was held in Hanoi, Vietnam in April 2010. I was commissioned to write two background papers for the Workshop, the proceedings of which are to be published this year. This issue's column is based on the first paper, 'Review of small-scale aquaculture: definitions, characterisation and numbers'. My next column will be based on the second paper,' Successful SSA's and their contribution to economic growth at the national level and poverty alleviation and rural development at the local level'. Both columns consider more recent publications and reflections on small-scale aquaculture.

Following consideration of various definitions relevant for small-scale aquaculture, I trace the development of the concept of small-scale aquaculture from rural aquaculture. The degree of contribution of small-scale aquaculture to Asian aquaculture at large is discussed. Farmer hopes and aspirations are then outlined, followed by sections on alternative development strategies, technical development options and finally promotion of small-scale aquaculture.

Definitions

I define traditional inland aquaculture as being developed and disseminated by farmers and local communities using on-farm and/or locally available resources in contrast to modern aquaculture that is science/industrial-based technology using agro-industrially formulated feed, new species and breeds, induced hormonal breeding and various techniques to control disease (Edwards, 2010). The main points in contrasting traditional and modern aquaculture are that most aquaculture, small as well as large, can only be very productive and therefore a significant livelihood income generating option by using modern technology.

Traditional aquaculture is mainly integrated with other human activity systems such as agriculture and animal husbandry, cottage agro-industry and sanitation. These were the only sources

Quasi-peasant, carp polyculture, Bangladesh.

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

of nutritional inputs for farmed aquatic organisms before the relatively recent manufacture of chemical fertilisers and pelleted feed. Exceptions are extensive systems such as culture-based reservoir fisheries; and coastal seaweed and mollusc culture which depend on suspended particles and dissolved nutrients in the water column, respectively.

Traditional systems vary in intensity of production. Intensity of production may be extensive, semi-intensive or intensive but these terms are used in such diverse ways as to be almost meaningless without definition: extensive systems depend on natural food produced within the system; semi-intensive systems depend on intentional fertilisation to produce natural food in situ and/or on the addition of supplementary feed to complement high-protein natural food; while intensive systems depend on nutritionally complete feed with little to no contribution from natural food.

The main types of traditional aquaculture are:

- Integrated agriculture–aquaculture systems (IAAS) with on-farm or local sources of vegetation, manures and agricultural by-products as nutritional inputs e.g. rice/fish; crop/fish; livestock/fish – extensive or semi-intensive production.

- Integrated peri-urban-aquaculture systems (IPAS) use wastes of cities and agro-industry, including wastewater (human sewage) – semi-intensive or intensive production.

- Integrated fisheries aquaculture systems (IFAS) use freshwater or marine trash /small low-value fish as feed - intensive production.

Recently I have introduced the terms direct and indirect IAAS to indicate the limited production and therefore potential of on-farm IAAS to contribute significantly to household income (Edwards, 2010). Direct IAAS use on-farm by-products which are usually limited while indirect IAAS use off-farm by-products which are potentially unlimited and therefore this strategy could comprise a major or even sole livelihood option.

Evolution of the small-scale aquaculture concept

Rural and small-scale aquaculture have both been defined in various ways although mainly in terms of poor beneficiaries. The term small-scale aquaculture has recently become more fashionable than rural aquaculture.

In his 1992 paper, 'Rural aquaculture, from myth to reality', Martinez-Espinosa raised concern about two issues: the rapid development of 'industrial aquaculture' of salmon and shrimps had almost eclipsed institutional support in rural aquaculture for needs of 'small farmers'; and although aquaculture may play an important role in improving welfare of rural people, the 'approach applied so far to development projects must be changed'. He opined that aquaculture is no panacea for solving problems of rural poverty; although farmers in economically depressed areas with very low fish production may value limited supplies of fish and continue with aquaculture, farmers in areas with more remunerative economic activities off-farm are more likely to abandon low-intensity fish culture. Therefore, he believed that there is a need to support better-off small-scale farmers who could intensify aquaculture and sell fish as a business rather than supporting farmers for subsistence.

In a 1995 paper, Martinez-Espinosa proposed two categories for rural aquaculture:

- Type 1' for the 'poorest of the poor' - mostly subsistence aquaculture with a small part of the production not consumed by the household being sold.

- 'Type 2' for the 'less poor' aquaculture - low/medium cost, low/medium output by better-off farmers who are financially solvent and have managerial capacity and add aquaculture to the traditional agriculture activities, with fish mostly sold to generate income.

Quasi-peasant, tilapia monoculture, Bangladesh.

Quasi-peasant, tilapia monoculture, Myanmar.

According to Martinez-Espinosa, 'Type 2' rural aquaculture had received hardly any assistance from governments and development agencies despite having greater potential than 'Type 1'

Edwards and Demaine (1997) later called the above categorisation of rural aquaculture a 'false dichotomy' because most small-scale farmers are motivated to carry out aquaculture mainly to provide income rather than as a source of household subsistence. As many if not most potential new entrant aquaculturists are poor rather than 'better-off', considerable promotion is required for aquaculture to fulfill its potential to provide food security, employment and income for small-scale households. These authors redefined rural aquaculture into a single definition: 'the farming of aquatic organisms by small-scale farming households using mainly extensive and semi-intensive husbandry for household consumption and/or income'.

Yap (1999) based on his experience in the Philippines with coastal aquaculture subsequently pointed out that intensity of production and use of cultured organism are not necessarily good criteria for rural aquaculture as small-scale grouper cage farming is intensive and produces high-value fish, small-scale seaweed faming is extensive and produces colloids for export, and large-scale milkfish farms owned by wealthy people are extensive to semi-intensive and support national food security by producing relatively low-cost fish.

Defining rural aquaculture had thus become problematic:

- Small-scale farming for food and/or income?
- Small-scale farmers using extensive to intensive production?
- Large-scale farmers using semi-intensive production for national food security?

Small-scale aquaculture, which has now become the most popular term, clearly requires redefining.

Towards better definition

At an earlier FAO workshop on small-scale aquaculture in Nha Trang, Vietnam, it was recognised as a continuum between 'Type 1' and 'Type 2' of rural aquaculture (Bondad-Reasanto and Prein, 2009). Common elements characterising this definition of small-scale aquaculture were ownership of or access to an aquatic resource, ownership by family or community and a relatively small size of landholding. However, the working SSA definition did not address the issue of the boundary between SSA and medium to large-scale aquaculture, and it did not distinguish between 'owner-operator' characteristic of small-scale aquaculture and 'hired-operator' by an off-farm investor or entrepreneur which may characterise medium to large as well

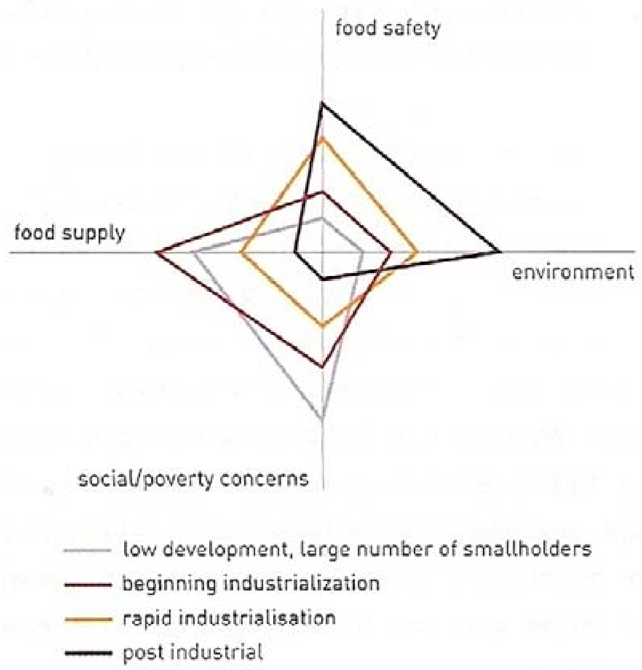


Figure 1. Changing national policy objectives with economic development. Source: Steinfeld *et al*. (2006).

as small-scale farms; while 'Type 2' small scale aquaculture is mostly based on farm labour, it does not specify the upper limit of hired labour.

It is also useful to consider the fairly recent concept of small and medium enterprises (SMEs) that bridges more commercial SSA and medium-scale aquaculture.

Ben Belton and colleagues developed a table with a spectrum of five categories of farms from subsistence to corporate-scale aquaculture in a paper on catfish farming in Vietnam (Belton et al. 2011) This I modified for the FAO workshop by adding a 6th category to specifically include 'Type 1' small-scale aquaculture. Ben accepted the six categories and further improved the table (included here as Table 1) by basing it on the concept of relations of production i.e. market orientation, investment, ownership, labour and organisation rather than scale or size (Belton et al. 2012). The discussion below is derived from the section on 'Relations of production' in the Belton et al. (2012) paper.

The typology of aquaculture is based on relations of production, a continuum of aquaculture running from 'quasi-peasant', through 'quasi-capitalist', to fully capitalist relations of production. The term quasi-peasant refers to farming systems in which the household controls the means of production (most importantly ponds) and organises the labour necessary to utilise them productively based on kinship (as opposed to market) relations. The household owns the fish and may

Quasi-peasant, tilapia monoculture, Nepal.

Quasi-capitalist, striped catfish monoculture, Bangladesh.

consume it or sell some or all of it in the market. Consumption of fish, or of the cash incomes derived from sales of fish, helps to sustain the household. Quasi-peasant aquaculture thus contributes to the maintenance of the household unit as both a biological and economic entity by continuous recirculation of resources but creates no additional surplus value. The term 'quasi-capitalist' refers to farm operations that have started towards becoming capitalist by scale expansion and hired labour but are still predominantly family run enterprises with no reliance on outside investors. Quasi-capitalist operations thus combine the use of labour based on both kinship and market relations and are thus able to accumulate some surplus capital through the exploitation of wage labour. The surplus capital may subsequently be used for reinvestment in expansion, intensification, or diversification. Capitalist aquaculture tends to result in substantial or complete delinking of farm operations from the household economic unit, with increasing levels of professionalisation and corporatisation. As intensity rises and production becomes more capitalised, fixed costs, operating costs and demand for labour all increase, marking a shift from quasi-peasant to quasi-capitalist and, finally, capitalist relations of production. Aquaculture becomes increasingly delinked from agricultural livelihoods as ever-more intensive culture systems and capitalist relations of production are developed. Market entry by entrepreneurial investors and, in some instances, vertically integrated agribusinesses, occurs. Markets tend to expand beyond the immediate locality of the farm to wider national and international markets.

Numbers of small-scale aquaculture

It is commonly stated that aquaculture in Asia is predominantly small-scale e.g the 'great bulk of aquaculture farming systems in Asia are small-scale' (De Silva and Davey, 2009); and aquaculture is 'at large a small-scale farmer driven

Quasi capitalist, giant gourami monoculture, Indonesia.

production sector ....production remains predominantly Asian and is still largely based on small-scale operations' (Subasingh, Soto and Jia, 2009). Data to support such views are lacking as national governments provide FAO only with total farmed area and number of farms. Furthermore, estimations based on average size are not statistically valid as aptly described by a quotation from Grigg (1966): 'to ask what the average size of farm is for the country as a whole is as absurd as to enquire how large are the animals in the London zoo'. Much of what is considered today to be small-scale aquaculture is probably at least small-medium enterprise, if not medium-scale. Small-scale aquaculture almost certainly dominates in terms of number of farms but not total production.

Farmer hopes and aspirations

As most farmers compare the attractiveness of aquaculture to alternative livelihood options both on-farm and off-farm, aquaculture should make money and be profitable if it is to be a significant source of income. Small amounts of fish may still be highly significant to the relatively small overall household economy of 'Type 1' small-scale aquaculture, households which are likely to derive their income from a range of on-farm activities in agriculture and livestock as well as various off-farm activities. There are probably millions of small-scale farming households with Type 1 SSA in Asia whose ponds and rice fields do not generate significant household income but they provide small amounts of fish for food and/or cash at very low opportunity cost and risk and therefore make an important contribution to poor farming households.

Developmental options have been vividly described (Dorward, 2009) as:

- "Hanging in" and barely surviving
- "Stepping up" and improving their farming system, or
- "Stepping out" and leaving the farm for the factory or the city.

