ISSN 0859-600X
Volume VII NO.3 July - September 2002

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

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Printed by Craftsman Press

From the Editor's desk

Who wants free trade ?

Free Trade, what a great idea (try telling an economist that it's not). Trade, to quote Australia's Treasurer "is the best poverty buster we know of". According to the World Bank, countries that have increased the share of trade in their GDP have grown faster and reduced poverty more rapidly than others.

Unfortunately the nirvana of free trade is largely an illusion at present. The global trading and production system is badly distorted by a legacy of subsidies and import tariffs that have their roots in decades or even centuries past. Entire industries have grown and blossomed under the shelter of such policies - industries that are in many cases - in the context of the global marketplace - inefficient and uncompetitive.

Recent World Bank research has shown that agricultural subsidies in rich countries total about $300 billion a year - roughly six times the amount spent on development aid. The Bank has also found that full elimination of agricultural protection and production subsidies in rich countries would increase global trade in agriculture by 17 percent. This increase would enable agricultural and food exports from low and middle-income countries to rise by 24 percent. As a result, total annual rural income in these countries would be estimated to rise by about $60 billion, or roughly six percent (coincidentally, a bit more than the total amount spent on development aid).

While notionally advocating 'free trade', recent decisions to delay the reform of Europe's Common Agricultural Policy and to increase agricultural subsidies in the United States are examples of rich countries opting to underwrite the status quo rather than using their wealth to support growth and facilitate development.

The current dispute over the importation of Vietnamese catfish to the United States is a case in point. Last year Vietnam signed a trade agreement in return for access to US markets. Following pressure from the US catfish industry, congress subsequently passed legislation that disallows imported Vietnamese catfish from being labeled as catfish (in case you are wondering, they can call it 'Basa'). The US Department of Commerce (DOC) also investigated claims of dumping. The DOC were unable to substantiate such claims - they found, not suprisingly, that the domestic price for catfish in Vietnam is the same or lower than the market price in the US. However, in spite of these findings and to the outrage of Vietnamese exporters, the DOC has proceeded to designate Vietnam as "a non-market economy for the purpose of US anti-dumping law" effectively leaving the door open to impose punitive 'anti-dumping' tariffs on imported Vietnamese product.

Which is a shame. Subsidies and tariffs are ultimately a tax on consumers. Consumers in developed countries would probably be quite happy to have their $300 billion back, and to enjoy lower prices into the bargain. Rural people in developing countries would also, one assumes, be quite happy about greater market access for their products and increased income. As noted by Nicholas Stern, Chief Economist at the World Bank "it is hypocritical to preach the advantages of trade and markets and then erect obstacles in precisely those markets in which developing countries have a comparative advantage."

A preliminary US judgement on the matter is due on 24 January.

Simon Wilkinson

AQUACULTURE ASIA

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Research and Farming Techniques

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Aquatic Animal Health

What's New in Aquaculture

On Trade and Investment

Pedro B, Bueno, Director-General of NACA, conceived of and was Editor of Aquaculture Asia for six years. He now writes from the vantage view of the Publisher.

For this issue, we are borrowing three items from Dave Conley's Aquaculture Newsclips, an excellent Internet-based emailed service that we first mentioned in our October-December 2001 issue. (Send an email to Dave to subscribe: **Aquaculture Newsclips**, D.C. Conley & Associates, Aquaculture Communication Consultants, Ottawa, Canada, dave.conley@sympatico.ca).

We selected these news clips items from two recent issues for no other reason than to give some real-world illustration of a few problems that the aquaculture sector of both developing and developed countries face, and how they deal with them.

The first is of an anti-dumping draft legislation before the US Congress that proposes strong measures be taken against several countries, including India, China, Brazil, Ecuador, Indonesia, Thailand and Vietnam, until each of them drastically reduces their shrimp exports to the US, and, calls for a virtual ban on all financial aid to the countries concerned if they don't comply.

The second is an editorial comment on a baffling conclusion of the US ITC that "Vietnam is not a market economy."

The third is an announcement of the plans of the municipal government of Ho Chi Minh City (formerly known as Saigon) to invest in improvements to its seafood farming and processing industry to help develop its economy and increase jobs.

US anti-dumping laws threaten shrimp exports

The crisis over allegations of dumping on the US market is posing a serious threat to shrimp exports, as draft legislation before the US House of Representatives calls for a virtual ban on all financial aid to the countries concerned.

The draft bill proposes that strong measures be taken against several countries, including India, China, Brazil, Ecuador, Indonesia, Thailand and Vietnam, until each of them drastically reduces their shrimp exports to the US.

India is the second largest shrimp exporter to the US after Thailand. During the first seven months of 2002, India's shrimp exports to the US grew 56 per cent. At the same time total shrimp imports declined by nine per cent, reports the Economic Times.

However US shrimpers claim their livelihoods are under threat from cheap imported shrimp and as a result representatives for the shrimp industry in several states are considering legal action against countries exporting shrimp to the US at rock-bottom prices.

It is in this context that the draft bill has been introduced, calling for shrimp imports from these countries to be reduced to three million pounds per month for three consecutive months, which represents a significant reduction from the 20 million pounds imported during the first half of this year. It also calls for a ban on financial assistance to any of these countries.

Calling the proposed legislation "unfair and misguided", Indian officials in the US say they may challenge the Bill at the WTO if it is passed (Helen Roberts, FIS.COM).

US catfish industry likely to win trade suit through unfair laws

SEAFOOD.COM [editorial comment by John Sackton] Nov. 15, 2002.

The announcement earlier this week that the U.S. ITC has determined that Vietnam is not a market economy just about assures that the catfish industry will win an anti-dumping verdict.

U.S. trade laws regarding dumping and countervailing duty follow the logic of Alice in Wonderland. The root issue in international trade is that countries or producing areas who can manufacture or grow products at the lowest cost have an advantage. Consumers in importing countries around the world benefit through buying from the lowest cost producer.

U.S. trade laws would be much more fair if they accurately measured costs. But in a left over relic from the cold war, the ITC has a loophole that allows it to declare a country, such as Vietnam, a 'non-market' economy. Once the ITC makes this declaration, costs don't matter. The judgment against the Vietnamese will not be based on their true cost of production, but on an imaginary cost constructed by government bureaucrats of a U.S. run catfish farm in India. Anyone who has done business in India would be hard pressed to say it is more of a 'market economy' than Vietnam.

The 'Market Economy' idea is strictly in the eye of the beholder. U.S. agriculture, which is consistently the lowest cost producer in the world, benefits from tremendous subsidies and price supports. These price supports mandate the production of surplus commodities, rewarding efficiency in large farms and driving down costs. These subsidies make it impossible for farmers in less developed countries, such as Brazil or China, to effectively compete. Yet no one says that U.S. agriculture is not a market economy.

Seafood consumption has thrived in the U.S. based on relatively free access to imports from around the world. This has transformed an industry that used to sell unappetizing white fish as a penance food during Lent into an industry selling the most glamorous, healthful, and sought after center of the plate products.

U.S. producers, such as catfish farmers and Gulf shrimpers are facing tough economic times, and they need adjustment assistance and support from the government. However, this support should not be in the form of unfair trade laws, which

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APEC, FAO, NACA, and OIE enhance Capacity on Risk Analysis (IRA) in Aquatic Animal Movement in Asia-Pacific region

Dr Melba Reantaso

Movement of aquaculture species and trans-boundary diseases

Species movement for aquaculture dates back to the mid-19th century when ancient Romans and medieval European monks transported common carp and perch around Europe and in the Roman Empire; the Greeks also transported oysters during the Golden Age of Greece around the Greek Islands[1]. The past three decades have seen tremendous expansion, intensification, and diversification of the aquaculture sector which now has become increasingly reliant on external inputs through movements of live aquatic animals and animal products (broodstock, eggs, fry/fingerlings, seed, and feed). The present trend towards world trade liberalization and globalisation as well as improved transportation efficiency contributed greatly to this development. The aquaculture sector has thus become a major supplier of aquatic food, provider of direct and indirect employment, a great source of foreign earnings through trade.

Some of the most serious diseases faced by the aquaculture sector are those pathogens and diseases which were spread and introduced through movements of hatchery produced stocks, new species for aquaculture and development and enhancement of the ornamental fish trade. The sector is faced with what is now known as trans-boundary aquatic animal pathogens/ diseases (TAAPs/TAADs), similar to the TAPs in the livestock sector. These are pathogens/diseases which are highly transmissible, with the potential for very rapid spread irrespective of national borders and cause serious socio-economic consequences. Movement of live aquatic animals has clearly been the major mode of transfer and spread of TAADs/TAAPs[2]. Classic examples are serious pathogens such as White Spot Disease (WSD), Yellowhead Disease (YHD), and Taura Syndrome Virus (TSV) affecting crustaceans; Epizootic Ulcerative Syndrome (EUS), Viral Nervous Necrosis (VNN) affecting finfish; *Perkinsus* sp., and *Bonamia* sp., *Haplosporidium* sp., protistan parasites, affecting molluscs. Koi herpes virus (suspected to cause a serious outbreak of koi and common carp in Indonesia since April 2002), Spring Viremia of Carp (reported for the first time in the US in July 2002); and *Haplosporidium nelsoni*, (reported for the first time in Canada in October 2002) are recent cross border issuess (http:// www.oie.int).

Risk analysis in the health management process

What is risk analysis?

MacDiarmid[3] defined 'risk analysis' as a tool intended to provide decision-makers with an objective, repeatable and documented assessment of the risks posed by a particular course of action. It is intended to answer the following questions:

- What can go wrong?
- How likely is it to go wrong?
- What would be the consequence of its going wrong?
- What can be done to reduce either the likelihood or the consequence of its going wrong?

In the past, the 'normal' unsuspecting, unplanned and qualitative approach has led to inconsistent policy decisions and restrictions made for different methods of transfer, species and life-cycle stages (e.g., broodstock, larvae, fertilised ova, gametes) which can be imported, geographic ranges and requirements for mitigative measures (e.g., quarantine, health certificates, etc.). This 'ad hoc' approach is now under increasing scrutiny and the global trading system is increasing the demand for a more structured approach to risk analyses for aquatic animal transfers and policy decisions based on science[4].

A multilateral mechanism to protect human, animal and plant health in WTO's member countries was established by the Uruguay Round's Sanitary and Phytosanitary (SPS) Agreement. WTO member countries are protected from other countries' use of health-related measures to disguise barriers to trade. SPS measures, within the context of the SPS Agreement, refer to any measure, procedure, requirement, or regulation, taken by governments to protect human, animal, or plant life from the risks arising from the spread of pests, diseases, disease-causing organisms, or from additives, toxins or contaminants found in food, beverages, or feedstuff. The SPS Agreement contains 14 articles and 3 annexes covering the following: basic rights and obligations; harmonization; equivalency; risk assessments; pest- or disease-free areas; transparency; control, inspection and approval procedures; technical assistance; special and differential treatment; consultations and dispute settlement; administration; and implementation (http:// www.wto.org/english/tratop_e/sps_e/ spsagr_e.htm). To comply with WTO-SPS obligations, governments are encouraged to implement import/export decisions based on international standards or using science-based risk assessments.

While there are more advances in conducting IRAs in the livestock and plant sectors, IRA for aquatic animal movement is a new concept and a new process. It may appear complicated and it some cases it is complicated. Therefore, it is important that countries, at the first instance, familarize, understand and embrace the concept and not be discouraged by the expected intricacy of the process[5].

Import risk analysis is the process by which importing authorities determine whether live aquatic animal imports or their products (e.g. genetic material, feed stuff, biological products, pathological material) pose a threat to the aquatic resources of their country.

The process identifies the hazards associated with the movement of a particular commodity and mitigative options assessed; the results of the analyses are communicated to the authorities responsible for approving or rejecting the import. IRA is usually undertaken by the Competent Authority (CA) for the importing country; IRAs can, nonetheless, range from an individual farmer analyzing and assessing the risks associated with a potential, specific importation, to a full range IRA carried out by a multidisciplinary team[1]. It is systematic, iterative, transparent, science-based and the process involves four major steps[6].

- Hazard Identification;
- Risk Assessment;
- Risk Management; and
- Risk Communication, which is a step that takes place throughout the entire IRA process.

There are practical difficulties in interpreting the provisions in the SPS Agreement. It is therefore necessary that developing countries are empowered with appropriate skills that will allow them to develop technically valid import restrictions through the application of the risk analysis process so that they are able to meet international obligations. Countries will be confronted with a range of conditions and scenarios when conducting an IRA and regulations will vary from country to country. For developing countries, the greatest struggle will be deciding what constitutes "acceptable risks" and establishing consistent approach to the concept of 'appropriate levels of protection'; availability of information (both quantity and quality), capacity of staff and legislation. Legislation to enforce sanitary measures recommended from an IRA, disease surveillance information to demonstrate country/ regional freedom from specific disease agents and that which determines the need for applying sanitary measures, and scientific input from disease specialists and risk analysts are some of the more important requirements for conducting an IRA.

As more skills and expertise in risk analysis are developed and as more scientific information become available, we will see good models of risk analysis that will provide further guidance to countries. There are also expert input and experience that can be utilised from the livestock and plant sectors.

Of the three SPS issues that have been elevated to WTO's dispute settlement panels – the Canada vs Australia dispute on salmon provides valuable lessons. It is to the best interest of trading partners to avoid as much as possible taking formal WTO dispute settlement action because it could be very costly and resource intensive. At the bilateral level, there are opportunities for trading partners to undertake consultation and for developed countries to assist developing country trade partners.

Current efforts on IRA for aquatic animals

Since 1997 when the European Association of Fish Pathology organized, at its 8th EAFP Conference, the EAFP Risk Assessment in Aquaculture, there followed more activities all aimed at better understanding and gaining skills in conducting IRAs for aquatic animal health. In 2000, the Office International des Epizooties (OIE) organized the International Conference on Risk Analysis in Aquatic Animal Health. This conference was organized in order to initiate international dialogue and provide information to scientists, academics and regulators responsible for developing, evaluating and implementing import measures in aquatic animal health[7]. This year, the Fisheries Working Group of the Asia-Pacific Economic Cooperation (APEC) in cooperation with the Food and Agriculture Organization of the United Nations (FAO), the Network of Aquaculture Centres in Asia-Pacific (NACA), and the OIE jointly implements a project (APEC FWG 01/ 2002 "Capacity and Awareness Building on Import Risk Analysis (IRA) for Aquatic Animals") that will bring together policy makers, administrators, aquatic animal health scientists and private sector representatives to build awareness and capacity to understand and undertake risk analysis for aquatic animals at national and regional levels. Two regional training workshops were conducted: the First Training/Workshop in 1-6 April 2002 in Bangkok, Thailand, participated by 23 governments; and the Second Training/Workshop in Mazatlan, Mexico from 12-17 August 2002, with participation from 20 countries in Asia-Pacific and the Americas. This Project is expected to (a) produce a Manual on IRA for Aquatic Animals which will provide guidance to economies and governments in conducting IRAs for the international trade of aquatic animals; (b) establish a network of people with skills and capacities on IRAs that will lead to increased contacts between individuals and governments in undertaking improved biosecurity measures in the international trade of aquatic animals; and (c) improve capacity in surveillance, monitoring and reporting of aquatic animal diseases and contingency plans for emergency disease situations.

Conclusion

IRA is a core activity that will assist in minimizing the threat of trans-boundary aquatic animal diseases. There is much more that we need to understand with respect to risk analyses. Many regional/ international and inter-governmental organizations and professional bodies are making the right initiative in taking the first step at providing support to projects that will raise awareness, and build capacity. There is an enormous challenge ahead of us. Aquaculture health will receive high priority and we will see more and more cooperative efforts among stakeholders at all levels, hopefully to the full benefit of fishfarmers and farming communities heavily dependent on this sector for their subsistence.

Health management is a shared responsibility, and each stakeholder has an important role to play. Aquaculture suffered enormous losses and there are now important lessons learned from the past. Movement of aquatic animals and its products is a necessity for aquaculture development at both subsistence and commercial levels. Intensified trade will, however, foster increased global exposure to disease agents, the impacts of which may be irreversible. On the other hand, strict or excessive controls will also lead to trade underground. The risks of major disease incursion and newly emerging diseases will continue to threaten the sector, and unless appropriate health management measures are put in place, will cost the government and private sectors much more in terms of production losses, and efforts to contain and eradicate them than would have spent in preventing their entries into the system. There is no clear cut strategy - strong national commitment from responsible administration and pro-active support and cooperation from the private sector and stakeholders toward harmonizing health management measures and promoting responsible trans-boundary movement of aquatic animals and products will reduce the risk.

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World Trade Organizations's Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement)

...continued from page 3

end up taking money out of all our pockets." (John Sackton, New.Seafood.com).

Ho Chi Minh City announces aquaculture plans

Ho Chi Minh City has worked out solutions to develop its aquaculture sector into an economic spearhead by 2010, reports the Vietnam News Agency. Local enterprises plan to invest about USD 65 million for developing infrastructure facilities and importing advanced technology by 2005, and a similar amount for the 2006-2010 period.

One of the aims of the investment is to help local enterprises meet the requirements of the US Hazard Analysis and Critical Control Point (HACCP), International Standard Organisation (ISO), and Good Manufacturing Product (GMP). It is believed that with those international certificates, Vietnamese seafood products can enter Western European and North American markets.

Ho Chi Minh City now has 14 frozen seafood processing companies licensed to directly export their products to the EU market. The figure of the whole country is 68.

One-sixth of the 300 local processing establishments specialize in processing frozen seafood products for export with a combined capacity of 120,000 tonnes per year. However, local processors currently run at only 50 per cent of their designed capacity, turning out 60,000 tonnes of frozen aquatic products.

About 50 local factories specialize in processing dried aquatic products, mainly dried cuttlefish. Meanwhile, 100 processing establishments in the city annually produce between 25-30 million litres of fish sauce. The city also serves as a fishfeed supply centre with a network of more than 20 processors and six suppliers. (By FIS Asia).

Properties of Liming Materials

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Liming materials are used widely in aquaculture to neutralize acidity in pond soil and water, to increase alkalinity and hardness of water, to destroy disease carriers in soil, and for other purposes. Nevertheless, many who use these materials do not understand their properties.

There are several sources of liming materials. The most common source is limestone. Limestone is a rock with a relatively hard and massive structure. Chalk, marl, and seashells are similar to limestone in chemical composition and are sometimes used for liming materials. Chalk is much softer than limestone. Marl is a loose material that is deposited in lakes, and often is mixed with clay.

The main chemical components of limestone, chalk, marble, marl, and seashells are calcium and magnesium carbonates. Calcitic limestone is comprised almost entirely of calcium carbonate ($CaCO_3$) while dolomitic limestone is comprised of calcium and magnesium carbonate ($MgCO_3$) in a 1:1 ratio ($CaCO_3 \times MgCO_3$). Most limestone is neither calcitic nor dolomitic, but a mixture of calcium and magnesium carbonates in some proportion other than 1:1.

The most frequently used liming material in aquaculture, and in agriculture in general, is agricultural limestone. It is made by crushing limestone to a fine particle size. Materials similar to agricultural limestone may be made by crushing chalk, marl, and seashells.

A product called burnt lime is made by burning limestone or other sources of calcium and magnesium carbonate in kilns at high temperature. This may be done on an industrial scale, but in many nations, much of the burnt lime is made by small-scale producers using wood-fired kilns. The resulting reaction and product is illustrated below for calcitic limestone:

$$CaCO_3 \xrightarrow[\Delta]{} CaO + CO_2 \uparrow$$

Carbon dioxide is driven off, and the resulting product is calcium oxide (CaO). Usually, the product will be a mixture of calcium and magnesium oxides, for limestone or other carbonate-bearing source materials are a mixture of calcium and magnesium carbonates. The product made by burning limestone also may be called quick lime or unslaked lime, but it is most commonly called burnt lime.

Burnt lime may be treated with water to produce hydrated lime as illustrated below for the conversion of calcium oxide to calcium hydroxide [$Ca(OH)_2$]:

$$CaO + H_2O \rightarrow Ca(OH)_2$$

Hydration of burnt lime usually gives a mixture of calcium and magnesium hydroxides, because burnt lime usually is a mixture of calcium and magnesium oxides. The hydrated product is known as calcium hydroxide if made from pure calcium oxide. It is more commonly, and often more properly, referred to as hydrated lime. It also may be called slaked lime.

Burning of lime may not be complete, and the final product may be a mixture of oxides and carbonates. Likewise, if hydration of burnt lime is incomplete, the resulting product may be a mixture of carbonates, oxides, and hydroxides or of oxides and hydroxides.

In aquaculture, it is more practical to use the term agricultural limestone for the crushed, raw product just as done in other kinds of agriculture. It may be called calcitic agricultural limestone if it is nearly pure calcium carbonate or dolomitic agricultural limestone if it has calcium and magnesium carbonates in essentially 1:1 proportion. Most agricultural limestone is made from limestone rock, and the vendor should indicate if the source is marl, chalk, or seashells instead of limestone. The burnt and hydrated products can be referred to as lime.

All of the liming materials react with hydrogen ion (H^+) or acidity and carbon dioxide (CO_2) in basically the same way as illustrated below for calcium carbonate, calcium oxide, and calcium hydroxide.

$$CaCO_3 + 2H^+ = Ca^{2+} + CO_2 + H_2O$$
$$CaCO_3 + CO_2 + H_2O = Ca^{2+} + 2HCO_3^-$$

$$CaO + 2H^+ = Ca^{2+} + H_2O$$
$$CaO + 2CO_2 + H_2O = Ca^{2+} + 2HCO_3^-$$

$$Ca(OH)_2 + 2H^+ = Ca^{2+} + 2H_2O$$
$$Ca(OH)_2 + 2CO_2 = Ca^{2+} + 2HCO_3^-$$

If the carbonate, oxide, or hydroxide of magnesium are present, they react in the same manner as illustrated above for calcium compounds.

The ability of a liming material to react with acidity is the neutralizing value. Pure calcium carbonate is the standard for comparison with other compounds, and it is assigned a neutralizing value of 100%. One molecule of each of the liming compounds will react with two hydrogen ions (H^+), but the molecular weights of the compounds are different: CaO = 56, $Ca(OH)_2$ = 74; $CaCO_3$ = 100. Thus, CaO is 100/56 or 178.6% stronger than $CaCO_3$, and $Ca(OH)_2$ is 100/74 or 135% stronger than $CaCO_3$. Pure dolomite has the formula $CaCO_3 \times MgCO_3$, and one molecule will react with four hydrogen ions. It is 200/184.31 or 108.5% stronger than $CaCO_3$. Thus the neutralizing value of the products mentioned above are: $CaCO_3$, 100%; $CaCO_3 \times MgCO_3$, 108.5%; $Ca(OH)_2$, 135% ; CaO, 178.6%. Of course, products mixed with magnesium compounds will be stronger than pure calcium compounds because the atomic weight of magnesium (24.31) is less than for calcium (40.08). Also, agricultural limestone and lime seldom are made from pure compounds and lime may not be completely burned or hydrated. Thus, the neutralizing value must be determined by a laboratory test. Agricultural limestone should have a neutralizing value of 95% or more to be considered of good quality. High quality lime should have a neutralizing value of

130%, and if it is sold specifically as burnt lime (unhydrated), the neutralizing value should be no less than 160%.

Fig. 1. A finely-ground agricultural limestone (right) versus a coarsely-ground one (left).