'Hanging in' which characterises the poorest of the poor is clearly unacceptable and is hardly a sustainable option. Only two and three are feasible development options. Furthermore, only option two involves farming; and furthermore, farmers may choose to intensify crops and/or livestock rather than fish although integration of aquaculture with crops and/or livestock is a feasible option in some contexts.

Typology of the social and material characteristics of pond-based finfish culture (Belton *et al*, 2012)

Characteristics						
Relations of production	**Quasi-peasant**		**Quasi-capitalist**		**Capitalist**	
Production intensity	Low	Low or moderate		Moderate or intensive		Highly intensive
Capital & operating costs	Limited	Moderate	Substantial		High	Very high
Ownership & labour	Family owned & operated	Family owned & operated	Family owned & operated	Family owned & operated or absentee owner Part-time &/ or permanent labour	Family owned & operated or absentee owner Permanent labour	Absentee owner or corporate ownership Permanent labour
					Managerial staff	Professionalised managerial, technical & clerical staff
Organisation of production	Minor activity in a portfolio of livelihood options	One of a portfolio of livelihood options	Primary livelihood activity	Primary livelihood activity or entrepreneurial investment activity	Primary livelihood activity or entrepreneurial investment activity	Entrepreneurial investment activity or large business
					Possible or partial or complete vertical integration	Likely partial or complete vertical integration
Market orientation	Subsistence / local / district		District/urban / national		National/export	

Quasi-capitalist, striped catfish monoculture, Nepal.

Alternative development strategies

The aquaculture 'Blue Revolution' increasingly resembles that of the 'Green Revolution' through which the general consensus is the application of science and technology in agriculture has transformed people's lives for the better and reduced hunger and poverty. The same may be said for aquaculture although there are social and environmental issues.

So-called 'post-developmentalists' propose returning to a largely pre-modern agricultural society based on a 'self-sufficient' economy because of the adverse impact of modern 'Green Revolution' and 'Blue Revolution' technology. A major constraint is that while such 'alternative agricultural systems' are largely based on ecologically sound, traditional technology they could not produce significant yields of fish because they are usually low-input and therefore insufficiently productive. The fundamental message is 'higher productivity is likely to be the source of agricultural sustainability and not a return to the methods of the past' (Hesser, 2009). As pointed out by Rigg (2003), there is no radical alternative path to development even though major issues of inequality and environmental degradation remain to be addressed.

Technological developmental options for small-scale aquaculture

Generic technologies exist for aquaculture for both inland and coastal areas. Rather than grow-out which usually involves considerable time and expense for feed and risk until harvest-able size is reached, small-scale farmers are increasingly involved in nursing to produce fingerlings in several countries as aquaculture becomes more specialised and segmented. In contrast to grow-out, nursery is attractive to small-scale farmers because of less expenditure on feed, shorter cycles and therefore less risk and increased cash flow.

For small-scale aqaculture to become a meaningful livelihood option to provide significant income rather than only subsist-ence, there is a need to intensify aquaculture to become a small-medium enterprise (SME). The main options to achieve this are the use of off-farm inputs because the on-farm resource base is usually poor on small-scale farms. Off-farm inputs may still involve the use of fertilisers and supplemen-tary feed as in traditional aquaculture i.e., to move from direct IAA to indirect IAA, as well as the major trend of increasing use of formulated pelleted feed in aquaculture.

A major issue is the potential instability of high-input systems, especially those using modern technology, from mortality caused by poor water quality and disease. Relatively poor small-scale aquaculture farmers may also have difficulty selling their produce if markets are flooded with produce. While some small-scale farmers have 'graduated' from Type 1 small-scale aquaculture to Type 2 small-scale aquaculture/SME, others have lost everything they own through high risk modern aquaculture. There are many other adverse social and environmental impacts of modern technology that do need to be reduced, or in the words of Costa-Pierce (2002), the 'Blue Revolution must go green' with socially sustainable 'ecological aquaculture'. This should be facilitated through application of the recently published FAO technical guidelines on the Ecosystem Approach to Aquaculture (FAO, 2010).

Promotion of small-scale aquaculture

Small-scale aquaculture must be a private sector activity of farmers without project support to be sustainable. Government, NGO and international donor poverty alleviation or rural development initiatives may promote 'Type 1' small-scale aquaculture to help the poorest farming households although aquaculture would be one of several possible on-farm and off-farm income generating activities.

However, 'quasi-capitalist' forms of small-scale aquaculture may possess greater capacity to mitigate poverty, enhance food security and bring about growth than the 'quasi-peasant' forms, which have been commonly promoted for this purpose to date. Introduction of better management practices (BMPs) would help to increase sustainable production of 'Type 2' small-scale aquaculture and possibly certification to increase access to markets although this is becoming controversial (Belton *et al*. 2012b).

It is commonly believed that direct participation in aquaculture by low-income small-scale farming households has the greatest potential to alleviate poverty but it is becoming appreciated that employment of poor people in value chains associated with more capital intensive forms of fish production has a greater poverty reducing effect.

There is a shift in national policy objectives with development (Figure 1). Policy formulation is driven by concerns for poverty alleviation in countries with low levels of economic development and large numbers of small-scale farmers. As countries industrialise and traditional small-scale aquaculture is increasingly replaced by modern aquaculture and produce is exported to developed countries, and a more educated middle class develops, food safety and certification become more important.

Acknowledgement

I thank Ben Belton for helping me to make some of my statements less dogmatic.

References

Belton,B., M, M. Haque, D.C.Little and L.X. Sinh. 2011. Certifying catfish in Vietnam and Bangladesh: who will make the grade and will it matter? Food Policy 36: 289-299.

Quasi capitalist, carp and tilapia polyculture, Vietnam.

Belton, B., M.M. Haque and D.C. Little. 2012. Does size matter? Reassessing the relationship between aquaculture and poverty in Bangladesh. Journal of Development Studies. First article 2012, p.1-19.

Bondad-Reantaso, M.G. & M. Prein. 2009. Measuring the contribution of small-scale aquaculture: an assessment. FAO Fisheries and Aquaculture Technical Paper No. 534. Rome.

Costa-Pierce, B. 2002. Ecological aquaculture: the evolution of the blue revolution. Oxford, Blackwell Science.

De Silva, S.S. & F.B. Davy. 2009. Aquaculture success in Asia: contributing to sustained development and poverty alleviation. In: S.S. De Silva and F.B. Davy eds. Success stories in Asian aquaculture, pp.1-14. Dordrecht, Springer.

Dorward, A. 2009. Integrating contested aspirations, processes and policy: development as hanging in, stepping up and stepping out. Development Policy Review 27 (2): 131-146.

Edwards, P. 2009. Traditional Asian aquaculture. In G.Burnell and G.Allan eds. New technologies in aquaculture, improving production, efficiency, quantity and environmental management. pp. 1029-1063. Oxford, UK. Woodhead Publishing Limited.

Edwards, P. & H. Demaine. 1997. Rural aquaculture: overview & framework for country reviews. RAP Publ. 1997/36. Bangkok, RAP/FAO.

FAO, 2010. Aquaculture development. 4. Ecosystem approach to aquaculture. FAO Technical Gidelines for Responsible Fisheries No. 5, Suppl.4. FAO, Rome. 53pp.

Grigg, D. 1966. The geography of farm size, a preliminary survey. Economic Geography 42: 205-235.

Hesser, L. 2009. The man who fed the world, Nobel Peace Prize Laureate Norman Borlaug and his battle to end world hunger. Dallas, USA. Durban House Publishing Company, Inc.,

Martinez-Espinosa, M. 1992. Rural aquaculture, from myth to reality. FAO Aquaculture Newsletter Number 2: 13-14.

Martinez-Espinosa, M. 1995. Development of type II rural aquaculture in Latin America. FAO Aquaculture Newsletter Number 11: 6-10 .

Rigg, J. 2003. Southeast Asia, the human landscape of modernization and development. London, Routledge, Second Edition.

Steinfeld,, H. P.Gerber, T. Wassenaar, V. Castel, M. Rosales, & C. de Haan. 2006. Livestock's long shadow, environmental issues and options. Rome, FAO.

Subasinghe, S., D.Soto & J.S. Jia. 2009. Global aquaculture and its role in sustainable development. Reviews in Aquaculture 1: 2-9.

Yap, W.G. 1999. Rural aquaculture in the Philippines. RAP Publication 1999/20, RAP Publication 1999/22, Bangkok, Regional Office for Asia and the Pacific, FAO.

Azolla – an aquatic fern of significance to small-scale aquaculture

R.N. Mandal, B.K. Pandey, D.N. Chattopadhyay and P.K. Mukhopadhyay

Regional Research centre, Central Institute of Freshwater Aquaculture (ICAR), Rahara, Kolkata, PIN- 700 118.
Email: rnmandal2003@yahoo.com

In vast regions of the eastern part of India, along with Bangladesh, small scale aquaculture contributes to around 80% of fish production. Importantly, this sector is considered to be the major support for livelihood of marginal fish farmers, and also benefits traditional fish eaters who constitute nearly 100% of the population in this region across all the communities. However, aquaculture production at large lags behind its potential, in terms of the quantity of fish produced. This is due to a lack of genetically improved strains, low adoption of scientific culture practices

Tilapia harvested from fish-Azolla integration aquaculture.

related to the fertilisation of ponds, and the high cost of feed, which represents about 60% of production cost. These factors are all significant bottlenecks for improving the yield of small-scale aquaculture systems.

One way to improve production in these farming systems is to provide alternative, low-cost methods of pond fertilisation, such as through use of the floating aquatic plant *Azolla*. Proven as useful biofertiliser, already widely used in agriculture easily grown, the culture and application of *Azolla* can significantly improve the fertility of ponds at minimal cost. *Azolla* can also potentially be used as an ingredient for the preparation of feed for fish, poultry and pigs, and to make green and composted manures. The versatility of *Azolla* make it a useful candidate for inclusion in an integrated farming system involving selected horticulture, livestock and aquaculture crops. In the recent past, *Azolla* has been grown in sewage-fed aquaculture as an agent to remove nutrients from water bodies, improving water quality.

Beta carotene content of *Azolla* and common leafy vegetables (after Gopalan *et al*., Nutritive value of Indian Foods, 2007, NIN, pp 1-161; *Dewanji, A., J. Agric. Food Chem. 1993, 41,1232-1236)

Name of common leafy vegetables	Carotene amount (µg/100g)
Azolla pinnata	63,200
Amaranthus paniculatus	14,190
Colocasia leaves (black variety)	12,000
Colocasia leaves (green variety)	10,278
Curry leaves	7,560
Coriander leaves	6,918
Drumstick leaves	6,780
Cow pea leaves	6,702
Carrot leaves	5,700
Spinach	5,580
Amaranthus gangeticus (tender)	5,520
Radish leaves	5,295
Mustard leaves	2,622
Ipomoea leaves	1,980
Bethua leaves	1,740
Lettuce	990
Cabbage	120

Biology of *Azolla*

Azolla is a free floating aquatic fern whose foliage has an association with nitrogen fixing cyanobacteria, *Anabaenae azollae* which has capacity to fix nitrogen (N_2) directly from the atmosphere. This nitrogen remains available in the foliage, and thus *Azolla* is a good source of protein and can contribute to pond fertility when nutrients are eventually released into the pond environment on decomposition. As *Azolla* reproduces rapidly and easily, it can thus can form a very useful fertiliser for aquaculture ponds.

The genus *Azolla* belonging to family Azollaceae comprises six species, namely *Azolla pinnata, A. nilotica, A. caroliniana, A. filiculoides, A. microphylla, and A. rubra;* among which *Azolla pinnata* occupies a prominent place as biological fertiliser in agriculture, including aquaculture, in India. *Azolla pinnata* has its main axis with alternate leaves and adventitious roots at regular intervals. It forms a dense mat of vegetation floating freely on the water surface or in muddy areas and rice fields, tolerating a wide range of lighting conditions from shade to full sunlight. Even in otherwise unproductive habitats, the nitrogen fixing capability of *Azolla* leads to lush and growth, with the plant being capable of doubling its biomass in 3-10 days. In tropical rice fields *Azolla* typically forms a standing crop of 8-10 tonnes/ha on wet weight basis, fixing nitrogen at approximately 2-3 kg/ha/day. *Azolla* tolerates a wide range of conditions including pH from 4.0-9.0; temperature from 20-33˚C and humidity of 30-95%.