The fineness rating also is important in determining the quality of agricultural limestone. Limestone and other sources of calcium and magnesium carbonates are highly insoluble, and they must be crushed to fine particle size (0.25 mm or less; 60 mesh or less) to make them reactive. Material passing a 60 mesh (0.25 mm. opening) screen is given a fineness rating of 100%. The fineness rating declines as the proportion of coarse particles increases, and a laboratory procedure based on sieve analysis of agricultural limestone is used to assign a fineness rating. A good quality agricultural limestone must have a neutralizing value of 95% or more and a fineness rating of 95% or greater. A finely-ground and a coarsely-ground agricultural limestone are shown in Fig. 1. The fineness rating usually is not applied to lime, for the burning process converts limestone to a fine powder.

Liming materials tend to have a similar appearance. It usually is impossible to visually distinguish differences among samples of them (Fig. 2). A quick test of the pH of a slurry of 1 part liming material and 5 parts distilled water can reveal if a material has been burned. Burned materials, either hydrated or not, will have a pH of 11 or above.

Fig. 2. Samples of six different samples of liming materials including calcitic agricultural limestone, dolomitic agricultural limestone, marl, and burnt lime. They are visually indistinguishable

It is possible to identify liming materials by calcium and magnesium content. The percentages of calcium and magnesium in pure samples of agricultural limestone and lime are provided in Table 1. The ratio of calcium: magnesium in products made from pure dolomite is 1.65.

"...these products vary greatly in quality in most nations..."

Most countries do not require vendors to label liming products according to composition, neutralizing value, or fineness rating. Experience indicates that these products vary greatly in quality in most nations, and some products are not labeled even as to the correct compound. For example, a recent study of the properties of 49 brands of liming products in Thailand revealed that only about one half of them were of high quality and labeled as to the correct compound. Shrimp and fish farmers should acquaint themselves with the properties of liming materials and insist that vendors provide data regarding product quality. Vendors providing this information would have a competitive advantage, and other vendors would be forced to follow their lead. This would greatly reduce the possibility of inferior products remaining in the market for long.

"...farmers should acquaint themselves with the properties of liming materials and insist that vendors provide data..."

Application rates for liming materials given in pond management manuals and reported by testing laboratories are given in terms of pure calcium carbonate with neutralizing value and fineness rating of 100%. Most commercially available liming products will not have neutralizing values and fineness ratings of 100%, but their equivalent dose may be calculated as follows:

$$\text{Dose} = \frac{\text{Recommended dose (kg/ha)}}{\text{NV}/100 \times \text{FR}/100}$$

Where:

- Dose = liming rate for available product (kg/ha)
- NV = neutralizing value of available product (%)
- FR = fineness rating of available product (%)

For example, suppose that the recommend liming dose is 1,000 kg/ha, and the product available for use has a neutralizing value of 90% and a fineness rating of 82%. The dose is calculated below:

$$\frac{1{,}000\ \text{kg/ha}}{90\%/100 \times 82\%/100}$$

Table 1. Percentages of calcium and magnesium in samples of agricultural limestoneand lime made from pure calcitic or dolomitic limestone.

Product		% Ca	% Mg
Agricultual limestone			
Calcitic	$CaCO_3$	40.08	0.00
Dolomitic	$CaCO_3 \cdot MgCO_3$	21.74	13.18
Burnt lime			
Calcitic	CaO	71.47	0.00
Dolomitic	$CaO \cdot MgO$	41.58	25.22
Hydrated lime			
Calcitic	$Ca(OH)_2$	54.10	0.00
Dolomitic	$Ca(OH)_2 \cdot Mg(OH)_2$	30.27	18.36

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Advice on Aquatic Animal Health Care

Questions & Answers on drugs & chemicals

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Shrimp pond waste management

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A brief history of sludge

Intensive shrimp farming developed rapidly in the mid 1980's, especially in the Southeast Asian region. Shrimp production level increased mainly due to expansion of farming area and adoption of intensive farming practice.

Improvements in water and waste management during the last decade have been a response to a wide range of problems in the shrimp-farming sector. Most management issues have focused on water and wastewater management, little attention has been paid to improve management of solid or semisolid state of shrimp pond waste. At the same time, the environmental impact of shrimp farming has been highlighted especially with regard to farm wastewater discharge. This has lead to the development of improved water management techniques including water pre-treatment and recirculating systems. Both researchers and farmers have worked to improve pond management techniques. Yet complete sludge management has not received much attention.

After years of culture operation, disposal of accumulated sludge is posing a problem. Farmers are concerned about the initial capital cost and limited area is available on farm, so further post-culture management of shrimp pond waste (SPW) has not been well pursued although it has long term gain. The results of a recent farm survey I conducted[1] on shrimp pond waste management in three southern provinces (Ranong, Phang Nga and Chumpon) show that most farm operators are willing to improve their waste management techniques. However, they don't have enough information to enable them to make effective changes.

Therefore, a systematic waste management strategy that includes treatment, disposal and recycling is needed for sustainable shrimp farming management. In this article I will describe a number of innovative approaches employed by farmers in Thailand.

What is Shrimp Pond Waste

Waste products are being produced continuously during shrimp culture in a mixture of gases, liquids, semi-solid and solid forms. When the concentration of wastes builds up to undesirable levels in pond water some is discharged and ponds are topped up with better quality water to maintain water quality. Some of these waste materials are removed in the discharge, however, some settles out on the pond bottom and becomes semi-solid and solid waste. In this article, SPW refers only to semisolid and solid form of shrimp pond waste. These are formed largely from the residue of pond inputs such as uneaten feed, biological wastes from the shrimp and other organisms and eroded soil.

SPW Characteristics

The characteristic of sludge or SPW is dependent upon design and type of pond, culture system, pond management regime, and pond inputs. Due mainly to its nature and source, SPW have higher value of organic matter, total nitrogen and phosphorous than normal soil[2,3]. SPW may also have a high biological and chemical oxygen demand (BOD, COD)[3]. These clearly show the high nutrient loading in SPW and the need for appropriate treatment prior to disposal.

Effects of SPW

Effect of SPW on Shrimp Culture

Shrimp pond waste affects greatly to growth and survival of shrimp and water quality of the pond. Too frequent removal of SPW deposited in the pond bottom, significantly reduces the organic nutrient concentration in water and can result in low levels of phytoplankton and low pond productivity. In *Penaeus setiferus* culture pond, shrimp survival and production has been shown to be very low in ponds with no to moderate removal of sludge during culture period[2]. The growth of *P. monodon* fry has also been shown to have a negative correlation with ammonium and sulfide concentrations of sediment[3].

Accumulation of SPW may lead not only to increases in sediment oxygen demand but also to anaerobic conditions resulting in production of undesirable gasses such as hydrogen sulfide. The sediment consumes a large percentage of the pond oxygen budget and so a large volume of accumlated shrimp pond waste will increase oxygen demand and may cause oxygen depletion on the bottom where the shrimp live. This in turn will stress shrimp and render them more susceptible to disease. The undesirable gasses produced from SPW can also affect the appetite of shrimp thereby increasing feed conversion ratios and leading to further deterioration of water quality. Therefore, SPW management during culture operation plays vial role in shrimp production and prevention of disease.

Table 1: Characteristics of sludge just prior to pond harvest and characteristics of soil at the time of pond harvest for the three sludge regimes[2]

Parameters	Remain	Remove	Resuspend
Sludge			
Wet volume (m^3/ha)	90.0	n.a	95.0
Moisture (%)	87.0	n.a	93.2
Loss on ignition (% dry wt.)	26.2	n.a	37.1
Kjendahl nitrogen (ml/L)	2,560.0	n.a	1,620.0
Total phosphorous (mg/L)	1,480.0	n.a	1,840.0
Soil			
Loss on ignition (% dry wt.)	1.9	1.4	2.5
Kjendahl nitrogen (ml/L)	663.0	300.0	700.0
Total phosphorous (mg/L)	860.0	580.0	1,140.0

Impact of SPW on Environment

Little information is available on effect of SPW on environment. Shrimp pond waste produces negative, neutral and positive impacts on environment. The degree of impact intensity and its consequences is largely dependent upon SPW management practiced during culture operation and post culture period. Usually, negative impacts are reported and positive impacts of SPW are ignored for the fear of encouraging a high incidence of negligence in proper SPW management. Nevertheless, release of SPW into the environment has already raised many controversies in the shrimp farming industry in terms of environmental issues. The environmental impact of SPW can be divided into three parts: (1) impact on coastal water quality and hydrology, (2) impact on aquatic organisms, and (3) impact on mangrove and terrestrial vegetation.

Impact on Coastal Water Quality and Hydrology

Since SPW contains high level of nutrients, it will cause eutrophication to nearby aquatic environment if discharged without any treatment. Little or moderate amount of SPW disposal into open environment may increase nutrient availability in receiving water thus creating food source for many aquatic life. Phosphorous and nitrogen, which promotes the growth of phytoplankton are high in the SPW, therefore, it should be treated prior to discharging into open water environment.

Effect on Aquatic Organisms

Disposal of untreated SPW may cause turbidity in receiving waters since it contains lots of suspended solid particles. Suspended solid, as high as 4,200 mg/L from plastic lined intensive shrimp pond have been reported[3]. High turbidity reduces light penetration into water, which is limiting factor for photosynthesis and may lead to lower dissolved oxygen value in receiving waters, which may stress to aquatic organisms. Long-term exposure to high suspended sediment levels can have an adverse effect on bottom-dwelling organisms as it settles. High nutrient levels such as nitrogen and phosphorous in SPW may also contribute to certain level of eutrophication in waters.

Effect on Mangrove and Terrestrial Vegetation

Some studies show that SPW has positive impacts on the growth of some species of mangroves, for example a mixture of soil and SPW (up to 75% SPW and 25% soil) increases the growth of *Rhizophora mucronata*, *R. apiculata* and *Bruguiera cylindrica*. During my farm survey, many farmers also reported that better growth of mangrove grown in area where dried SPW is dumped[1]. Natural regeneration of mangrove plants especially *Rhizophora* spp. has occurred in discharge canals of a shrimp farm which were half filled with SPW in the TIR-Jawai Shrimp Farming Project site in Sinkawan province, West Kalimantan, Indonesia. However, overloading of SPW into natural mangrove forest should be avoided as this could cause mortality due to lack of respiration by the plant root structure.

The salt content of SPW can be a problem in its application to terrestrial vegetation. The tolerance level of different plant species varies widely with some such as coconut having higher tolerance than strictly freshwater species. The characteristics of SPW vary with pond water quality, rainfall and pond inputs. Logically, higher salinity pond water may result in higher content of salts in the SPW, however, the salt content is reduced by exposure to rain. In my farm survey[1] some farmers reported applying SPW to terrestrial plants. Some fruiting plants like Papaya were reported to be affected by application of SPW in that plants were producing more leaves but no fruits were attained. No negative effect were reported with regular application on banana plants, or on regular application of two week old dried SPW to a rubber plantation for two continuous years in Kuraburi district of Phan Nga province. At one farm in Kuraburi district a Jasmine flower plantation has been fertilised with raw SPW for a couple of years without any negative effects. This information clearly shows the potential usability of SPW for other purposes.

SPW Management

Effective SPW management has to be carried out in two separate phases – production management and post-harvest management. A complete SPW management strategy combines four approaches: Control, treatment, disposal and reuse. Management techniques are different from one farm to another depending upon personal preference, affordability, suitability and pond management techniques.

SPW management during culture operation

While in a production period farmers employ different techniques to manage the SPW depending upon culture situation, pond and environmental condition and resources availability. Three of the most useful approaches to SPW management are 'remain', 'remove' and re-suspend'[2].

The 'remain' management technique refers to accumulation of SPW within the pond where it may produce least negative effects to shrimp population. In this approach, SPW is usually concentrated in the middle of culture pond in order to create larger clean space for the shrimp to inhabit around the edges. Different aeration equipment is commonly used to create circular currents that sweep SPW into the middle of pond where it is deposited. Some farms use shallow ditches in different shapes to collect SPW during the culture in order to keep the volume of SPW in the pond low.

This approach is often combined with the control and partial re-suspend strategies. The control approach minimizes SPW volume by effectively managing feed and pond erosion to reduce SPW production. Chemicals such as oxidants may be used to allow aerobic decomposition on the surface layer so that the negative effects of SPW on pond water quality can be reduced. Some farms try to improve the quality of SPW using bacterial digestion under aerobic conditions. I observed a bacterial digestion method being applied to improve SPW quality in fifteen farms surveyed in southern Thailand (50% of total surveyed) during culture operation. Probiotics are applied routinely in grow-out ponds from the beginning of shrimp culture to maintain sufficient bacterial population that can digest SPW. The effect of probiotics is not clear. Some farms claim to have a reduced volume of SPW after the harvest using probiotics but comparative trials have not been carried out under controlled conditions.

In addition, a partial re-suspend method is also used to supplement the 'remain' approach. Some SPW is re-suspended through use of bottom aeration so that biodegradable parts of the SPW are digested aerobically. Some use hanging substrata to allow additional growth of microorganisms that degrade re-suspended SPW aerobically, reducing SPW volume and improving water quality.

The 'remove' management technique implies removal of SPW from grow out ponds during the culture period. This aims to create more clean space for shrimp in order to improve FCR, promote shrimp growth and reduce risk of disease. Complete removal of SPW is not commonly practised since it may cause a plankton crash due to low level of nutrient availability in pond ecosystem. Only partial removal of SPW is practised in lined ponds in order to allow nutrient lease from SPW to water. However, ponds with high nutrient availability and high waste loading rate usually have continuous deposition of SPW at a high rate. In this case, SPW that deposited in the middle of the pond is usually removed completely as new SPW keeps moving inward so nutrients are available for maintaining plankton growth.

In aquaculture ponds, the rate of oxygen consumption by the mud increases during a grow-out period because inputs of organic matter tend to increase. In intensive shrimp culture ponds feeding increases organic matter in SPW leading to higher oxygen demand at the mud-water interface and may cause production of hydrogen sulfide gas. In order to avoid these unfavourable conditions in pond environment, SPW has to be managed by removing at certain period of time.

Removal techniques

Different devices are being used to remove SPW from pond during the culture operation. Some farms effectively use the central drain system with additional pipe structure affixed to

Figure 1: Rotating SPW removal device

the central drainpipe. The additional pipe sweeps the waste deposited in the middle of pond bottom in a circular motion and discharges into the drainage canal. Electric or mechanical suction pumps are employed. These techniques consume energy and require manpower but improve bottom quality and thus safeguard production. Some farm operators have invented rotational SPW removal devices (figure 1) that do not require extra energy but simply utilise the water currents available within the pond1. The use of this device needs initial investment for the structure and slab at its base but it is worth the cost.

The resuspension method uses aeration or bioturbation but the technique is not widely practiced in shrimp farming. Small particles of re-suspended SPW increase the surface area available for bacterial attachment leading to faster breakdown. Utilization of this technique causes high BOD in the water column requiring more dissolved oxygen to balance the oxygen budget in the pond. Higher suspended solid concentrations also reduce light penetration, which is crucial for photosynthesis. Control and experience are needed to perform this technique as it may create problems if to much re-suspension occurs.

Re-suspension via bioturbation has a mild affect on water quality but again stocking density of fish defines the efficiency and biomass loading to the pond apart from its feeds competence. A farm that stocks all male tilapia fry as co-culture, at a rate of 2,000 pcs/ha approximately 45 days after stocking P. monodon achieved good production while a reasonable FCR of 1.72 was maintained, and produced 300g tilapia as a by-product.

In recent years, a number of farms have started employing bottom aeration techniques to improve quality of total suspended solid (TSS) that gradually forms SPW. A series of PVC pipes (about 1 inch diameter) with small holes are placed on the pond bottom at 2-4 metre intervals and connected to main air feeder pipe (about 2.5 to 3.5 inch diameter) that is fitted on the pond dike. Aeration is supplied by rotary type air blower powered either by electric motor or diesel engine. Since bottom aeration is provided from the beginning most wastes are digested aerobically and only a small portion of waste is deposited on the bottom after the harvest. However, this management technique does not produce good FCR and growth rate if the gathering of SPW is not well managed. The extensive aeration provided on the pond bottom, oxidises

Figure 2: Removal of SPW by pressurised pumps is becoming less common

Figure 3: Bags of SPW fertilizer for sale in southern Thailand

waste particles and allows aerobic decomposition and thus produces a beneficial outcome. Volume of SPW remained after the harvest significantly reduced. Some farmers use probiotics to improve digestion of re-suspended SPW and claimed good results.

Post-culture SPW Management

Post culture SPW management is not well practised in most farms simply because it is not seen to directly affect production and also due to additional cost. However, in recent years, farms have started paying attention to post culture management of SPW for different reasons. Unsustainable practices such as removing SPW by pressurised hose after the harvest (figure 2) are becoming less common, particularly in crowded farming areas where conflicts may arise with other users of the water resource such as local fishermen and fish cage farmers. The disposed SPW is usually settled or sun-dried naturally and its salinity thoroughly reduced by rain.

Proper post culture SPW management procedure can be divided into four phases, "control","treatment", "disposal" and "reuse/utilization". The four management phases carriedout after harvest are in sequential order and its level of management, in terms of environmental sustainability, increases with the phase.

"The ultimate goal of SPW management is 'utilization' including recycling waste products and increasing productivity..."

The 'control' phase refers to preventing SPW effects on shrimp culture itself, and minimizing the discharge of untreated SPW into open environments. This phase includes proper planning of SPW treatment and disposal activities on farm. SPW is gathered at one place and at least confined to the on-farm environment even if the waste is untreated. The degree of control depends on awareness and affordability of individual farmers, local conditions and regulations and enforcement of concerned authority.

The second phase of post-culture SPW management, 'treatment', aims to reduce the volume and toxicity of SPW and make it useful for other purposes. This phase is beyond the reach of most shrimp farmers at present. Even for a professional it is not easy as the required treatment of SPW varies with its characteristics, which is again dependent upon pond management technique, type of pond and pond inputs.

Simple primary treatment such as de-watering of SPW by sun drying or sand bedding are within the reach of farm operators' capacity and are usually carried out by some farms in southern Thailand[1]. When SPW is dried, a considerable amount of toxic compounds and microbial population are reduced and the volume of SPW decreases. Utilization of constructed wetland and mangrove forest has been proposed to treat shrimp pond waste[5,6] along with other more conventional methods[3,7].

Because of the changing characteristics of SPW, treatability of the waste is varied. Therefore, when treatment process and design is going to develop, it is required to understand: (1) the general approach and methodology involved in assessment and treatability of SPW, (2) factors affecting SPW characteristics, and (3) required local and regional SPW disposal standards and regulations.

'Disposal' implies proper planning and the provision of area (figure 8 & 9) for discharging SPW in an environmentally friendly and safe manner. Implementation of this phase greatly improves environmental quality and reduces health risks.

The ultimate goal of SPW management is 'utilization' including recycling waste products and increasing productivity of other production sectors such as agriculture. SPW is even useful in shrimp culture as a nutrient source when culturing phytoplankton. Some farm operators from Thailand and East Indonesia leave some SPW in the pond

Figure 4: Jasmin plants at a shrimp farm are fertilized with raw SPW.

A wide variety of freshwater plants growing in a SPW disposal pond

after the harvest in order to make easy to condition water culture for the next crop. Some farms in Indonesia and Thailand use dried SPW as landfill within the farm and also in earthen structure maintenance in order to solve storage problems. Some companies in Thailand are now producing fertilizer for agricultural use from SPW and these are already available in market (figure 3). However, wide spread use of this kind of fertilizer has not been adopted as the price of the product is the same as inorganic (NPK) fertilizers while the performance of the SPW fertilizer is not known and likely to be variable.

Utilization of SPW is practiced in a small proportion of farms (7 farms out of 30 surveyed farms[1]) but in a variety of applications. SPW was utilized for different purposes, mainly in agriculture. Raw SPW application on terrestrial plants (jasmine flower plantation) was tried in Phan Nga Province where the owner has 400 plants commercially growing on farm. A table spoon of fresh wet SPW is applied per plant per week and normal growth was noticed without addition of other fertilizers (figure 4). Use of dried SPW to fertilize rubber plantation was noted at one farm in Ranong Province where the shrimp farm owner has been applying half month old SPW to his own plantation for years with no negative impact. The SPW was applied around the trees but in the ditch in a thin layer only. Better growth of mangrove trees is often seen around shrimp ponds compared to those far from the farm.

Use of dried SPW on Papaya plants as fertilizer was reported by a farm in Kapoe district of Ranong Province where they found only leaves growth but no fruits. Disposing raw SPW on to a banana plantation did not affect the survival of the plants. However, another farmer reported dead coconut trees after dumping dried SPW in high volume. Palm oil plantations in Chumpon Province have contacted farms asking to collect SPW with their own expense to utilize at their farms. All these observations clearly indicate potential for utilisation of SPW and therefore, a study on the feasibility of using SPW fertilizer for different sectors should be conducted.

Management Application Issues

When it comes to promotion on implementation of such management practices, primary stakeholders' views and opinion, attitude and capabilities as well as affordability are extremely important.

In my survey I only found one out of 30 farms to be planning for long-term sustainability. However, a good sign is that about 88% of surveyed farms (22) were aware of the impact of SPW. They also seemed to understand the environmental implications of SPW but only roughly. Most farm operators think that SPW is harmful and that it can affect the environment and shrimp farming.

Regarding utilisation of SPW, farmers do not show any immediate plan to develop SPW based fertilizer as they do not expect to be able to generate a side income from it. However, some shrimp farmers (approximately 10%) have ideas on utilization of SPW and most of them have already tried. This shows some prospects in improving post-culture SPW management especially in utilization.

Planning on further development of treatment methods is not regarded as a priority by most farms. They are afraid that the uncertainty surrounding shrimp farming in the future may be a larger concern compared to handling problems of accumulated SPW after years of operation. Some farmers expressed their concern on how to improve cooperation amongst operators and with other sectors. Some believed that governments and other concerned agencies should involve not just in strong co-ordination but also in regulating supporting industries such as chemicals and feeds manufacturers, and cold storage (processing plants) and exporters so that proper information would be provided to farm operators. Supply of technical information input on SPW would be of great help in activating farmers to achieve further developments in waste management.

Guidelines for SPW management during culture operation

The following should be observed as a general guideline for SPW management. Although these are mainly for the farm operators and owners to follow it still needs assistance of related government agencies.

- All production farms (regardless of size or production capacity) should have area for disposing waste before planning any production activities.
- Waste disposal area should be adjusted after every crop in line with waste production level, local environmental conditions and government requirements.
- Farms that use 'remain' management approaches should have additional management systems to lower SPW volume and improve quality of SPW while in operation.
- Farms that use 'remove' management approaches should have a proper waste management system before disposing out of farm environment.
- Use of chemicals and drugs to manage SPW should be avoided where possible.

Guidelines for Post-culture SPW management

- Shrimp Pond Waste should not be discharged to outside environment.
- There should be proper and sufficient disposal area for Shrimp pond waste on farm.
- Primary treatment such as sedimentation and sun drying should be performed before the waste is disposed off.
- A certain degree of treatment should be applied to SPW before the disposal based on SPW condition: quality, volume and especially if the pond had received some probiotic and antibiotic treatment or if the pond had disease problems.

- Avoid disposing any form of SPW either dried or wet into freshwater aquatic environments.
- SPW disposal areas should not be near freshwater sources that are shared by other resource users.
- SPW should be recycled to use in pond where possible.

Aknowledgement

This study was supported by DANCED TCE Project (1998).