Production of *Azolla* using different methods

Azolla pinnata has been grown in tanks using different wastes such as dairy sludge, brewery sludge and rice mill sludge. Initially, a soil base of 2.5cm was provided in each tank and was filled with semi treated dairy effluent up to 50 cm. Analysis of water showed that pH increased slightly, but biological oxygen demand, total ammonia and phosphate levels were found to decrease during cultivation, as the plants assimilated nutrients and decomposition of the substrate occurred. Application of dairy and brewery sludge in culture tanks enabled *Azolla pinnata* to be produced at around 70g /m^2/day and 80g /m^2/day, respectively.

The Central Institute of Freshwater Aquaculture, India, has developed standardised cultivation practices for *Azolla pinnata* using earthen raceways (10 m × 1.5m × 0.3m), with water supply and drainage facilities. Initially, 6 kg of inoculum was applied in each raceway, with 50g of single super phosphate fertiliser and maintenance of a water depth of 5-10cm. The harvest of *Azolla* crop accounted for 18-24kg/week. About one ton of Azolla could be harvested every week from approximately 650^2, with phosphorus input and nitrogen output ratio of 1:4.8.

Essential elements required for *Azolla* growth

Phosphorus is the most important nutrient for growing *Azolla*, and requirements have been estimated at about 0.06 mg/l/day. Apart from

Ducks feeding on Azolla

Azolla compost used in horticulture field.

macronutrients such as potassium, calcium and magnesium, micronutrients such as iron, molybdenum and cobalt are also essential for the growth and nitrogen fixation of *Azolla*. Continuous shade (light intensity less than 1500 lux) reduces the growth and productivity of *Azolla*. It grows best partial to full sunlight (50-100%). *Azolla* can withstand salinity to a maximum of about 10 ppt.

Simple method of cultivation for its large scale multiplication

A simple method of creating an *Azolla* nursery to support its large scale production is as follows:

- Prepare a nursery field with water supply inlet and outlet for managing water level.

- Water depth should be maintained at around 10cm usually and may vary depending up on the situation of the field.

- Spread around 10kg of fresh cattle dung mixed with 20 litres of water in each plot, followed by inoculation of around 8 kg of *Azolla*.

- Apply 100g of single super phosphate in three split doses at intervals of four days, as a top dressing fertiliser.

- Fifteen days after inoculation, *Azolla* can begin to be harvested. From one harvest, around 40-55 kg of fresh *Azolla* can be expected from each plot.

Composition and utilisation of *Azolla*

The proximate composition of *Azolla pinnata* is mentioned on dry matter basis: Crude protein 21.6%; ash 15.4%; crude fiber 16.6%; dry matter 6.6%; crude fat 3.8%; with a caloric value of 4.2 kcal/g and in-vitro digestibility of around 78%. The composition of *Azolla* appears to be rich because of the 21.6% crude protein with essential amino acids, including a rich source of lysine, along with arginine and methionine. Since *Azolla* is a lysine rich protein it is useful as a fresh food to animals including fish (Cagauan and Pullin, 1991).

Fish feed ingredient and food

Azolla based diets have been shown to give quite encouraging results when fed to juvenile tilapia (*Oreochromis nilotica*). Prepared diets with incorporation of dry *Azolla* meal at different rates (0, 15, 20, 30, 40 and 45) resulted in better growth for tilapia, although the benefit plateaued at 15% inclusion. This benefit might be further improved if *Azolla* was mixed rice bran, yeasts or purified enzymes to improve its ingestion and digestibility. Grass carp (*Ctenopharyngodon idella*) fingerlings can accept fresh *Azolla* well and have recorded satisfactory growth.

Chart 1: Steps for *Azolla* production in-situ and ex-situ

Criteria	Small scale (in-situ)		Large scale (ex-situ)
Purpose	Nursery pond management and animal food		Bio-fertiliser and fodder
Used for	Fish	Fish and livestock	Livestock and agriculture
Fertilisers used	Using different wastes	Using chemical fertilisers	Using cow dung and chemical fertilisers
System used	Cemented tank	Earthen raceway	Open field
Plot size	5m x 1.5m x 0.3m	10m x 1.5m x 0.3m	1 hectare (0.3-0.5m depth) With outlet and inlet facilities
Plot preparation	2.5cm soil base	Existing bottom soil	Existing bottom soil
Plot fertilisation	50cm filled with semi-treated effluents (dairy and brewery)	5-10cm water depth With 50g single super phosphate	5-10cm water depth Sprinkling of 20 litre water mixed with 10kg cow dung along with 100g single super phosphate
Inoculation of *Azolla*	3kg	6kg	8kg
Harvest after 15 days	5-7kg/week	18-24kg/week	40-55kg

Carotene content of Azolla

Azolla is a major source of β-carotene content when used fresh, and has a relatively high β-carotene content when compared to leafy vegetables. Importantly, the β-carotene content of leaf protein is considered a major source of provitamin-A which has been used for treatment of cancer and respiratory diseases.

Integrated rice-fish-*Azolla* farming system

Three components such as rice, fish and *Azolla* can be combined in farming system based on their compatibility. To gain the maximum production benefit from this approach, one has to design a layout wherein each of the components contributes to the overall productivity of the system without hampering ecological equilibrium. *Azolla* being a bio-fertiliser, can enrich habitats through fixation of nitrogen and recycle other matter which altogether can promote plankton populations, benthic density, periphyton growth and to some extent growth of macrophytes. All these biota can be utilised as food by different species of fish occupying different feeding niches. Fish wastes and nutrients contributed by *Azolla* can also improve the environment for rice cultivation. In this ecosystem fish play an important role to protect rice plants and *Azolla* from a number of insect pests.

Physical set up

Cagauan and Pullin (1991) have described one physical set up for rice-fish-*Azolla* integration. A peripheral channel in the rice field, 1.0m depth × 1.5m wide connecting several lateral channels of 0.5m width and 0.5m depth. Depending on the size of the rice field, lateral channels may be dug at 15-20 m intervals in single or rib-shaped patterns. In India, rice fields of 0.2 ha have been provided with trenches 0.5 m deep and 0.5 m wide, with a main channel 1.0 m deep and 1.5 mm wide (Shanmugasundaram and Ravi, 1992). The trenches and main channels should occupy about 10-15% of the rice field. Trenches serve as links for the fish from the main channel to rice field area and also as growing area for *Azolla* during the paddy cultivation period.

Cultivation procedure

Inoculation of *Azolla* at 4.5-6.0 tons/ha is applied in the field. *Azolla* biomass is then ploughed in, followed by addition of inorganic fertiliser 20 days before rice transplantation. *Azolla* acts as manure. When the field is again flooded, residue of *Azolla* float, grow and serve as fish food. Additional feed is required when *Azolla* mass remains insufficient in the channel and trenches. Nile tilapia among other fish species is ideal for culture in these rice-fish-*Azolla* systems. Other suitable species include common carp, Indian major carps and Java barb. Grass carp may not be a suitable species for this system, as they may damage the rice crop by feeding on its leaves.

Stocking density of fish

The stocking density of fingerlings is recommended at 6,000/ha, with individuals of around 20g in size. Usually, catla, rohu and mrigal are stocked as 1:1:1 ratio. *Azolla* can be applied twice at 2.0 tons/ha. Fingerlings can feed upon both fresh and dried *Azolla*. Dried *Azolla* @ 5% body weight (BW)/day can also be incorporated in a supplemental fish feed. The formula of this supplementary feed includes *Azolla* (50%), rice bran (15%), chicken manure (10%), corn meal (5%), sorghum meal (5%), broken rice (2.5%) and groundnut cake (2.5%). The provision of fish in this system reduces yield of rice by 300 kg/ha. However, this loss is compensated with fish production and overall the system is more profitable.

Sewage-fed aquaculture

The best way to harness sewage water is to reduce, recycle and reuse; in this respect aquaculture is one suitable application where sewage water can be utilised through biological treatment. The agents that can treat biologically sewage water include aquatic plants among which *Azolla pinnata* is a very good candidate as mentioned earlier. In particular, *Azolla* has the capacity to absorb a huge amount of phosphorus from sewage water and thus is a useful supplement to phytoplankton growth, followed by herbivorous fish culture.

Azolla is well known to farmers as a useful bio-fertiliser especially in agriculture. Nevertheless, its other potential uses such as a feed, green or composted manure have many applications in aquaculture as well, although it is not yet widely utilised by the fish farming community due to limited publicity. To overcome this bottleneck the potential applications and benefits of Azolla need to be more widely disseminated amongst farming communities.

Monitoring quantity and quality of striped catfish pond effluent

Peter G.M. van der Heijden[1], Marnix Poelman[1], Roel Bosma[1] Nhut Long[2] and Vo Minh Son[3]

1. Wageningen University & Research, Wageningen, the Netherlands, 2. Can Tho University, Can Tho, 3. Research Institute for Aquaculture No. 2, Ho Chi Minh City.

The production of striped catfish (Pangasianodon hypophthalmus) and other fish species in ponds has several possible impacts on the environment, one of which is caused by the discharge of pond waste water (effluent), which is enriched with nitrogen and phosphorous compounds as result of feeding and fish faeces. To restrict the impact of effluent on the environment, organisations such as the Global Aquaculture Alliance (GAA) and the World Wildlife Fund (WWF) have recently started certification programs that have defined standards for fish farms that strive to produce responsibly, which include limiting the impact of the fish farming activity on the surrounding open waters. This article reports the results of a study in which pangasius pond effluent quality and quantity were monitored with the objective to develop simple but still scientifically reliable methods to assess the impact of pond effluent on the waters surrounding the farm. We found that the procedures for monitoring influent and effluent have great influence on the results of the assessment of the impact and of the pond's nutrient balance.

The standard for striped catfish production programme of the GAA, the Best Aquaculture Practices programme, states that pangasius farms should discharge effluent with a total ammonium nitrogen (TAN) content of less than 5 mg/l, and that this level should be reduced to 3 mg/l within 5 years after a certificate was issued. In case the source (inlet) water has already TAN levels higher than 5 mg/l, the TAN level of the pond outlet water should not be higher than the TAN level of the inlet water. The standard for pangasius farms of the Aquaculture Stewardship Council (ASC), the programme that was set up by the WFF, is less absolute and compares the levels of outlet water with the levels of inlet water. It states that the average difference between the total nitrogen (TN) level and the total phosphorous (TP) level of the effluent and of the source water should not be more than 70% for the TN and 100% for the TP level.

To stimulate efficient use of the water (and reduce quantities of waste water released) the ASC standard includes a maximum water use of 5,000 m^3 per ton of fish produced.

To find out in practice what the data collection required by these standards would entail for fish farmers participating in these programmes or for organisations charged with control of the compliance, we executed a basic monitoring programme on four pangasius farms situated in three provinces of the Mekong Delta of Vietnam. Partial water replacement is common practice in pangasius production ponds.

The study had the objective to see if the impact of the partial water replacement on the surrounding waters could be assessed with simple, but still robust methods. The four farms that participated in this study were selected by staff of the Research Institute for Aquaculture No. 2 (RIA 2) and the Department of Freshwater Aquaculture of Can Tho University from the farms they had worked with earlier. All four farms were relatively large (> 5 ha water surface). Three ponds were monitored on each farm. Data on pond size and depth, stocking, amount and protein level of the feed provided, and harvest were obtained from the records kept by the farm managers. A stationary measuring stick was placed in each pond to record water level changes. The dates or the frequency of partial water replacement and subsequent water level changes of the ponds as result of water discharge and refilling were recorded daily by the farm managers. Staff of RIA 2 and Can Tho University visited the farms on a monthly basis for 6 months in the 2010 growing season to discuss progress and collect the records. During these visits the staff took two samples from the source water at the pond inlet, and three samples of the effluent water of each pond that was monitored in this study. The source water was sampled at the beginning and towards the end of the period the water was let into the ponds. The pond effluent was sampled at the beginning, in the middle and towards the end of the draining period.

For logistical reasons all sampling took place during one farm visit and drainage water data reported in Table 2 were taken on the same day before the incoming water was sampled. Draining lasted between 0.5 and 2.5 hours and took place only once or twice per month in the early stage of the production cycle. During the last months of the production cycle the frequency of partial water replacement increased to daily. A total of 30 water samples were taken from each pond (360 samples in the whole study). The water samples were analysed in the laboratories of RIA2 and Can Tho University. The total nitrogen (TN) and total phosphorus (TP) content of all samples was determined using standard titration and spectrophotometric methods.