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What's New on the Web

www.developmentgateway.com

This website is very useful for those people involved in all aspects of development – I would have to say it is one of the best designed portal websites I've ever seen. The Development Gateway is an interactive portal for information and knowledge sharing on sustainable development and poverty reduction. The site is available in English, French and Spanish languages. The website has been established by the Development Gateway Foundation, a not-for-profit organization based initially in Washington DC. Its core objectives are to reduce poverty and support sustainable development through the use of information and communication technologies (ICT).

The most outstanding feature of this site is its Ideas and Knowledge Sharing function, which contains information-rich pages with news, statistics, calendars, grants, discussion groups, country reviews and many other resources covering a wide range of development topics, including e-learning, food security, gender and development, indigenous knowledge, information and communication technology for development, micro finance, poverty, water resources development and many more. You can subscribe to a very comprehensive email alert service that will inform you when a new item is added.

Another useful tool offered by the gateway is a comprehensive searchable database of development projects, searchable by country and topic. This complements a series of 'Country Development Gateways', which have an emphasis on activities in particular participating nations. I visited a few and found them considerably less useful than the main site, but if you are working in a particular region they may be a useful way of finding out what is going on in your area.

The site also offers a virtual 'procurement market' where participating development agencies (such as the World Bank) advertise tenders for development projects. This section of the site is (disapointingly) not entirely free – you can see the summaries but if you want the full information you have to pay a subscription fee. I suspect that if you take the trouble to visit the source organization's website you can probably get the same information for nothing.

Shrimp email discussion list

Recently I subscribed to the 'Shrimp' email discussion group hosted through Yahoo Groups. This is 'a mailing list for those involved in all aspects of the shrimp farming industry'. I have to say that this is a really excellent resource for shrimp farmers everywhere. The discussion group has about 800 members from across the globe and most of the postings appear to be from people actively engaged in shrimp farming, with contributions from a few scientists as well. The group operates in a friendly and constructive manner with participants happy to answer questions and share experience on shrimp farming issues. You can subscribe to the group by visiting http://groups.yahoo.com/group/shrimp/. There are a lot of postings so make sure you subscribe in 'digest mode'.

Responsible use of antibiotics in shrimp farming

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The recent scares in Europe about antibiotic residues in food are one of many reasons to decrease the use of antibiotics in shrimp farming. Findings of antibiotic residues in shrimps have been given much attention lately, both in importing countries and shrimp producing countries, and today many farmers are well aware of this issue.

However, one of the most important reasons to control the use of antibiotics in aquaculture is the risk of development of resistant bacteria ("stubborn bacteria"). This can occur both among bacteria infecting shrimp and bacteria infecting humans. When bacteria have acquired resistance, it is not longer possible to get rid of them with the antibiotic that caused the resistance. Furthermore, some antibiotics can cause bacteria to develop resistance not only to that specific antibiotic, but also to other, different antibiotics. Additionally, resistance-encoding elements can be transferred from one bacteria species to another. This way bacteria can indirectly become resistant to an antibiotic without being directly exposed to it.

Another important issue is that many antibiotics are occupational health hazards. Skin exposure as well as inhalation of dust from antibiotic powder may cause health problems to farmers, workers and others that are present when antibiotics are being handled.

Many of the antibiotics that are used in shrimp farming are quite persistent in the environment and can spread to surrounding waterways with the outlet water or sludge flushing or removal. In the surrounding environment they can change the ecosystems by changing the normal composition of bacteria, and also have acute toxic effects on aquatic animals and plants. They can also be taken up by organisms, for example mussels, which are collected and eaten by locals. That is, antibiotic residues in food is not only a threat to shrimp consumers in importing countries, but also a threat to people living in shrimp farming areas.

These are some important issues that should be considered by shrimp farmers regarding the use of antibiotics:

When should antibiotics be used?

- Only use antibiotics to treat bacterial infections, not for any other reason.
- Antibiotics cannot cure viral diseases such as White Spot or Yellow Head disease. Be aware that some antibiotic products available for shrimp farmers in Thailand are wrongly marketed as cure for viral diseases.

What should be used?

- Use fresh antibiotics from a reliable source. Information about active ingredient should be available on the label.
- Make sure the antibiotic is pharmaceutical grade. Do not use chemical grade, since these products are of lower quality.
- Avoid using antibiotics that are used in humane medicine.
- Do not use chloramphenicol or nitrofurans (e.g. furazolidone, nitrofurazone, nitrofurantoin, nitroquine and nitfuratel). They are hazardous, and not allowed in animal feed in Thailand.

How should it be used?

- Keep detailed recording of all antibiotic use.
- Prophylactic use of antibiotics should be avoided as far as possible. Prophylactic use is a major reason behind resistance development.
- Avoid repeated use of the same antibiotic, in order to avoid development of resistance
- Use correct doses and durations of treatment. Do not use more or less than recommended.
- Do not use more than one antibiotic at the same time if it is not specifically recommended. Do not distribute other drugs or chemicals to the shrimp during an antibiotic treatment.
- Handle and store the antibiotic products carefully, considering the risks with human exposure. Use tools and/or gloves to avoid skin contact if antibiotics are mixed with feed.
- The shrimps should not be treated with antibiotics within at least two weeks before harvest, preferably longer, to avoid residues.
- If the shrimps do not eat well due to an infection, it is not likely that they will consume antibiotics with feed.
- The use of antibiotics should preferably be under veterinary supervision.

In an interview study made in Thailand 2000, it was shown that 20% of all the interviewed shrimp farmers used antibiotics against viral diseases. Additionally, more than 60% of the farmers used antibiotics prophylactically. These results indicate that there is a widespread wrong use of antibiotics. But it also indicates that the usage could be decreased, according to the points made above, without negatively effecting shrimp production.

One large problem that remains to be solved is that producers and retailers of antibiotic products often neglect to provide shrimp farmers with accurate information about their products. These players must be put under pressure to provide farmers with better information regarding content and safe and efficient use of the products.

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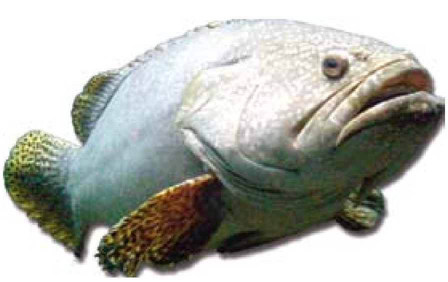

Marine finfish section

The Grouper Section has taken on a new and broader name: It has become the Marine Finfish Section to take account of other species. This Section is almost wholly based on the Grouper Electronic Network which is prepared by Sih Yang Sim (Editor), Michael Phillips (NACA Environment Specialist) and Mike Rimmer (Principal Fisheries Biologist of the Queensland Department of Primary Industries). Visit www.enaca.org/grouper for more information on the network.

Marine Finfish Aquaculture Network meets in Vietnam

The farming of marine fish is contributing increasingly to national economic development and livelihoods of people. There is a growing demand for marine finfish, including high value coral reef species such as groupers. For example, in 2001, Hong Kong, destination of most of the live fish traded in the region, imported an estimated 15-19,000 tons of live reef fish (caught and farmed) valued at more than US$ 315 million. The trade in fry, fingerling and juveniles is also flourishing. Marine fish farming, experts say, has become a promising area of aquaculture. The problem, among others, is that supply of seed from wild fishery sources is either dwindling or getting more expensive to obtain. There is also a growing concern over damage to the environment and resources from over-fishing or destructive collection of seed or adults from the wild. A special concern is incorporating into research planning and technology development the priorities of farmers and then translating their results into socio-economic benefits to the industry, especially to the small farmers and their communities.

It is these concerns that are being addressed in a regional technical and policy workshop being held from 30 September to 4 October at the picturesque and rapidly developing coastal city of Halong in Vietnam. The meeting – attended by some 100 participants from government, scientific organizations, industry, NGO's and regional and international organizations, from Vietnam, and 11 other countries in Asia-Pacific – is on Sustainable Marine Finfish Aquaculture in the Asia-Pacific Region. The participants are reviewing the status, research and development needs for marine finfish aquaculture in the Asia-Pacific region. From the review will come recommendations for collaborative actions to assist the sustainable development of marine finfish aquaculture in the region. In practical terms, the workshop looked at effective substitutes for trash fish in feed, more economical feed, better feeding systems and better culture systems and techniques for hatchery and grow-out, and good management practices. The workshop includes a special session on the development of a set of standards for farming of coral reef fish as part of a wider Asia-Pacific initiative to develop industry standards for the live reef fish trade, a joint project of the International Marinelife Alliance (IMA), Marine Aquarium Council (MAC), and The Nature Conservancy (TNC), with the support of the APEC Fisheries Working Group.

The scientific gathering is sponsored by the Ministry of Fisheries, Vietnam, the Australian Centre for International Agricultural Research (ACIAR), the Australian Academy of Technological Sciences and Engineering (ATS)E, the Network of Aquaculture Centres in Asia-Pacific (NACA) and the Asia-Pacific Economic Cooperation (APEC).

Results of the regional collaborative grouper research and development network supported by the Asia-Pacific Economic Cooperation (APEC) and NACA and the findings of an Australian Centre for International Agricultural Research (ACIAR) project "Improved hatchery and grow-out technology for grouper aquaculture in the Asia-Pacific region" are being reported and will suggest further steps for research, development and policy This ACIAR project involves the collaboration of scientists and technologists from several institutions in Australia, Indonesia, Thailand, Vietnam, and the SEAFDEC Aquaculture Department in the Philippines.

The development of sustainable hatchery systems and farming systems for groupers and other coral reef fish species, environmental management and planning for aquaculture, extension of research findings to farmers, and ways in which sustainable development of marine aquaculture can be best used to create employment and alleviate poverty among coastal communities will be addressed by the workshop.

An additional value from the workshop is the opportunity it is giving to many young researchers in marine fish culture working in different laboratories in various countries in Asia-Pacific to share their results with each other.

Speaking at the opening, Dr Nguyen Xuan Ly, head of science and technology of the Ministry of Fisheries of Vietnam, emphasized the high level of government support for marine aquaculture in Vietnam, as a means of earning income and creating employment in coastal communities. He urged further collaboration in Asia, and support from international and regional agencies such as ACIAR and APEC for sustainable development of marine aquaculture in Vietnam.

Mr Barney Smith, Fisheries Program Manager of ACIAR, said he was pleased to see the participation of so many young scientists in the workshop. He praised the marine finfish research and development network — coordinated since 1998 by the Network of Aquaculture Centres in Asia-Pacific, and recently adopted by its member governments into NACA's regular work program -as an excellent example of institutional, donor and government cooperation in support of sustainable aquaculture development in Asia.

As such, governments have committed to provide the resources, through NACA's regular program, to support the needed additional technology development work and information exchange activities, and to take up the results of the regional program into their fishery extension programs and development policies.

Dr Rachel Peitsch from the US Department of State, representing the Fisheries Working Group of APEC emphasized the importance APEC gives on sustainable aquaculture. APEC has given support to the activities of the Asia-Pacific marine fish R and D network. It has also recently approved a project addressing alternative livelihood strategies for communities in stressed coral reef areas. The project concept was presented at the workshop. It is being implemented by the NACA-hosted initiative on Support to Regional Aquatic Resources Management (STREAM).

Former Deputy Prime Minister of Vietnam, Mr Nguyen Cong Than emphasized the high priority the Government of Vietnam gives on sustainable development of marine fish aquaculture. In his keynote address, Mr Than identified the importance of building skills for managing environmental impacts, the need to develop hatchery technology to avoid use of wild resources, the importance of using manufactured feed, rather than wild "fish by-catch" resources, for development of marine fish culture, building skills in health management and market diversification as key issues to address for sustainable development of marine fish farming in Vietnam. He requested APEC, NACA and ACIAR and other agencies to provide further support for transfer of technology on seed production and advanced, environmentally friendly farming systems, to assist in building human resources, especially in technical, environmental and socio-economic skills, so that Vietnam could develop its aquaculture, and economy in general, in a sustainable manner.