Measuring stick to record water level changes during draining and refilling.

Results

Table 1 summarises the information on the ponds as well as the data on stocking, harvest and feed for the monitored production cycle. The method used to estimate the water quantity passing through the ponds (with a stationary measuring pole and daily records of water level changes after discharge and after refilling) worked well as long as the records were kept in detail. Farm C had a water management regime that was different from the other farms and it was difficult to reliably estimate the volume of water that was exchanged. Hence for farm C no estimate of water use per kg of fish harvested are included in Table 1. Of the other farms, two had an average level of water use per ton of fish produced that was within the ASC standard of 5000 m^3 per tonne of fish produced.

The samples taken from inlet (source) water and from the pond effluent showed significant variability, not only between farms and ponds but also within one period of pond filling or discharge. This observation is illustrated in Table 2, which has a selection of data taken from all four farms and over a number of months. The standard deviation of the total nitrogen content of the three samples taken at the outlet of one pond within one partial draining was over 100% in 44% of the cases.

Even with the reported high variability one expects that the average total nitrogen and total phosphorus level of the pond effluent would be higher than the levels of the inlet water on the same day, as result of feed provided to and waste generated by the fish. But in 33% of the cases the average total nitrogen level in the source water was higher than the average levels in the samples of pond effluent taken on the same day. One could expect such to be the case more often in the earlier stages of the production cycle, when biomass of fish in the pond and quantities of feed provided are relatively low and water exchange is still minimal. Sedimentation and biological turnover in the pond would explain a lower total nitrogen and total phosphorus level in the effluent. However, in this study there was no trend to more or greater positive differences between nitrogen and phosphorus levels of the effluent and the levels of the source water towards the later stages of the production cycle.

Discussion on water use per kg of fish produced

The average water use per kg of striped catfish produced as established in this study is in line with estimates by Verdegem & Bosma (2009) of global freshwater water use by aquaculture enterprises. These authors estimated the average system-associated water use of global aquaculture at 15.2 m^3/kg. This estimate includes losses resulting from evaporation (5.2 m^3/kg product) and infiltration (6.9 kg/m^3) and drainage and recharge (together 3.1 m^3/kg). The latter value is close to average water use resulting from drainage and discharge of striped catfish ponds as reported in this study (3.84 m^3/kg). The efficiency varies greatly between

Table 1. Dimension of ponds that were monitored, average stocking and harvest data, feed conversion ratio (FCR) and water exchange per kg fish produced. Except for the last row the data are averages of the three ponds per farm that were monitored.

Farm	Pond surface (m^2)	Pond volume (m^3)	Weight fingerlings (kg)	Number of fingerlings stocked	Production cycle (days)	Fish harvest (kg)	Individual weight (kg)	Survival %	FCR	M^3 of water exchanged per kg of fish harvested (St. dev)
A	1473	6,119	1,633	85,692	197	49,182	0.98	58.3	1.69	2.18 (0.22)
B	3496	12,720	2,309	109,696	192	75,748	0.96	72.3	1.59	3.08 (0.38)
C	7606	32,738	36,791	613,643	206	352,280	0.96	61.5	1.87	
D	4800	19,333	6,970	299,949	245	165,330	0.82	69.0	1.68	6.27 (1.69)
Average of all ponds	4287	19142	10299	263974	206	157612	0.93	66	1.69	3.84 (2.02)

Table 2. Selection of data of inlet water and effluent to demonstrate variability.

Farm, pond No.	A, 2	A, 2	B, 2	B, 2	C, 3	C,3	D, 3	D, 3
Month of sampling	August	November	October	December	May	September	May	September
TN (mg/l) just after start of refilling	10.759	2.628	3.379	5.159	7.01	5.04	126.09	10.93
TN (mg/l) towards end of refilling	14.104	1.367	2.263	3.877	40.63	5.88	189.42	8.41
TP (mg/l) just after start of refilling	1.445	0.288	1.34	0.217	1.495	1.035	0.955	4.990
TP (mg/l) towards end of refilling	3.645	0.015	0.365	0.481	12.955	5.765	3.150	1.830
TN (mg/l) just after start of draining	8.374	1.448	3.624	3.725	120.49	8.41	10.65	12.89
TN (mg/l) in middle of draining period	15.469	2.735	3.104	4.457	16.81	4.76	16.81	12.05
TN (mg/l) towards the end of draining	7.669	3.464	7.099	2.859	168.12	7.01	99.75	12.89
TP (mg/l) just after start of draining	0.477	0.036	1.337	0.453	7.635	2.530	1.335	4.165
TP (mg/l) in middle of draining period	2.753	0.395	0.597	0.454	3.025	2.980	2.835	3.830
TP (mg/l) towards the end of draining	0.529	0.396	0.665	0.343	6.150	3.235	1.070	4.070

country and production system and depends much on the fish production per unit area. The results reported in this study are also similar to the results of a water use study in two intensive tilapia farms in Egypt. These farms applied aeration and partial daily water renewal and had an average water use of 2.7 and 3.1 m^3/kg fish produced (Heijden, Nasr Allah & Kenawy, 2011).

Recommendations for farms and institutes taking part in certification programs

If partial draining and refilling is common practice and the total amount of water used in a fish production cycle has to be known, the method of placing a measuring stick in each pond and detailed recording of the water levels before and after draining and refilling on a daily basis will work well. To calculate the volume one needs to know the exact dimensions of the pond and take the slope of the dam into consideration. Conclusions regarding the relative nitrogen and phosphorus level increase as result of fish culture activities that are based on the analysis of one sample taken from the source water and one sample taken from the pond effluent are not sufficiently reliable. Our study has shown that nitrogen and phosphorus levels of both inlet water and effluent fluctuate without a pattern or trend, and chance would determine to a large extend whether the difference between total nitrogen or total phosphorus levels of inlet water and effluent would be positive or negative. More study is needed to work out the exact details of a protocol for a relatively simple but reliable sampling procedure.

At this stage we recommend that samples of equal size are taken at least three times during a period of draining and refilling, and samples should be evenly distributed over a period of draining and refilling. Samples taken during one draining or refilling period can be pooled prior to analysis.

In case the source of water of a fish farm is influenced by sea tides, the influence of tidal fluctuations on water quality should be taken into consideration.

For a correct assessment of the impact of the fish culture activity one should compare the total nitrogen, total phosphorus or other compound levels of a water sample taken at the pond inlet with the levels of effluent samples taken during the next drainage period.

Because the procedures for sampling and storage as well as the number and timing of the samples affects the reliability of the outcome, it is recommended to carefully instruct the farm staff in these matters.

The number of farms entering certification programmes is expected to increase. Analysis of water samples on a regular basis in a well-equipped laboratory with trained personnel is a requirement but it does bring costs. Laboratories in provinces and districts with concentration of fish farms may have to be assisted to build the capacity required for analysis of the number of samples expected to be delivered to the laboratory.

References

Heijden, P.G.M. van der, Nasr Allah and D. Kenawy (2011). Integrating fish farming and agriculture: monitoring Egyptian experiences (in press).

Verdegem, M.C.J. and R.H. Bosma (2009) Water withdrawal for brackish and inland aquaculture, and potions to produce more fishponds with present water use. Water Policy 11, Supplement 1: 52 – 68.

Feeding strategies adopted by fish farmers in Andhra Pradesh, India

Saravanan, K., Antony Jesu Prabhu, P and Biju Sam Kamalam, J.

Central Institute of Fisheries Education, Mumbai, India.

In India, the state of Andhra Pradesh stands out in aquaculture practices; it ranks first in both coastal and inland aquaculture production in the country. The fish farmers of Andhra Pradesh adopt some unique practices in seed production, nursery rearing, grow-out culture, feeding practices. The feeding strategies adopted by the fish farmers play an important role in maximising the nutrient availability as well as determine the success of the culture economically. Specifically defined feeding strategies have to be adopted to minimise feed wastage, nutrient loss by leaching and to maximise growth. Andhra Pradesh remains a pioneering state in Indian aquaculture because of the innovative thinking and entrepreneurial approach of its fish farmers. They have developed their own successful feeding strategies without scientific knowledge, which in turn has boosted their aquaculture production. In this article, we brief some of the unconventional feeding strategies employed by the fish farmers of East Godavari, West Godavari and Krishna Districts in Andhra Pradesh, India.

Stunted yearling.

Specific feeding strategies

Carp culture

The mainstay of carp culture in Andhra Pradesh are the Indian Major Carps, namely catla, rohu and mrigal. There are also to a lesser extent culture of Chinese carps such as silver carp, grass carp and common carp. Most of the fish farmers in India feed carps with mash feed made up of rice bran and oil cake either in dough or powder form in the ratio 50:50; de-oiled rice bran is mostly preferred over raw bran due to lower price. Among oil cakes, either groundnut oil cake or mustard oil cake or cotton seed cake is utilised depending on their seasonal availability and cost effectiveness. The fish farmers in Andhra Pradesh also utilise the same ingredients but the ratio they apply makes them stand out from the others. On an average, they provide 70-80% of de-oiled rice bran and 20-30% of oil cake, since oil cakes are much costlier when compared to de-oiled rice bran. By adopting such feed management practices they increase their profitability by cutting down the production cost considerably without compromising on the production capacity and FCR. The phenomenon of the protein sparing effect of carbohydrates is exploited by increasing the level of rice bran and reducing the level of oil cake in the feed. They feed at a rate of 7- 10 % of the body weight per day initially and then as the fish grows the feeding rate is gradually reduced to 2-5 % per day. This is due to the fact that juvenile fish require relatively more energy for metabolism per unit body weight than adults; this is scientifically termed as the scaling effect. Another reason attributed to this difference in feeding rates is that the juveniles have the potential to grow faster than adult fish, hence the early life stages of fish are provided with higher ration of feed than the later stages. These facts are accounted for along with increased feeding frequency since the fishes can't feed more in a single time since the carps lack a true stomach.

Pangasius culture

In recent times apart from carp culture some of the fish farmers in Andhra Pradesh have initiated *Pangasius* culture, which is an exotic catfish. *Pangasius hypopthalmus* is the main candidate species that is cultured with great success in Andhra Pradesh. Pangasius culture is not yet legalised in India but it has a market demand in par with carps in certain parts of the country. If legalised, more and more farmers will enter pangasius farming. The voracious and omnivorous feeding nature of *Pangasius hypopthalmus* is the main characteristic feature that has attracted the fish farmers to culture it and also it fetches a good market price. This naturally allows the fish farmers to incorporate an increased ratio of plant based materials in the feed especially during early life stages. De-oiled rice bran, broken rice, maize, pulses, sugarcane jaggery and defatted silk worm pupae are commonly used as feed ingredients depending on the seasonal availability and cost. Generally, commercially avail-

Tying of feed bags.

dykes or with the help of small boats based on the size of the pond; broadcasting is done twice a day. They report an FCR of 1:1.2 to 1:1.5 with the use of commercial feed pellets. Also the water quality deterioration is much less with the use of commercial pelleted feeds when compared to mash feed.

Unique feeding strategies

There are some unique practices followed by the Andhra fish farmers in feeding and feed management based only on their experience. These practices make them the pioneers of fish culture in India. Some of the practices are briefly discussed below.

able floating pellets are used in grow-out culture. The feeding rate follows the same trend as for carps, upto a size of 5g the feeding rate is 10% of body weight, 5-20g the feeding rate is 8%, 20-200g the feeding rate is 6% and from 200g onwards the fishes are fed at 4% of body weight. Feeding is done twice a day, in the morning and evening respectively.

Common methods of feeding

Bag feeding

Fish fed to satiation through demand feeding shows higher growth rate in terms of weight gain and protein gain. This principle is effectively exploited by these fish farmers based on their experience and keen observation. Mainly for carps they practice a different type of feeding termed as "bag feeding" in which, the semi-moist mash of feed ingredients are filled in perforated bags and suspended in the water column by tying it to bamboo poles. The fishes feed by nibbling through the holes of the bag upto their satiation level, thus avoiding over feeding and thereby reducing pollution of the pond water to a greater extent. The bags are replenished with the mashed feed twice a day, in the morning and evening respectively. The number of feed bags that has to be provided ranges from 20-25 per hectare and the FCR ranges from 1:2.5 to 1:3.5.