The same sentiments would apply to the greater Asia-Pacific region.

For more information on cooperation in marine fish aquaculture in Asia and NACA, APEC and ACIAR projects, and to find out about the outcomes of the workshop, contact grouper@enaca.org or visit the grouper web site www.enaca.org/grouper.

New APEC Project: Improving Coastal Livelihoods Through Sustainable Aquaculture Practices

In recent years significant technological advancements have taken place in sustainable grouper and reef fish aquaculture. Now, APEC member economies wish to find out how best to implement these advances in coastal communities. It is hoped that this can improve community livelihoods and prevent unsustainable and destructive fishing practices. In order to take this forward APEC have selected the STREAM Initiative to undertake a short Sub-project of the APEC Grouper Research and Development Network aimed at "Improving coastal livelihoods through sustainable aquaculture practices". The project will begin by identifying four reef fisheries in APEC economies that are most at risk from unsustainable fishing and sea-farming practices. The overall objective is to develop a strategy for encouraging sustainable aquaculture in communities that are dependent upon each of the identified reef fisheries - addressing social, economic and ecologically sustainable issues. The project will be in three phases:

i) identifying at-risk reef fisheries,
ii) conducting four case studies of the identified reef fisheries and developing an understanding of socio-economic constraints and opportunities and factors that might influence the ability of the community to adopt sustainable sea farming,
iii) attempting to identify strategies for coastal communities in regions that are most at risk, that can be taken and applied by APEC economies in their own communities as required.

A number of current activities have already been identified, which attempt to address unsustainable fishing and sea farming practices and which are well placed to both learn from and contribute to case studies, these include the Nature Conservancy Aquaculture Project in the Komodo Island Marine Park, Indonesia, the IUCN Na Trang Marine Protected Area Project in Vietnam, and the Bureau of Aquatic Resources and Fisheries alternative livelihoods approaches to unsustainable reef exploitation on Panay Island, Philippines. The project will begin shortly and will report its findings in January 2003. For further information contact Graham Haylor, STREAM Director, email: ghaylor@loxinfo.co.th.

New Network Publications

Marine Finfish Aquaculture Network Website available on CD

The entire Collaborative APEC Grouper R&D Network website has been put on a CD, featuring two newly-released technical proceeding from previous network meetings and other associated publications including a complete set of network e-newsletters. (Note: Since this is a 'hard copy' version of the information freely available on the website a nominal production/postage charge applies). To order, contact publications@enaca.org.

Regional Workshop on Sustainable Seafarming and Grouper Aquaculture

The Report of the Regional Workshop on Sustainable Seafarming and Grouper Aquaculture held in Medan, Indonesia, 17-20 April 2000 is now available. This was the second workshop hosted by APEC and NACA under the project 'Collaborative APEC-NACA Grouper Aquaculture Network' (APEC Project FWG 01/99). The workshop was held to further develop a sustainable seafarming and grouper aquaculture industry in the Asia-Pacific region through collaborative networking among researchers. The report is available online and is free for download, click the title for an electronic version in pdf format (2.15 MB). The hard copy is available for a cost of US$25 (including postage), if you are interested please contact: Mr Sih Yang SIM, Asia-Pacific Marine Finfish Aquaculture Network, c/o: Network Of Aquaculture Centres in Asia-Pacific (NACA), P.O. Box 1040, Kasetsart Post Office, Bangkok 10903, Thailand, Tel: (66-2) 561-1728 to 9
Fax: (66-2) 561-1727, Email: grouper@enaca.org.

Report on the Formalization of an Asia-Pacific Marine Finfish Aquaculture Network

This is the report of a sub-section of 'Collaborative APEC-NACA Grouper Aquaculture Network' (APEC Project FWG 01/99) project on "Formalization of an Asia-Pacific Marine Finfish Aquaculture Network" (formally known as Asia-Pacific Grouper Network). One of the recommendations from the Medan Seafarming Workshop held in April 2000, Medan, Indonesia was to formalize the grouper network participation, which should included all regional institutes which are actively involve in R & D on grouper and other marine finfish. As a result of the recommendation, a project proposal was submitted and approved by APEC FWG in 2000, and was being carried out in 2001. The aim of the formalization are to create a strong network of research institutes and experts that are actively involve in grouper and other marine finfish R & D in the region; resources sharing through cooperation in order to make maximum use of limited resources; and improve information exchange and dissemination. The final report is available for free download from http://www.enaca.org/grouper

Technical developments

Breakthrough in Bluefin Tuna Breeding Cycle

Japanese researchers have achieved the first full-cycle breeding of the endangered bluefin tuna. Scientists at the Fisheries Laboratory of Kinki University in Wakayama made the breakthrough in late June. It is the first time the species has achieved a full breeding cycle, with matured fish spawning their own eggs. Researchers said the breakthrough meant there was potential not only to satisfy the demand for the prized fish without depleting wild stocks, but also for future ocean restocking. The matured tuna spawned around one million eggs, and Fisheries Laboratory officials said they expected around 800,000 to hatch. The research center began bluefin tuna breeding experiments in 1970, with the capture of wild fish to raise to sexual maturity, as its experiment station in Kushimoto, 450 km from Tokyo. It was successfully achieved spawning in 1979.

Attempts to breed bluefin are also taking place in Australia and the Mediterranean, where captured bluefin are being raised in captivity. South Australian company the Stehr Group is one company aiming to propogate southern bluefin tuna to sell to Japan and other lucrative markets. The Japanese government granted the programme at Kinki University funding of 100 m yen (US$832,000) over the next five years, in recognition of its increasing success. A CNN report claimed lack of funding had meant researchers had previously bred fish such as sea bream to raise funds for the bluefin experiments. Environmentalists have been calling for some time for restrictions on Japanese catches of the endangered southern bluefin tuna. A conservation report by WWF and IUCN in 1997 called for the total annual catch to be reduced by 35%, and claimed that "the status of the southern bluefin tuna parental population is now less than 9% of that in 1960". *Source: Fish Farming International, August 2002, Volume 29, No. 8*

Breakthrough in Yellowfin Breading

The Achotines Laboratory of the Inter American Tropical Tuna Commission (IATTC) in Panama is successfully spawning the yellowfin tuna in land-based tanks. The IATTC believes that this is the only successful example of yellowfin tuna breeding in the world. Senior scientist Dan Margulies says the tuna has been spawning almost daily since 1996.

Juveniles have been cultured for up to 100 days, and are routinely reared up to six weeks after hatching. The lab was established as part of the IATTC's Tuna Billfish Programme, and has two main responsibilities. One is to study the biology of the tunas and tuna-like species of the Eastern Pacific Ocean to estimate the effects that fishing and natural factors have on their abundance. The other is to recommend appropriate conservation measures so that stocks of fish can be maintained at levels that will afford maximum sustainable catches. *Source: INFOFISH International 4/2002*

Resistance of Cobia *Rachycentron canadum* Juveniles to Low Salinity and Low Temperatures

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To determine the lower salinity tolerance of cobia fingerlings, seven circular tanks (61 cn in diameter) were each stocked with 10 fish (31.5 ±9.64g, mean ±SD). Each tank contained approximately 75 L of 20 g/L-salinity, constantly-aerated water and was equipped with its own biofilter. Fish were allowed to acclimate to the tanks overnight, and then the salinity was reduced in five of the tanks by 2 g/L per day (27.3 ±1.36 °C). All fish survived exposure to salinities down to and including 10 g/L. First mortality occurred after the salinity was lowered to 8 g/L. Survival then declined steadily until stabilizing at 20% in 2 g/L. All fish in four of the tanks were dead after 24h of exposure to 2 g/L salinity. Surprisingly, all fish in one tank survived in 2 g/L salinity for six days, at which time the experiment was terminated. Repeated analyses of the water (including determining calcium concentrations) containing the surviving fish did not indicate anything unique. All control fish survived.

To determine the tolerance of cobia to low temperature, 10 fish (30.5 ±10.88 g, mean ±SD) were stocked into each of five temperature-controlled and aerated recirculating systems containing 375 L of 20.5 ±0.28 g/L-salinity, 22.6 ±0.59 °C water. Fish were acclimated to the systems for 3 days and then the water temperature was reduced an average of 0.53 ±0.03 °C/d (r = 0.95) until all fish died. Fish were offered feed daily during the experiment, until they ceased feeding. By the time the water reached 16 °C, most fish had ceased feeding. The first mortality occurred at 12.9 °C, the median-lethal tenperature was 11.9 °C, and all fish were dead by the time the temperature reached 10.4 °C.

The results of this study indicate that cobia juveniles require at least 10 g/L salinity and water temperatures above 12.9 °C for survival. Future studies will define the salinity and temperature requirements for growth.

Production and Characterization of Monoclonal Antibodies against *Lutjanus argentimaculatus* Immunoglobulins

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The serum immunoglobulins (Ig) of four fish species, mangrove red snapper *Lutjanus argentimaculatus* (Forsskal), banded grouper *Epinephelus awoara* (Temminck et Schlegel), white seabass *Lates calcarifer* (Bloch) and Japanese flounder *Paralichthys olivaceus* (Temminck et Schlegel) were purified by affinity chromatography on protein A- sepharose. Using SDS-PAGE, the molecular weight of heavy chains of serum immunoglobulins were, respectively, 79.5 kDa and 75.0 kDa for *L. argentimaculatus*, 77.2 kDa for *E. awoara*, and 81.8 kDa and 75.7 kDa for *L. calcarifer*, 73.5 kDa for *P. olivaceus*. The light chains were, respectively, 30.1 kDa, 31.1 kDa, 29.7 kDa and 15.0 kDa. The groin lymph nodes of Balb/c mice in six-week old immunized by intraperitoneally at foot pads with purified Ig of *Lujanus argentimaculatus*, were taken out sterilely and fused with mouse myeloma cells (SP2/0) at a ratio of 1:4 at 37¡æ, using PEG 4000. After selected by HAT medium and ELISA, and cloned, six monoclonal antibodies (McAbs) against *Lutjanus argentimaculatus* Ig were produced and characterized. All of the McAbs are functional for use in enzyme-linked immunosorbent assays (ELISAs) and immunoblotting applications. Characterization of the MAbs for mouse Ig class and subclass indicate that one was IgG 1, three were *Lutjanus argentimaculatus* Ig indicated that all six McAbs were heavy chain specific. ELISAs indicated that one of six MAbs hasa weak reaction with grouper Epinephelus awoara Ig, another one has a weak reaction with Lates calcarifer, and no McAb reacted with *Paralichthys olivaceus*.

Molecular Cloning, Expression on the Goose-Type Lysozyme cDNA from Orange-Spotted Grouper (*Epinephelus coioides*), and the Lytic Activity of its Recombinant Protein

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Lysozyme acts as a non-specific innate immunity molecule against the invasion of bacteria pathogens. In this study, the molecular cloning, sequencing, and recombinant protein's lytic activity of the goose-type (g-type) lysozyme cDNA from the orange-spotted grouper (*Epinephelus coioides*) were described. A cDNA library was constructed in +EtripIEx2 by using total RNA extracted from orange-spotted grouper leukocytes 72h after stimulation with Polyribonucleotide Poly(I) Poly(C). By random sequencing of the library inserts, cDNA for g-type lysozyme was isolated. The complete cDNA is 788 bp with a 585 bp open reading frame (ORF) encoding a protein of 194 amino acids. The sequence predicts a molecular weight of 21178 Dalton and PI of 6.18. The cDNA shows 73.2% amino acid identity with the g-type lysozyme of Japanese flounder. Three catalytic residues, as well as their neighboring amino acids are conserved between the orange-spotted grouper, Japanese flounder and four avian g-type lysozymes (black swan, goose, ostrich and chicken). Not like avian g-type lysozymes which have four conserved Cysteine residues, grouper and Japanese flounder lysozymes have none. RT-PCR analysis told us that the g-type lysozyme gene was transcriped in all the tissues examined. Northern blot analysis indicated that it was expressed in the intestine liver, spleen, head kidney, posterial kidney, heart, brain, and leukocytes. When grouper was experimentally infected with *Vibrio alginolyticus* quantities of the g-type lysozyme mRNA increased in the stomach, spleen, head kidney, posterial kidney, heart, brain and leukocytes. The g-type lysozyme ORF was cloned into the pRSETA vector and expressed in *E.coli* BL21. The recombinant enzyme was with molecular weight of 21.4 kDa, and possessed lytic activity against *Micrococus lysodeikticus*, and four examined aquaculture pathogenic bacteria (*Vibro alginolykicus*, *Vibrio vulnificus*, *Aeromonas hydrophila* infecting soft-shell turtle, *Aeromonas hydrophila* infecting gold fish), but no lytic activity against *E. coli* DH5+A.