Broadcasting

A section of the fish farmers of Andhra Pradesh also use commercially available feeds since the cost of feed ingredients fluctuates frequently. The available feeds are either sinking or floating type; mainly sinking feeds are used for carps, whereas floating feeds are used for *Pangasius*. The market price of the available pelleted feeds ranges from Rs.18-24/kg of feed. The feed pellets are broadcast from the

Stunted yearling production

The concept of stunted yearling production for better growth rate and for minimising the culture period was introduced in India by the fish farmers of Andhra Pradesh. They stunt the fingerlings for a period of 10-12 months by maintaining them in high stocking densities and feeding them at a rate of 2-3% of their body weight, just for their survival and not for growth. On an average the stunted yearlings reach a size of 100-150g. The concept behind the production of stunted yearlings is that later when they are stocked in production ponds they will grow faster due to the phenomenon of compensatory growth and reach a marketable size of 700-1000g within 6-8 months. Although there is a lapse of one year for the stunted fingerling production this negative factor is overcome by the production of a greater number of yearlings due to high stocking density, higher growth rate in grow-out ponds and subsequent reduction in the culture period and feed cost.

Gelatinisation process.

Feeding enclosure.

Stop feeding

These farmers employ a simple feed management practice of not feeding the fishes at regular intervals. Generally, the fishes are not fed one day in every ten days and this allows the farmers to eliminate the cost of feeding for that particular day and ultimately the cost of production is cut down significantly. This practice of stop feeding is scientifically well supported by the fact that starvation and subsequent feeding enhances feed intake and improves growth rate through compensatory growth mechanism.

Break feeding

One of the basic principles in feed management is that an increase in the feeding frequency will lead to a uniform size of the population. When the total feed ration per meal is applied at a single time, the larger fishes or shooters dominate and consume most of the feed and the relatively smaller fishes only get the leftovers. This leads to largely unequal size of fishes during harvest which affects the market price of the produce. To solve this problem these farmers have devised a new technique known as break feeding in which the ration for each meal is split into two portions and applied at an interval of 20-30 minutes. The dominant fishes are fed to their level of satiation by the first portion, so that the smaller fishes also get to feed to satiation from the second portion of the ration and this helps to minimise size variation at harvest.

Feeding enclosures

The fish farmers are so concerned about every single penny they invest in the farming. This is the reason why some of them maintain a feeding enclosure in each pond while using floating pelleted feeds. The feeding enclosure is a small area in the centre of the pond enclosed on all sides by netting which extends one foot above and below the surface of the water column and is fixed in place using bamboo poles. The floating feed pellets are broadcasted only inside this netting enclosure to ensure that the pellets do not drift and accumulate in the shoreline of the pond due to wind action. In this way the feed is made easily accessible to the fishes in a specific area where the fishes can aggregate and feed, thus preventing wastage of feed.

Gelatinisation

Gelatinisation is a process by which the bound starch granules in some plant based feed ingredients is converted into an easily digestible and more bio-available form by means of cooking. Some of the fish farmers in Andhra Pradesh practice a method of cooking broken rice and feeding it to the fishes as a mash mixture in feedbags simply based on the common sense that cooking improves digestibility and thereby enhances growth.

Feed bags installed in a pond.

Mixed feeding schedule

This is another cost cutting measure followed by the fish farmers of Andhra Pradesh without compromising on the growth of the fishes. They alternatively feed the fishes with diets containing high and low protein percentage while using pelleted feeds. In case of farm made mashed feeds, they substitute the protein supplementing ingredients regularly based on their seasonal availability and market price fluctuations. This mixed feeding schedule not only helps in reducing the production cost but also reduces the negative environmental impacts.

Farmer specific feed

The most recent trend in Andhra Pradesh is the specific preference of the fish farmers. They make their own feed formulations based on their economic state, technical need and even decide the required water stability of the feed pellets. Feed manufacturers produce the feed based on these farmer specific requirements, provided the order is sufficiently large. But the farmers do not take into consideration the factors such as the nutrient profile of the soil, fertilisation rate applied, natural productivity of the pond etc. which should be accounted for in the formulation of a diet specific for their culture system. If these flaws are addressed it would help them in decreasing the production cost even further.

Conclusion

The good old adage "Necessity is the father of invention" have been proved time and again by the fish farmers of Andhra Pradesh, India. Driven by their necessities, these fish farmers have developed their own strategies with respect to seed production, nursery rearing, grow-out culture and feed management. With their vast experience, observational skill and courageous attitude they have demonstrated success to the fish farming community of the country.

Hatchery techniques applied for the artificial production of snout otter clam (*Lutraria rhynchaena*) in small scale farms in Nha Trang City, Vietnam

Micciche Luca[1] and Doan Xuan Nam[2]

1. Lucamicciche Department of earth and sea sciences, University of Palermo, Italy;
2. Faculty of Aquaculture, Nha Trang University, Vietnam

Some specimens of snout otter clams Lutraria rhynchaena.

Even if Nha Trang city, in Vietnam, has the look of a big touristic city with its beautiful beaches and landscapes and its big hotels scattered along the city coast, the surrounding area is characterised by the presence of a great number of small scale hatcheries producing shrimp, finfish, crustaceans and molluscs. All these products are often bought by other Vietnamese plants.

In this area of Vietnam the increased tourism and also aquaculture, in particular hatcheries, play a decisive role in the economic development of the entire country, creating employment for a large number of people and engaging research centres and universities.

After my first contacts with Dr Pham Quoc Hung, Head of the Aquaculture Department, University of Nha Trang, he invited me to write a review about a species recently introduced to

Nha Trang, Vietnam. Beaches and landscapes.

Snout otter clams average market size.

Vietnamese aquaculture production, the snout otter clams (*Lutraria rhynchaena*). I was very excited to work on this subject, since the culture of new species was one of my research interests during my work in the University of Palermo, Italy.

During my research and field work, I was accompained by Mr Doan Xuan Nam, aquaculture lecturer in Nha Trang University, associated owner and expert on small scale hatcheries of snout otter clams in Nha Trang.

The snout otter clams

Lutraria rhynchaena (Jonas,1844) is a bivalve species distributed in high salinity waters. Members of this genus have large, elongated oval shells with two equal sized valves. The anterior end is somewhat sharply curved but the posterior end is more rounded.

The valves gape slightly at both ends, more so at the posterior end. The shell is fairly thick and is sculptured with fine concentric lines corresponding to periods of growth. The basic colour is white and the periostracum is brown, but the latter is usually abraded. The interior surface of the valves is glossy white. The beaks are blunt and situated slightly closer to the anterior end. The ligament is small and largely internal. The foot is small and the siphons are long and are housed in a single sheath for most of their length. The average diameter of the animal is about 20 cm with an average weight of 70 g.

Their habitat is characterised by a salinity range from 17-48‰ and temperature from 12-37°C. According to research, snout otter clams are distributed in some Asian countries such as China, Thailand, Philippines and northern and central Vietnam.

This is a species of high economic value. Its meat is fragrant, delicious and rich in protein. However, the resource is declining due to excessive fishery exploitation (Spry, J.F. 1964; Beu A.G. 2006; Huber M. 2010).

In Vietnam, according to the season, average market price for this bivalve is around 100,000-140,000 VND/kg. In restaurants the average price is about 200,000-240.000 VND/kg.

Broodstock.

Hatchery production techniques

Mr Vu Trong Dai, lecturer in Nha Trang university and expert in mollusc production in Vietnam, says that production of snout otter clams in Vietnam started about seven years ago. So, even if the adopted techniques are quite recent, the efficiency in production is good and accordingly producers have good income throughout the year.

Larval rearing

Hatchery production starts with broodstock selection, this is bought in markets or directly from farms.

Broodstock acclimation covers an average period of about 1 month during which animals are placed in tanks of about 4 m^3, with a sandy bottom and around 20 animals per m^3. Water exchange is maintained at around 30-50% per day, with continuous aeration.

Microalgal mix growth in lightly filtered sea water with an add of Guillard F/2.

4 m³ tanks used in the hatchery for broodstock acclimation.

15-25 days after spawning the larvae reach spat stage and are placed in other 20m³ tanks, at a density of around 5,000,000 larvae/m³ ,in which the seawater has been previously treated with EDTA @ 5ppm and with a bottom covered in 2-3 cm of 1mm filtered and washed sand. During this period the larvae move to the bottom. Larvae are fed with the same microalgae at the same concentration but during this period is added the same solution of different microalgaes used to feed broodstock. Aeration is provided by pipes placed 20 cm above the bottom and water volume is changed at a rate of 20-50% per day.

Clam broodstock are fed twice a day with a solution of different microalgae, around 250,000-300,000 cells per ml, produced in 100 litre containers with seawater lightly filtered and enriched with culture medium, usually F/2 or Walne medium.

Spawning is induced through thermal shock. Broodstock are placed in smaller container of about 120 litres with filtered seawater, containing 2-4 kg of clams (30-60 individuals). Temperature is lowered from 28-29°C to 22-23°C, for 30 minutes, using ice packs. After 30 minutes the broodstock are placed in 4m3, larval tanks, with filtered seawater, where fertilisation occurs.

After 20 hours after spawning, fertilised eggs reach D-larvae stadium. Snout otter clam D-larvae have a diameter of about 55-75µm. They are collected via a siphon and transferred to a bigger tank, usually from 4 to 40 m³, in this particular hatchery 5 m³ tanks are used, with seawater at 28-29°C and a salinity of about 28-31‰.

Farmers in small scale hatcheries usually calculate larval density based on their own experience but researchers say that the optimum of density during this stage of growth is 3 milion larvae per m³.

In the rearing tanks filtered sea water is changed at around 10-50% per day depending on the water quality and season. During this period farmer experience is fundamental to have successful production at the end of the process.

After transfer, larval feeding commences using microalgae. Usually farmers use a mix of *Chaetoceros* spp., and *Nannochloropsis* spp., but also *Isochrysis* spp., can be used to replace *Nannochloropsis* spp. Farmers buy microalgae from a laboratory located in the city and then cultivate them through a batch system. The initial concentation of microalgae is around 6 to 8 millon cells per ml. Larvae are fed twice a day with the microalgal mix at a density of about 250,000-300,000 cells per ml.

Harvesting and transfer to growing site

Larvae reach 2-3mm in size at 40-45 days after eggs fertilisation. This is the right time to collect and transfer them to the grow out site in the sea. Larvae are collected from the bottom of each tank with a 1mm mesh net. Harvesting is usually conducted at night to reduce animal stress due to temperature variations. Larvae are placed into little plastic bags with 1.5 litres of filtered and sterilised seawater and oxigen. Larval density depends on the distance to the grow out site in the sea, but the

Chaetoceros spp., and Nannochloropsis spp. cultivated in the hatchery through batch system.

20 m³ tanks used by farmer to cultivate larvae until day 45.

usual packing density is around 5,000 to 10,000 larvae per bag. If the site is really far farmers usually lower water temperature in the bags from 28 to 25°C using ice packs.

Grow out site

The grow out site consists of a platform in the sea, made of big bamboo canes, in the center of which there is usually a house for workers to stay and supervise the site, and advise farmers where necessary. Two species of molluscs are usually cultured together, in this case snout otter clams and the pacific oyster *Crossostrea gigas*.

After their arrival, larvae are placed into plastic baskets (40 x 60 x 20 cm), previously filled to about 60% capacity with fine sand filtered with a 5mm mesh. About 500 larvae are placed in each basket. Baskets are then attached to the bamboo canes and suspended at 2 metres below sea level.

Sea water in this province of Vietnam has an average temperature of 28-29°C and at this temperature larvae reach 1cm in size after 10 days and 2-2.5 cm after one month.

Finally larvae reach commercial size after 10-12 months with a size of 20 cm and a weight of 50-70g. Now the product is ready to reach markets and fulfill the desires of consumers of this delicacy.

References

Beu A.G. 2006 Marine Mollusca of oxygen isotope stages of the last 2 million years in New Zealand. Part 2. Biostratigraphically useful and new Pliocene to Recent bivalves. Journal of the Royal Society of New Zealand 36(4): 151-338.

Huber M. 2010 Compendium of bivalves. A full-color guide to 3,300 of the world's marine bivalves. A status on Bivalvia after 250 years of research. Hackenheim: ConchBooks. 901 pp.