Optimum Dietary Protein to Energy Ratios in Juvenile Parrot Fish, *Oplegnathus fasciatus*

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This study was conducted to determine the optimum dietary protein to energy (P/E) ratio in juvenile parrot fish, *Oplegnathus fasciatus*, fed the white fish meal and casein based diets for 8 weeks.

Ten experimental diets were formulated with two energy levels and five protein levels at each energy level. Two energy levels of 12.5 and 16.7 kJ/kg diets contained at crude protein (CP) levels of 35, 40, 45, 50 and 55%, respectively. The energy value of each diet was estimated based in standard physiological fuel values (16.7 J/g protein or carbohydrate and 37.6 J/g lipid). After two week of the conditioning period, triplicate groups of 20 fish initially averaging 7.1 ±0.06 g (mean ±SD) were randomly distributed into the aquarium.

After 8 weeks of the feeding trial, the optimum dietary protein level from fish fed 12.5 kJ/kg diets could be 40% for the maximum weight gain and feed efficiency, and this from fish fed 16.7 kJ/kg diets could be 50%. Diets containing 50% crude protein and 16.7 kJ/kg diet appeared to be utilized more efficiently in terms of percent weight gain than diets containing the other crude protein and energy levels.

Therefore, based on weight gain, feed efficiency and specific growth rate, diets containing energy levels between 12.5 and 16.7 kJ/kg diet had an optimum P/E ratio of approximately 125-133 mg protein/kcal.

Offshore Culture of the Pacific Threadfin *Polydactylus sexfilis* in Hawaii: Results of the Hawaii Offshore Aquaculture Research Project (HOARP) Phase II

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NOAA and the National Sea Grant Office have identified demonstration of the feasibility of offshore aquaculture in the United States as a top priority to address issues of sustainability of U.S. fisheries. HOARP is a joint research effort between the Oceanic Institute (OI) and the University of Hawaii Sea Grant College Program, in partnership with state governmental agencies, commercial farmers, and seafood processors. The ultimate goal of HOARP is to provide a scientific basis for evaluation of the biological, environmental, and economic feasibility of offshore aquaculture in the Pacific region. HOARP Phase I sought to combine newly developed sea cage designs from Ocean Spar Technologies, Inc. of Washington with technologies of Pacific threadfin mass culture and fish management developed by OI. Phase I successfully demonstrated the technical feasibility of raising and harvesting large numbers of fish in an offshore containment structure under completely submerged conditions. Phase II addressed issues to increase final harvest density, improve feed utilization, lower harvest size variability, and expand environmental monitoring efforts. Phase II also addressed the economics of production.

Monthly growth of fish raised in a single 2,600 m^3 Sea Station offshore during Phase II paralleled that of siblings raised in triplicate, onshore reference tanks at similar biomass densities. Peak biomass before harvest at 235 days of age offshore (mean wt. = 417.7 ±33.0g) was 12.1 kg/m^3, double that achieved during Phase I. The overall feed conversion ratio offshore (2.4) was higher than that achieved in onshore tanks (1.3 ±0.1) at the end of the trial. Overall recovery of fish offshore (57.5%) was lower than that achieved onshore (90.2 ±0.5%) owing largely to unaccounted losses. Harvested fish fell into a normal bell-shaped distribution with 66.9% of the fish falling into size classes ranging from 400-899 g.

Total ammonia levels measured near peak biomass and directly downstream from the cage four hours after the initial feeding of the day tended to increase slightly from upstream levels and began to dilute 15 m from the cage edge. There were no discernable trends in total phosphorous, chlorophyll A, turbidity, and total dissolved solids in weekly or quarterly samples. The polychaete, *Ophryotrocha*, became more abundant in the benthos directly underneath the cage than at control sites indicating a community response to increased organic load. The cage also acted as a fish aggregation device sustaining approximately 800 kg of resident species near the end of the trial. Improved economic outlook of Pacific threadfin culture offshore requires increasing offshore nursery survival and final harvest density, and lowered feeding costs.

Induction of Sex Reversal n Juvenile Sevenband Grouper, *Epinephelus septemfasciatus* by Injection of 17a-Methyltestosterone

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Grouper a high potential fish species for aquaculture because of their high economic values in fisheries. There are active efforts in seed production and breeding in hatcheries of many countries including Korea, Japan, China and ASEAN. There are also several ongoing research efforts in grouper aquaculture. However, seed production of groupers has not always achieved great success. This difficulty may be partially due to inadequate sex ratio in breeding of adult groupers for the obtaining of fertilized eggs. The sevenband grouper, *Epinephelus septemfasciatus* is a common species in coastal of Juju Island. It is protogynous hermaphrodite; sex reversal to male occurs at the age of 7-9 years. In this study, we attempted sex reversal by injection of 17a-methyltestosteron (MT) with juvenile sevenband grouper for obtaining of functional male.

Juvenile sevenband groupers were collected at the coastal area of Jeju Island, Korea. At the beginning of the experiment, body weight ranged from 578 to 1,168 g. Fish were divided into four experimental groups of 2 to 4 individuals; control, MT 0.5 mg/kg fish, MT 1.0 mg/kg fish and MT 2.0 mg/kg fish. MT was dissolved in 1ml of 70% ethanol and added with 9 ml of dissolved coconut oil and the resulting mixture was emulsified by mixing. MT mixture was injected weekly for 5 weeks and gonad of fish was prepared with histological procedures at the beginning of the experiment and at 10th weeks after MT injection.

At the beginning of the experiment, gonads of fish were occupied by oocytes of the perinucleolus stage and bundles of gonial cells in the area of germinal epithelium. After 10 weeks, fish from all treatment groups except control group were appeared spermatogenesis in gonads and several fish observed that the remnant of the oocytes are scattered through the testicular tissue.

International Certification for the Quality and Sustainability of Marine Aquarium Organisms

A new certification system for the marine aquarium trade has been launched by Marine Aquarium Council (MAC). The certification system which was developed through an international consultation process involving conservation groups, the industry, hobbyists, public aquaria and government agencies, enables customers and the marine industry to identify certified facilities and organisms of the marine trade. The goal is to put an end to unsustainable harvesting practices and enhance the conservation of the marine environment. This will also ensure economic stability of collectors and is considered to be a win-win solution for the entire supply chain, including coastal communities and the marine industry. The new certification system also provides consumers access to healthy products. The goals are to:

- Established independent standards and certification of “best practices”
- Raise public awareness of the industry role in conservation
- Provide objective, accurate data on the marine ornamental trade
- Ensure the health and quality of marine life through responsible collection, handling and transporting practices
- Encourage responsible husbandry through education and training

For update information on this please visit the Marine Aquarium Council website at http://www.aquariumcouncil.org/.

Low Cost Light Traps for Coral Reef Fishery Research and Sustainable Ornamental Fisheries

M. Watson, R. Power, S. Simpson and J.L. Munro

Source: NAGA, The ICLARM Quarterly (Vol. 25, No 2) April-June 2002

Light traps are generally considered as expensive research equipment with practical applications. They can provide a more sustainable alternative method for collecting reef fish to the destructive fishing practices used in the marine aquarium fisheries. In this article, the authors described one low cost and one minimal cost light trap modified from published designs. The design of light source and light traps are provided in details with additional construction diagrams used for illustration. The design of these light traps are based on ease of construction and cost effectiveness, these will allow the light traps to be deployed, and applications can extend beyond scientific research.

Temporal Growth Patterns of Farmed Juvenile Southern Bluefin Tuna, *Thunnus maccoyii* (Castelnau) Fed Moist Pellets

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Journal of the World Aquaculture Society, 33(2): 138-145 (from Current Contents)

The growth, condition, and feed utilization patterns of juvenile southern bluefin tuna (SBT) fed moist-pellets were examined over a 19-wk period from March to July 1999. The SBT had significant weight gain over the course of the study, increasing on average from about 27 to 34 kg (dependent on size class). No significant weight gain by the SBT occurred in the first 5 wk of the study. Following this initial period of slow growth, the rate of weight gain increased, ranging between 40 to 90 g/d. Weight gain peaked after 11 week, with no further gain occurring after this time point. Weight gain was strongly related to average daily feed intake (AFI) which was predominantly influenced by water temperature. Weight gain was minimal following the decrease of water temperatures below 15 C, consistent with a decrease in feed intake from peak values at the beginning of the study to basal levels by week 13. Basal feeding levels were maintained for the remainder of the study through to week 19. Although water temperature and AFI were strongly related, other time related effects also appeared to be significant. A relationship between condition index and feed intake was also identified. Condition index of the SBT increased from about 19 kg/m (3) to 22 kg/m (3) over the 19-week period. Similar to the patterns observed in growth, there was also an initial delay in increases of condition index. The results from this study support that the majority of weight gain by juvenile SBT occurs during the early part of the production season and that this is most likely influenced indirectly through responses to water temperature. The results of this study also suggest that there is little value in conducting growth trials beyond the point where water temperatures decrease below 15 C. Although there was minimal weight gain or improvement in condition beyond the 11-wk time point, these parameters would need to be considered in conjunction with flesh quality characteristics to identify optimum harvesting regimes.

Effects of Salinity, Aeration and Light Intensity on Oil Globule Absorption, Feeding Incidence, Growth and Survival of Early-stage Grouper *Epinephelus coioides* Larvae

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Fisheries Science, 68(3): 478-483

A series of experiments were conducted to examine the effects of salinity, aeration and light intensity on oil globule absorption, feeding incidence, and growth and survival of early-stage Epinephelus coioides larvae. Newly hatched larvae were transferred to 40-L aquaria at a density of 1500 individuals/ aquarium. Larvae were exposed to different levels of aeration (0 mL/min per L, 0.62 mL/min per L, 1.25 mL/min per L, 2.50 mL/min per L, or 3.75 mL/ min per L); salinity (8ppt, 16 ppt, 24 ppt, 32 ppt, or 40 ppt); and light intensity (0lx, 120lx, 230lx, 500lx, or 700lx) for 4-6 days. Twenty larvae were sampled daily at 11:00 hours to measure for total length (TL), oil globule volume, and feeding incidence. Survival rates were determined by counting the total number of larvae remaining in each aquarium at the end of the experiment. Significantly higher survival rates ($P<0.05$) were observed at aeration levels of 0.62mL/min per L and 1.25mL/min per L, at salinity levels of 16 ppt and 24 ppt, and at light intensities of 500lx and 700lx. The influence of aeration level, salinity and light intensity on oil globule absorption, feeding incidence, and growth and survival of early-stage grouper larvae are discussed.