Spry, J.F. 1964. The sea shells of Dar es Salaam: Pelecypoda *Bivalves*. Tanganyika Notes and Records.

Nha Trang night view

Crude palm oil is a sustainable alternative to the growing fish oil scarcity particularly for the aquaculture of warm freshwater fish species

Mohammed Aliyu-Paiko*[1], Roshada Hashim[1] and Alexander Chong Shu-Chien[2]

1. Laboratory of Aquafeed and Feeding Management, Aquaculture Research Group, School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia. E-mail: moleepaiko@yahoo.com. 2. Laboratory of Fish Biology, Aquaculture Research Group, School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia.

Without a shadow of doubt, fish farming continues to be the fastest growing animal food production sector in the world. Global food fish production has been growing annually at an average rate of about 7% between 1950 and 2006, the majority of which are freshwater finfish. Unfortunately, this rapid expansion of aquaculture is also known to be accompanied with its heavy dependence on added formulated feeds, since most farmed fish are stocked and reared at densities that cannot be supported by natural food. Invariably, the sustainable production of artificial feeds plays a crucial role in sustaining the continued expansion of the aquaculture enterprise, especially because fish feeds usually make up about 60% or more of the total production costs of most aquaculture production systems[1]. Sadly though, the two most dominant ingredients in fish feed are fishmeal and fish oil, both resources of which originate from marine fisheries. In other words, while aquaculture is seen as a possible solution to meet the ever increasing global demand for fish, it has also been accused to be a significant contributor to the collapse of fishery stocks worldwide[2], a trend which needs to be reversed.

In the last two decades or so, the global demand for fish meal and fish oil for aquaculture enterprises has increased steadily despite static global production levels and it is feared that the supply may be unable to meet demand in the near future. Calculations used by experts to emphasise the level of utilisation suggest that by year 2010, aquaculture could have accounted for between 80 and 98% of global fish oil consumption[3]. Recent estimates also show that the global supply of fish oil for the last 25 years was about 1.5 million tonnes per annum[4]. This emerging reality makes it very necessary for aquaculture feed manufacturers to search for sustainable alternatives, to decrease the current over reliance on these finite marine resources. Fundamentally, this is one of the reasons for the current interest within the aquaculture feed industry in evaluating alternatives to fish oil. In this case in general, vegetable oils have been reported as suitable candidates for this purpose. Furthermore, one of the best potential substitutes to fish oil among the vegetable oils used, particularly in the diets of warm freshwater fish

Photo by "Cayambe".

Photo: "Craig" (Wikimedia Commons).

species, is reported to be crude palm oil and some of its refinery products and by-products[5]. The importance of this is better appreciated in view of current trends in aquaculture production; most of the global production of aquaculture in recent times is from fresh water species, which exceed the production from mariculture and brackish water put together[1]. A reduction in the dependence of freshwater fish culture on fish oil would, ultimately exert a significant impact on the sustainability of marine fish species, many of which are reported to be over-fished, endangered or at levels that are considered unsustainable.

The principal aim of this article is to highlight and discuss the potential prospects and problems of palm-based oils as substitutes to fish oil in feeds for warm freshwater fish species, especially; Nile tilapia *(Oreochromis niloticus)*, African catfish *(Clarias gariepinus)*, iridescent shark *(Pangasius hypophthalmus)* and snakehead *(Channa striatus)*. This is to support the use of such vegetable oils for the continued expansion of aquaculture industry, as sustainable alternatives to fish oil, the supply of which continues to dwindle.

Utilisation of dietary fatty acids by warm freshwater fish

Reports of research findings in the literature support that warm freshwater fish (i.e. carps, eel, and possibly channel catfish) have requirements for both the omega 3 (n-3) and omega 6 (n-6) series of polyunsaturated fatty acids (PUFA) or for the n-6 series alone (i.e. tilapia and possibly the snakehead *Channa micropeltes*)[6] and that freshwater fish species (like African catfish *Heterobranchus longifilis*, *Mystus nemurus* and Nile tilapia *Oreochromis niloticus L*.) would normally not encounter much n-3 HUFA in their natural diets[7].

Furthermore, research findings with many fish species (Nile tilapia, African catfish, bagrid catfish, climbing perch, Atlantic salmon) indicate that vegetable oils are readily catabolised by warm freshwater fish as energy source for growth[7]. Expert opinion also support the preferential use of saturated fatty acids and monounsaturated fatty acids for energy production in the mitochondrial systems of fish, both of which are abundant in crude palm oil and some of its refinery products and by-products respectively. Unfortunately, vegetable oils in comparison to marine fish oil, are generally poor sources of n-3 fatty acids that are crucial for good growth and health of higher vertebrates, including fish[4]. On the other hand, the majority of the warm freshwater fish species studied so far are known to have the ability to "manufacture' these crucial and beneficial fatty acids like eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) when the essential raw materials required for the process are supplied in their diets.

Consequently therefore, it is quite presumable that a lot of the fish oil currently used in aquafeeds (particularly for warm freshwater fish species) might be unnecessary or wasteful, yet aquafeed producers continue to use fish oil in large quantities, probably due to familiarity with the product and/or the perception that it is the best lipid source to culture all fish species.

Photo by energie-experten.org.

Crude palm oil and its refinery products and by-products

Crude palm oil is an extract from the mesocarp of the fruit of the oil palm, Elaeis guineensis and has a deep orange-red colouration due to its high content of carotenoids. It is also a rich source of vitamin E consisting of tocopherols and tocotrienols. During refining, the carotenoids in crude palm oil undergo thermal destruction and bleaching processes to produce palm oil of desired color. The crude palm oil refining process also leads to the production of 2 by-products; spent bleaching clay and palm fatty acid distillate, both of which still contain significant quantities of valuable nutrients like lipids and vitamin E[8]. Crude palm kernel oil is also extracted from palm kernel leaving palm kernel cake as by-product. The nutritional properties and human consumption pattern of crude palm oil and its refinery products worldwide are properly reported in the literature as cooking oil, margarines and shortenings and also incorporated into fat blends and a wide variety of food products. From the trend of human consumption pattern, crude palm oil and some of its refinery products have great potentials as candidate ingredients to replace fish oil in the diets of warm freshwater fish for good growth performance and feed utilisation as discussed in the following sections.

Sustained increase in crude palm oil production in response to global demand

Whereas fish oil recorded peak global production volume of 1.481 million metric tons in 1985 and production volume has been either static or on the decline since then to a volume of 988, 000 metric tons in 2006, the global production of crude palm oil has, on the other hand been consistently on the increase in the last 25 years; from 6.832 million metric tonnes in 1985 to 36.733 million metric tons in year 2006, to become one of the most abundant oils in the world[4]. In a similar pattern, whereas the majority of marine resources (the principal source of fish oil) have been reported to be unsustainably over exploited[2], there has been consistent and sustained growth in the total land area for oil palm production over the last 10 years. For example, Indonesia (the world's largest crude palm oil producer) recorded an accelerated annual average growth of 340,000 ha per year between year 2000 to 2009 compared to 71,000 ha in the 1980's and 293,000 ha in the 1990's. Indonesia and Malaysia account for about 87% of world crude palm oil production, accounting for about 31.7 million metric tons of crude palm oil in year 2007. Considering production volume therefore, it is quite obvious that on the long run the sustained supply of crude palm oil is better assured compared to fish oil, to sustain aquaculture production.

Comparatively cheap and relatively stable price

Reports in the literature shows that the price of fish oil in North-Western European markets increased from US$314 per ton in 1999 to a record US$812 per ton in 2006 within a short 7 year span[4]. Similarly, fish oil prices worldwide skyrocketed in early 2008 (due to fluctuations in the prices of petroleum products), reaching an all time record of over US$2,000 per ton[9]. On the other hand, except for the sudden dramatic increase in the price of crude palm oil in late 2007 to early 2008, annual average price of crude palm oil per ton has generally fluctuated between US$200 to US$500 since year 2000[10]. Since the cost of feed could account for about 60% or more of the total cost of aquaculture production, the market price of a lipid source in aquaculture feeds is important to culturists, where crude palm oil has competitive advantage.

Performance of warm freshwater fish species fed diets containing crude palm oil

Since crude palm oil was first tested in fish diets, it showed great promise in the diets of freshwater fish species of different sizes. Better growth performance was observed in higher proportion in tambaqui *(Colossoma macropomum)* fingerlings fed diets containing crude palm oil than a diet containing soybean oil distillate. In separate studies, comparable growth to fish oil treatment was demonstrated in Nile tilapia when crude palm oil, palm fatty acid distillate or palm kernel oil was included in the diet. In African catfish *(Clarias gariepinus)*, positive effects on growth performance was also demonstrated when crude palm oil was included in the diet. Another warm freshwater fish species, bagrid catfish *(Mystus nemurus)* was evaluated with the inclusion of crude palm oil or its refinery product in the fish diet and positive growth results was noted. Climbing perch *(Anabas testudineus)* also grown on a diet containing palm oil performed as well as fish fed a similar level of coconut oil or cod liver oil (for detailed review, refer to[4]). In other studies in our laboratory in Universiti Sains Malaysia, we completely replaced fish oil in the diet of iridescent shark *(Pangasianodon hypophthalmus)* with three different vegetable oils and found that crude palm oil positively influenced higher growth performance. Similarly, we also noted higher growth performance in Snakehead *(Channa striatus)* fed with a diet in which 50% fish oil was replaced with either crude palm oil or palm fatty acid distillate and observed that the fish tolerates up to 50% fish oil substitution without showing any adverse effects on growth, feed utilisation and fillet fatty acids characteristics.

Although in other studies crude palm oil has been reported to be tolerated by some marine species, the results are generally not as compared to those reported for most warm freshwater species, principally because most marine species require EPA and DHA to be included in their diets.

Additional benefits of including crude palm oil in freshwater fish diets

There are several other advantages and benefits reported in the literature, to be associated with the inclussion of crude palm oil or some of its refinery products in feeds for the aquaculture of fish species. The low concentration of PUFA in crude palm oil (and its other derivatives) makes it resistant to oxidation, and in conjunction with the protective effects of its constituent natural anti-oxidants like carotenoids and vitamin E, incidences of spoilage of feeds via rancidity are substantially reduced when these oils are included in fish feeds; affording longer storage to maintain freshness and palatability.

In addition to achieving comparable (or better) growth performance, higher oxidative stability in fillets of tilapia fed a diet containing tocotrienol fraction from palm oil due to increased deposition of vitamin E in the fillets has been achieved. Similarly, increased deposition of vitamin E in the fillet, with subsequent reduction in lipid peroxidation products has been shown when African catfish was fed increasing levels of a palm oil refinery product, palm fatty acid distillate, resulting into increased shelf life of freshwater fish products. This is so because the level of vitamin E in fish muscle has been confirmed to influence the freshness and long term storage properties of fish fillets[8]. The improved growth performance with crude palm oil diets is generally known as an added benefit of improved protein retention in fish as a result of the protein sparing action of palm oil.

Very low levels of pollutants and potential toxic substances

Several survey reports and studies have shown that some aquafeed made with fish oil from marine sources are potential sources of certain harzadous environmental pollutants, such as polychlorinated biphenyls (PCBs) and polychlorinated dibenzo-p-dioxins and furans (commonly called 'dioxins') which are dangerous to consumers[11]. Most of the sources of these dangerous pollutants in the environment and food chain have been or are in the process of being banned[4]. In other developments, substitution of oils from marine sources with some vegetable oils are reported to effectively reduce or dilute the levels of these dioxins and dioxin-like PCBs and organo-chlorinated pesticides in fish feeds, adding more support to the use of crude palm oil.

Concern regarding feeding fish with lipids from vegetable sources

Several authors have expressed concern about prejudicing the health and welfare of fish and also compromising the health-promoting benefits to consumers, especially with regards to the omega-3 fatty acids content when vegetable oils (including crude palm oil) is used in fish feed. This is thought to occur due to the modification of the fillet fatty acids profile of the fish to reflect the content of the dietary sources fed. To overcome this problem, fish fed vegetable oils diets are often recommended to be placed on finishing diets containing rich sources of omega-3 fatty acids. On the other hand, some of the fatty acids in vegetable oils is reported to be resistant to 'dilution' and difficult to remove when large quantity is accumulated in fish tissues. Expert opinion regarding the vegetable oils most suited as fish oil substitutes is that; it should be high in mono-unsaturated fatty acids, contain saturated fatty acid levels similar to those in the fish being fed and contain low content of some omega-6 fatty acids, especially linoleic acid, because this fatty acid is poorly oxidised and difficult to remove using finishing diets. Among the vegetable oils commonly used in fish diets (refer to[4]), crude palm oil has relative advantage in fulfilling most of these conditions when used in the feeds for warm freshwater fish species because it has been demonstrated to have lower potential for the deposition of the undesirable linoleic acid in fish tissues compared to other vegetable oils.

Photo: Marco Schmidt.

Photo: Marco Schmidt.

Concluding remarks

So far, studies on the use of crude palm oil or some of its other refinery products as lipid source in aquafeed have been tested on only a few fish species and in different quantities. A lot still needs to be done, to fully understand and exploit the potentials of this novel and potentially sustainable lipid source in aquaculture. However, from the few studies so far conducted, warm freshwater fish species seem to be able to tolerate crude palm oil and some of its refinery products (though to varying degrees), without adverse effects on growth, feed utilisation or compromise to the fillet characteristics.

On the other hand, it is also becoming increasingly apparent that in spite of the growing inability of global supplies to the meet demand for fish oil due to continuous growth in Aquaculture production, the search for alternative, sustainable omega-3 fatty acids sources must continue, in order to ease the pressure on marine sources. This because vegetable oils alone may not be feasible to completely replace fish oil in fish diets. An improved understanding of genetic factors and developments in biotechnology could prove useful in assisting to solve this global problem.

References:

1. FAO (2009). State of World Fisheries and Aquaculture 2008. FAO Fisheries and Aquaculture Department; FAO Rome, Italy.
2. Naylor, RL, Goldburg, RJ, Primavera, J, Kautsky N, Beveridge MCM, Clay, J et al. (2000). Effects of aquaculture on world food supplies. Nature 405: 1017–1024.
3. Pike, IH and Barlow, SM (2003). Impact of fish farming on fish stocks. International Aquafeed directory 2003: 24-29.
4. Turchini, GM, Torstensen, BE and Ng, WK (2009). Fish oil replacement in finfish nutrition. Reviews in Aquaculture 1, 10–57.
5. Ng, WK, Lim, PK and Boey, PL (2003). Dietary lipid and palm oil source affects growth, fatty acid composition and muscle a-tocopherol concentration of African catfish, *Clarias gariepinus*. Aquaculture 215: 229–243.
6. De Silva, SS and Anderson, TA (1995) .Fish Nutrition in Aquaculture, Chapman and Hall, London 319 pp.
7. Bell, JG, Henderson, RJ, Tocher, DR, McGhee, F, Dick, JR, Porter, A, Smullen RP and Sargent, JR (2002). Substituting fish oil with crude palm oil in the diet of Atlantic salmon *(Salmo salar)* affects muscle fatty acid composition and hepatic fatty acid metabolism. J. Nutr. 132, 222–230.
8. Ng, WK, Wang, Y, Ketchimenin P and Yuen, KH (2004). Replacement of dietary fish oil with palm fatty acid distillate elevates tocopherol and tocotrienol concentrations and increases oxidative stability in the muscle of African catfish, *Clarias gariepinus*. Aquaculture 233: 423–437.
9. FAO (2007). State of world aquaculture: 2006. FAO Fisheries Technical Paper. No.500. Rome, FAO. 134 pp.
10. USDA (2009). Foreign Agricultural service, commodity intelligence report, March 19, 2009.
11. WHO (1999). Food Safety Issues Associated with Products from Aquaculture. World Health Organization Report of a Joint FAO/NACA (WHO Study Group).WHO Technical Report Series 883. World Health Organization, Geneva.

NACA Newsletter

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

ISSN 0115-8503

Volume XXVII, No. 1
January-March 2012

10th Meeting of the Asia Regional Advisory Group on Aquatic Animal Health

The two-day meeting was held in the Board Room of Hotel Motimahal, Mangalore, India on 19-20 November 2011. The meeting was attended by all the AG members including representatives from:

- OIE-AAHSC (Dr Barry Hill, President).
- OIE Regional Representation for Asia and the Pacific (Dr Hnin Thidar Myint).
- FAO (Dr Rohana Subasinghe).
- DAFF Australia (Drs Ingo Ernst and Brett Herbert).
- SEAFDEC AQD (Dr Edgar Amar).
- NACA (R&D Manager Dr CV Mohan and Aquatic Animal Health Programme Coordinator Dr Eduardo Leaño).
- Private sector (Dr Siow Foong Chang, Merck Animal Health).
- Aquatic animal health expert from the region (Prof. Timothy Flegel, Thailand).

Also in attendance are the Director General of NACA, Dr Ambekar Eknath, two co-opted members from Mangalore College of Fisheries Drs Indrani Karunasagar and Kalkuli Shankar, and guest participants from EU-ASEM platform project Drs John Bostock, Sandra Adams and Kim Thompson.

The meeting managed to accomplish the TOR set for the AG which includes reviewing the disease situation in Asia, considering the recent changes made to OIE global standards, revising the list of diseases for listing in the regional QAAD reporting system, assessing the progress made against the various elements contained in the Asia Regional Technical Guidelines on responsible movement of live aquatic animals, updating the regional resource centers, and developing recommendations and action points for the consideration of NACA and NACA Member Governments.

The report of the meeting, always of interest to the aquaculture industry, can be downloaded from the NACA website at the link below. The report will be tabled with member governments, regional and international organisations, including the OIE Aquatic Animal Health Sub-committee, the Food and Agriculture Organisation, the Southeast Asian Fisheries Development Center and ASEAN.

Flood

If you are wondering why NACA seemed to go a bit quiet for a while, it was largely due to the fact that our office was one of the casualties of the massive floods that affected central Thailand, including much of Bangkok, in the last quarter. The Secretariat was cut off by flood waters up to a metre deep for more than a month, and all of our staff (with the exception of the Editor) were forced out of their homes by the water, more than two metres deep in some cases, and had to find alternative accommodation elsewhere.

From time to time we get minor localised flooding for a few hours after heavy rains, but this time it was a solid wall of water trickling in from the north that just wouldn't go away. Roads and public transport shut down, power was out in many places and supermarkets were essentially emptied with no way to resupply. Boats (and the occasional crocodile) began to appear on the highways.

Finally the water was low enough to get back to the office and the clean-up began. Fortunately we had moved nearly everything upstairs in advance of the flooding, so damage to the Secretariat was minimal (if only we could say the same about houses). It will take a while longer to clear the backlog of email and to get things back to normal, but we are getting there and hope you will bear with us a bit longer.

Right: Floodwaters inundate the Department of Fisheries compound.

The first floodwaters arriving outside the NACA Secretariat.

Shrimp Price Study, Phase III: Case studies in Vietnam, Indonesia and Bangladesh

The Phase III report of the Shrimp Price Study is available for download. This study is a continuation of "Evaluation of the impact of the Indian Ocean tsunami and US anti-dumping duties on the shrimp farming sector of South and South-East Asia", a study conducted by NACA in 2006, with the aim of assessing the impact of the 2004 Indian Ocean tsunami and of the introduction of anti-dumping duties on the shrimp farming sectors of countries in the Asian region, with special focus on the effect that these unforeseen events had on shrimp prices and livelihoods of the stakeholders. The project was conducted in three countries selected as representatives for countries affected by the anti-dumping duties, the tsunami, and neither event respectively.

The first-round study, while giving an insight on the impact of the Indian Ocean tsunami and US anti-dumping, also highlighted the need for continuous collection of price data from a wider range of stakeholders in the supply chain in order to do a thorough evaluation of the health of the industry and to identify the interventions to be made to increase the sustainability of the sector. Phase II (January 2008 to June 2009) and Phase III (Current study) are follow-up studies based on the recommendations derived from the initial study. The present study is the 3rd phase of this extended study and aims to update the social and economic trends in the shrimp farming sector investigated during the previous phases.

This report is based on the data collected from the 3 representative countries, Vietnam, Indonesia and Bangladesh from July 2009 - November 2010. The report can be downloaded from the NACA website at:

http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=71&lid=1044

The Sultanate of Oman Embarks on Aquaculture Development

The Sultanate of Oman, with a coast line of 2092 km, pristine at that, and a large extent of land area is embarking on an ambitious aquaculture development program, primarily coastal, for food security and generation of employment opportunities as well as earning export income, targeting the adjacent countries in the region. The government has already taken many preliminary steps towards this development strategy and is determined to make it sustainable and environmentally friendly and most of all not repeat the mistakes that had occurred, too often elsewhere.

Among the steps taken to meet its strategic plans it has already identified coastal sites in eight regions, having taken into consideration all relevant climatic, topographical, water quality characteristics and social issues, to be allocated for aquaculture development in each, and made this information available in the Atlas of Suitable Sites for Aquaculture Projects, Sultanate of Oman. In addition, the government has custom built a state of the art Aquaculture Center, which will coordinate the envisaged activities and act as the main research provider, including demonstration units, and proceeded to formulate guidelines for prospective investors to bit for the proposed sites, spelt out in the Investment Guidelines. The aquaculture centre has proceeded to prepare and distribute information profile booklets on species suitable for the designated areas.

As a prelude the Sultanate of Oman convened the first ever conference on aquaculture, "International Conference on Sustainable Aquaculture Development in the Sultanate of Oman- Investment Opportunities", which brought together specialists in various sectors from all over the globe (Australia, Italy-FAO, Norway, US, UK, New Zealand, Vietnam etc.), prospective local and foreign investors on 10/11th of December in Muscat. The aquaculture development strategy was floated at this Conference. The Conference was presided by His Excellency the Minister for Agriculture and Fisheries Wealth, Dr Fuad Jaffer Al-Sajwani, and the government's commitment to the proposed development was most evident by the fact that his Excellency was in attendance throughout the two days of the conference and led the final discussions sessions. The keynote speaker at the conference was the former Director General of NACA, Professor Sena S De Silva, who spoke on "Current trends in commercial aquaculture in Asia & relevance to emerging aquaculture nations".

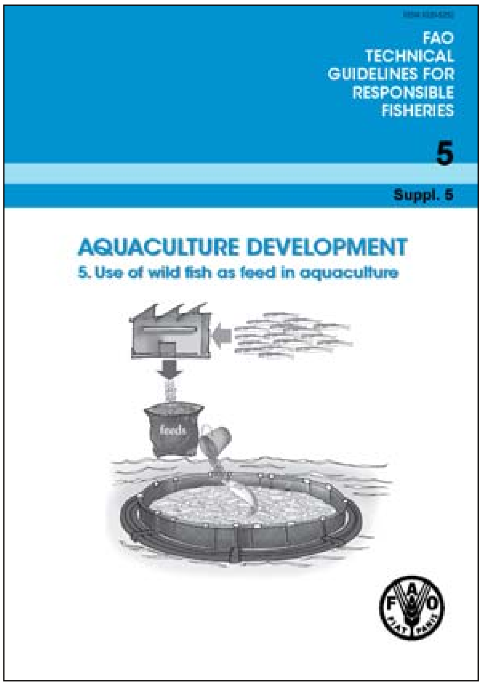
Downloads

The Atlas of Suitable Sites for Aquaculture Projects, Sultanate of Oman: http://bit.ly/Nulmxo

Investment Guidelines:

http://www.enaca.org/uploads/temporary/oman-aquaculture-investment-guidelines.pdf

FAO Technical Guidelines on Use of Wild Fish as Feed in Aquaculture



FAO has published technical guidelines on the use of wild fish as feed in aquaculture to support sections of FAO Code of Conduct for Responsible Fisheries (CCRF) addressing responsible fisheries management and aquaculture development. The objective of these guidelines is to assist those concerned to ensure both aquaculture growth and equitable and sustained use of available fish stocks. The guidelines are available for free download.

The guidelines cover a number of issues relevant to the use of wild fish in feeds in aquaculture, ranging from ecosystem and environmental impacts, ethical issues and responsible use of fish as feed, aquaculture technology and development, and statistics and information needs for management. However, issues relating fisheries management are not covered, as these have been considered within separate sets of guidelines related to fisheries management and there exist several sets of technical guidelines on the sustainable management of fisheries and several continuing initiatives to improve sustainable management of fisheries which inter alia would also apply to feed-fish fisheries.

These guidelines are intended to be flexible and capable of evolving as circumstances change or as new information becomes available. Please feel free to send your comments/observations to Mohammad.Hasan@fao.org for consideration in preparation of the next edition. The guidelines can be downloaded from:

http://www.fao.org/docrep/014/i1917e/i1917e00.pdf

FAO. Aquaculture development. 5. Use of wild fish as feed in aquaculture. FAO Technical Guidelines for Responsible Fisheries. No. 5, Suppl. 5. Rome, FAO. 2011. 79p.

New issue of Asian Fisheries Science and Asian Fisheries Society on Facebook

If you use Facebook, you may like to visit the Asian Fisheries Society Facebook Page. There is also an AFS Indian Branch page, and an AFS Gender in Fisheries and Aquaculture page.

A new issue of Asian Fisheries Science is also available for download from the AFS website (www.asianfisheries-society.org). The journal is free to all AFS members. Contents of Volume 24 (4) are:

Standardising stocking density for freshwater prawn *Macrobrachium rosenbergii* (De Man, 1879) farming in coconut garden channels

K. Ranjeet and B. Madhusoo-Dana Kurup

The effect of stocking density on the population structure, growth character-istics and production of *Macrobrachium rosenbergii* in coconut garden channels was studied. Final marketable yield structure and economics revealed that the stocking density of 15,000 ha^{-1} was optimum for coconut garden channels in Kuttanad, India.

The Lethal Impacts of Roundup (glyphosate) on the Fingerlings of Guppy, *Poecilia reticulata* Peters, 1859

W. U. Chandrasekera and N. P. Weeratunga

Investigation showed that the 24-hr and 96-hr LC_{50} for Roundup were 15.1 mg.L^{-1} and 9.76 mg.L^{-1} respectively well below the recommended field concen-tration of 2,592 mg.L^{-1}. Guppy (*Poecilia reticulta*) fingerlings exposed to all Roundup concentrations developed gill hyperplasia with severity dependent on the concen-tration used.

The Ontogeny of the Digestive Tract and Associated Organs of Humpback Grouper (*Cromileptes altivelis*) Larvae

A.B. Abol-Munafi, W. Andriyanto, S. Ismi, A. Y. Nirmala, I. Mastuti, A. Muzaki and A.W.M. Effendy

The ontogeny of the digestive tract and associated organs in humpback grouper (*Cromileptis altivelis*) larvae was observed until 40 days after hatching (DAH). The formation of the fundic stomach at 16 DAH signalled the starting point of weaning humpback grouper onto commercial pellets.

“Trash Fish” in a Small Scale Fishery: a Case Study of Nha Trang Based Trawl Fishery in Vietnam

Hai P. Nguyen, Roger B. Larsen, Hong H. Hoang

Trash fish (catch not used for human consumption) caught in the bottom pair trawling and the otter trawling fleets in Nha Trang, Vietnam accounted for 23% and 22% of the total catch respectively. Some potential measures to reduce the catch of trash fish in the fishery were discussed.

Some Approaches to Reducing Non-commercial Bycatch of Bottom Trawl Fisheries in the Western Bering Sea

A.M. Orlov

Trawl bycatch between 1995 and 1998 in the western Bering Sea was studied. The utilisation of bycatch of the commercial species into human and animal food, and the non-commercial species into fish powder was discussed.

Changes in Sperm Quality of Silver (*Hypophthalmichthys molitrix*) and Bighead Carps (*Hypophthalmichthys nobilis*) during the Spawning Seaso

MD. Mofizur Rahman, Mohammad Shgamsur Rahman and Mahmud Hasan

This study investigated the changes in spermatological parameters and biochemical composition of the seminal plasma of silver and bighead carps. The results of this study have implications in improving the quality of fish seed by improving the quality of fish sperm.

Otolith Mass Asymmetry in the Adult Indian Mackerel *Rastrelliger kanagurta* (Cuvier, 1816), Collected from the Sea of Oman

Aisha Ambuali, Laith A. Jawad and Juma Al-Mamry

As in other symmetrical fish species, the absolute value of the otolith mass asymmetry in Rastrelliger kanagurta does not depend on fish length and otolith growth rate, and has a value between -0.2 and +0.2.

Detection of *Listeria monocytogenes* from freshwater fish, prawn and chicken meat by direct nested PCR

Sanjoy Das, V.P. Singh, Keduzol Itu, S. Kathiresan, Bhaskar Sharma and K.N. Bhilegaonkar

Three different methods of processing samples from freshwater fish, prawn and chicken meat with nested PCR for the detection of *Listeria monocytogenes* were compared. The boiling lysis method could not detect the organisms from the various meat samples. The phenol extraction with enrichment method gave better sensitiv-ity than the phenol extraction without enrichment method.

Larval Settlement and Spat Growth of the Tropical Oyster *Crassostrea belcheri* (Sowerby, 1871) in Response to Substrate Preparations

S. Tanyaros and I.D. Kitt

Effects of substrate preparations on larval settlement and growth of spat of the tropical oyster *Crassostrea belcherei* were evaluated. The number of larvae that settled on substrate pre-soaked in adult tissue extracts or which has a biofilm were significantly higher than the number that settled on substrates immersed in sea-water for 2 hr.

Network of Aquaculture Centres in Asia-Pacific

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

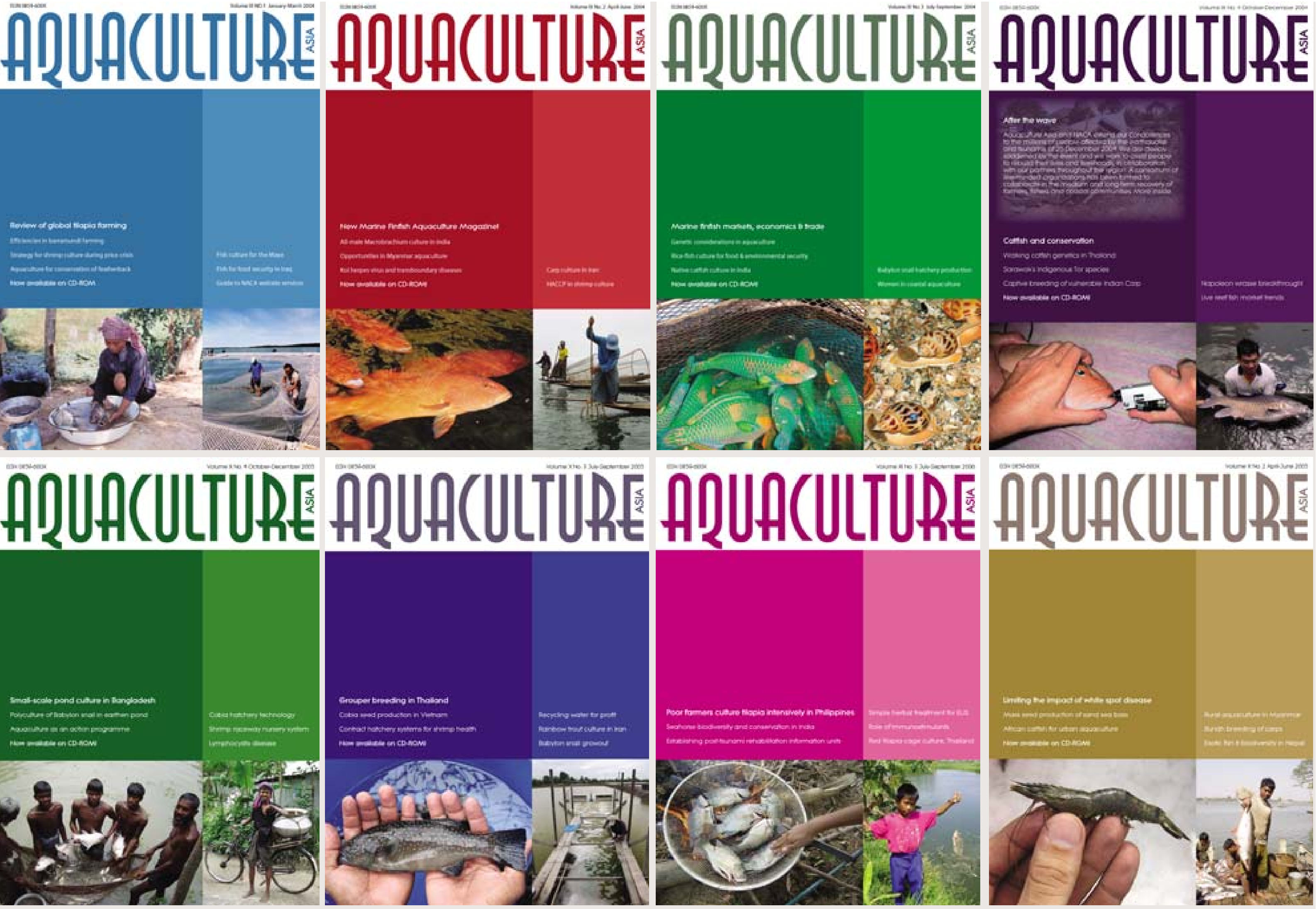
Phone +66 (2) 561 1728
Fax +66 (2) 561 1727
Email: info@enaca.org
Website: www.enaca.org

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

First Estimate of the Length–Weight Relationship of *Diaphus watasei* Jordan and Starks, 1904 Caught off the Southwest Coast of India

P. M. Vipin, K. Pradeep, Renuju Ravi, T. Jose Fernandez, M. P. Remesan, V.R. Madhu and M.R. Boopen-Dranath

The length-weight relationship of the myctophid fish species, *Diaphus watasei*, caught from waters off the southwest coast of India in the depth range of 300-400 m was estimated as males: $W=0.0026L^{3.39}$ and females: $W=0.0063L^{3.06}$.


AQUACULTURE ASIA
Review of global tilapia farming
New Marine Finfish Aquaculture Magazine!
Marine finfish markets, economics & trade
After the wave
Catfish and conservation
Small-scale pond culture in Bangladesh
Grouper breeding in Thailand
Poor farmers culture tilapia intensively in Philippines
Limiting the impact of white spot disease


AQUACULTURE ASIA
Farming carps in leased ponds, Bangladesh

Aquaculture Resources from Wiley-Blackwell

Wiley-Blackwell is the world's leading publisher in aquaculture, fisheries and fish science; disseminating the latest cutting edge research on every aspect of the industry through an extensive range of journals and books.

Recommended Reading

Reviews in Aquaculture

The first journal dedicated to the dissemination of consolidated information on aquaculture.

Ranked 3rd in the ISI® Fisheries category

Recent Advances and New Species in Aquaculture

by Ravi Fotedar and Bruce Phillips

This comprehensive, up-to-date new book delivers the latest must-have information on species new to aquaculture and documents the most important technological innovations of the past decade

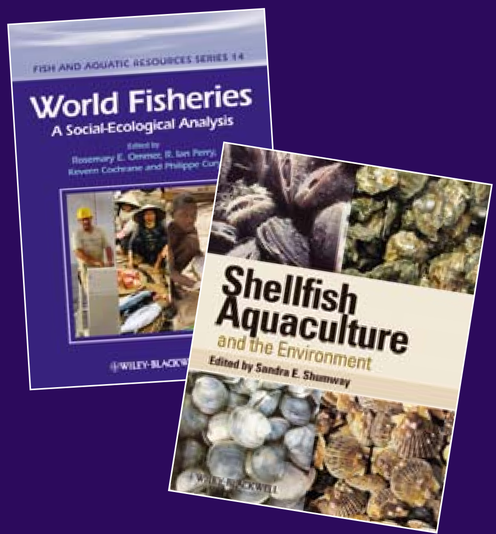
FREE 30 day trial

Activate your free trial* now and receive access to all of our aquaculture, fisheries and fish science journals.

Simply visit:
www.onlinelibrary.wiley.com/myprofile/trials and enter the trial code: **NACA11** (case sensitive)

**Please note you will need to register for a free Wiley Online Library account to activate the free trial. Trial ends 30th December 2012.*

20% discount on all books at www.wiley.com including:



Simply enter promo code **'LIFE'** at the check-out.

Visit **www.wileyonlinelibrary.com/subject/fish** for more information

WILEY-BLACKWELL

11-33902