Proteolytic Enzyme Activity of Juvenile Asian Sea bass, *Lates calcarifer* (Bloch), is increased with Protein Intake

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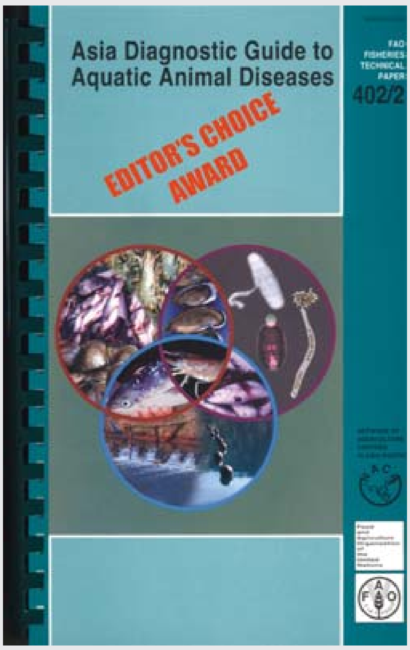
Aquaculture Research, 33(8): 569-574

The effect of high dietary protein intake on proteolytic enzyme activity of feeding juvenile Asian sea bass, Lates calcarifer (Bloch) was studied. Ninety fish [mean body weight±standard error (SE) 304.62±34.84g] were randomly assigned to two dietary treatments, each with three replicates. In treatment 1, fish were fed by-catch (Thunnus albacares) and in treatment 2, a formulated diet containing 50% protein. Proteolytic enzyme activity was determined in pyloric caecae and intestine at day 0, 7, 15, and 30. Initial proteolytic enzyme activity in sea bass ranged from 174 to 232 azocasein units (U^{AC}) per mg of protein. After 7days there was no significant difference in proteolytic enzyme activity of fish fed the two diets. However, a marked increase was observed in fish fed the formulated diet at day 15. After 30days, the proteolytic enzyme activity in fish fed the formulated diet was threefold higher than that in fish fed the by-catch diet. Fish fed the formulated diet had significantly higher total protein intake at day 7 than did fish fed by-catch. Thereafter, a twofold weekly increase in the total protein intake was observed in both fish fed the by-catch and formulated diets until day 30. These results suggest that a high dietary protein intake induces increased proteolytic enzyme activity in Asian sea bass.



Asia Diagnostic Guide to Aquatic Animal Diseases

The Asia Diagnostic Guide is a comprehensive, up-datable diagnostic guide for the pathogens and diseases listed in the NACA/FAO and OIE Quarterly Aquatic Animal Disease (QAAD) Reporting System including a number of other diseases which are significant in the Asia region. It jointly published by FAO and NACA under the Asia-Pacific Regional Programme on Aquatic Health Management.

This 240 page volume contains a general introduction on health and aquatic animals and the roles and levels of diagnostics. Section 2 to 4 cover Finfish Diseases, Molluscan Diseases and Crustacean Diseases. Each host section commences with a chapter on “General techniques” which covers essential starting points that will enable prompt and effective response(s) to disease situations in aquatic animal production. These chapters are not disease specific and emphasize the importance of gross observations and how and when they should be made, including information on environmental parameters worth recording, general procedures for sampling and fixation and the importance of record-keeping. The guide is illustrated with more than 160 colour photos. Limited hard copies and a CD version are available for cost of postage. A free electronic (PDF) version is available from the NACA website (http://www.enaca.org/aapqis/ - visit the publications link).

Breeding and Seed Production of the Mangrove Red Snapper

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Above: The mangrove red snapper

In recent years, mangrove red snapper (*Lutjanus argentimaculatus*) aquaculture has become popular in Southeast Asia and Australia. As an important food fish, it commands a relatively high market price. Supply of seeds to farms, however, is still dependent on fry collected from the wild, which is limited, seasonal, and unpredictable and therefore, limits the sustainability of its aquaculture. Thus, a reliable breeding and seed production protocol must be developed to ensure consistent and good quality seed supply to support snapper aquaculture. We will outline research highlights on snapper breeding and seed production at the Southeast Asian Fisheries Development Center's Aquaculture Department.

Using standardized indices of female maturity (based on mean oocyte diameter of > 0.40 mm), time of injection (1000 – 1130), and sex ratio (1 female to 2 males), a single injection of 100 mg/kg body weight (BW) of luteinizing hormone-releasing hormone analogue (LHRHa) successfully induced spawning. Out of 16 trials, 62.50% had egg production and 43.75% had hatched larvae. Spawning was not observed at 50 mg/kg BW LHRHa. Similarly, spawning was also not observed at 500 IU/kg BW of human chorionic gonadotropin (hCG). However, doses of 1,000 and 1,500 IU/kg BW of hCG induced spawning. Higher success rates of egg (77.27 and 80.00%, respectively) and larval (72.73 and 60.00%, respectively) production were obtained for 1,000 and 1,500 IU/kg BW hCG than LHRHa. Furthermore, 1,000 IU/kg BW hCG had a higher percentage (76.47%) of spawns with egg collection per spawn in excess of 1 million than those of 1,500 IU/kg BW hCG (41.67%) and 100 mg/kg BW LHRHa (30.00%).

Gonadal biopsy of mangrove red snapper broodstock to check for sexual maturity prior to induced spawning

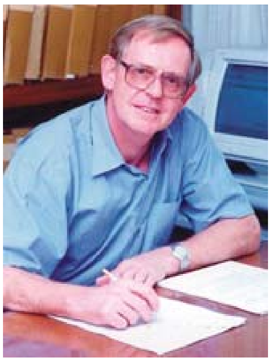
When left undisturbed in concrete tanks (150-ton capacity) and floating cages (10-m diameter by 3 m deep), mangrove red snapper, spawned naturally from March-April to November-December in Central Philippines. About 0.05 – 6.35 million eggs were collected per spawn. Total egg collection in tanks (68 million) and cages (75 million) for 2 years was similar. Each tank or cage was stocked with 10-15 females and males. The percentage of egg viability (those with developing embryo 12 hours after spawning) from natural spawns (75%) was not different from induced spawns (64%) but natural spawns had higher hatching rates (69%) and percentage of normal larvae (69%) than those of induced spawns (45 and 40%, respectively). On the average, for every spawn, about 35% normal larvae can be produced from natural spawns compared to only 16% from induced spawns. Natural spawning followed a lunar periodicity. Most spawns were observed about three days before or after the last quarter and new moon.

Broodstock were given a practical diet (39% protein, 9% lipid) had higher total egg collection (82 million from 69 spawns) and mean number of eggs per spawn (1.21 million) than those fed raw fish (77 million from 66 spawns; 1.18 million eggs/spawn). Broodstock fed the practical diet had higher percentage of spawns (49%) with egg collection in excess of 1 million per spawn than that of broodstock fed raw fish (41%). Rates of egg viability, hatching and normal larvae of spawns from broodstock given formulated diet were similar to spawns of broodstock fed raw fish. However, survival activity index (4.08) of broodstock given formulated diet was higher than that of broodstock fed raw fish (2.97). This indicates that larvae of broodstock fed formulated diet survived longer under starvation than larvae of broodstock fed raw fish.

In the hatchery, wastes in the rearing tanks were siphoned every other day. Water exchange was 20-30% on day 2 to day 20, 50-70% on day 21 to day 35. The tanks were supplied with flow-through water from day 35 until harvest. Green water using Chlorella was provided to the tanks from day 2 to 35. Larvae were fed rotifers at 20 individuals/ml (day 2 to 20) and 10 individual/ml (day 21 to day 28), brine shrimp nauplii (day 21 to day 50), and minced raw fish (day 38 to day 55). Larvae were harvested on Day 55 but over-all survival rate is still below 1%.

Newly-hatched larvae reared in 3-ton tanks had higher survival rate (13%) after 21 days when stocked at 15,000 than at 30,000 (4%) or 45,000 (5%) per ton. Older larvae fed a mixed diet (50:50) of brine shrimp nauplii and artificial diet had best growth and survival than those fed brine shrimp nauplii alone or weaned to the larval diet at 10% reduction in brine shrimp nauplii. The results suggest that the formulated diet can replace brine shrimp nauplii for snapper larviculture. The formulated diet will be tested on earlier larvae to determine its suitability.

Mangrove red snapper broodstock in cage lined with fine mesh net to retain eggs. The net is lifted every morning to allow water exchange. Eggs are collected with a sweeper (right)



Peter Edwards writes on

Rural Aquaculture

Aquaculture for Poverty Alleviation and Food Security - Part II

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This issue's column is based on the remaining seven presentations from the session on "Aquaculture for Poverty Alleviation and Food Security" at World Aquaculture 2002 held in Beijing in April. My previous column (Volume 7, No. 2, pp. 53-6) outlined five presentations.

Aquaculture is often considered to be the only way for small-scale farming households to increase their supply of aquatic organisms. This may lead to policy decisions detrimental to the overall output of the farming system, particularly if attention is devoted mainly to intensification of rice. As Matthias Halwart of FAO, Rome, pointed out, "rice fields provide much more than rice". In the presentation entitled "Availability and Use of Aquatic Organisms in Rice-based Farming Systems in the Southeast of the P.R. China" by M. Halwart, A. Luo, D. Bartley and J. Margraf, Matthias described the findings of a three month field study among 14 ethnic groups, predominantly the Dai minority, in Xishuangbanna, Yunnan province to gain insight into their indigenous knowledge of aquatic organisms in the ricefield agro-ecosystem. 65 species of fish, and five amphibian, five mollusc, three insect and two crustacean species were obtained by villagers using 25 collection methods and tools. There is a need to raise awareness of aquatic organisms among R & D practitioners and policy makers. Strategies and action plans for the protection and management of aquatic biodiversity in natural agro-ecosystems of the Lancang – Upper Mekong River Basin were drawn up in a provincial level workshop.

The next three presentations by David Little and his doctoral students from the University of Stirling were on inland rural aquaculture in South Asia. In "Identified Opportunities for Inland Aquaculture Development in Dry Zone, Northwest Sri Lanka" by D.C. Little, L.J. Pollock and F.J. Murray, David pointed out that rural aquaculture barely exists in the country because aquaculture has been promoted without adequate understanding of demand for the products, access or rights to utilize water resources, or the needs and assets of potential beneficiaries. A surprising conclusion of the study is that semi-intensive aquaculture in on-farm ponds depending on hatchery-produced seed that has proved successful elsewhere in Asia, is currently inappropriate for Sri Lanka.

Tilapia harvested from a seasonal tank in Sri Lanka. Courtesy Murray, Pollock and Little

Analysis of resources and needs has led to the view that aquaculture can be promoted without conventional hatchery development through transfer of adult and wild-spawned tilapia seed at local level. Opportunities for the development of aquaculture lie mainly at either end of the aquaculture intensity spectrum within communal water bodies and thus need to consider the multidisciplinary nature of, and access to, such water resources. The two technologies currently being investigated are extensive stock manipulation by poor groups of locally available tilapia and indigenous fish in community-managed seasonal reservoirs or tanks, and cage-based fattening of tilapias by poor fishers around perennial reservoirs. Their sustainability and wider dissemination are considered to be feasible because of low reliance by the community on external inputs such as seed and feed.

Lindsay Pollock presented case studies comparing an agricultural with a fishing community in which cage-based fattening of tilapia was introduced to households in both, in "Participation of the Rural Poor in Aquaculture: Case studies in Northwest Sri Lanka" by L.J. Pollock and D.C. Little. Various resources were required such as access to live fish for stocking, access to feed ingredients, time for feed preparation (from wild fish and rice bran) and feeding, and access to markets. Household-level activities involved cage construction, feed preparation, feeding, observation, and harvesting and selling fish. Participation in trials was affected by access to resources, gender, risk and other income generating activities. Reasons for continued involvement in, or abandonment of cage culture were numerous but further improvement of the system may increase the rate of adoption.

Women participating in cage culture in a perennial tank in Sri Lanka. Courtesy Pollock and Little

Cage-based fattening of tilapia in a perrennial tank in Sri Lanka. Courtesy Pollock and Little

Francis Murray outlined approaches for developing aquaculture in seasonal water bodies (SWBs) in "Managing Aquatic Resources to Benefit the Poor Where Water is Limiting: Lessons from India and Sri Lanka" by F.J. Murray and D.C. Little. SWBs are a substantial yet underutilized resource for rural aquaculture in water-stressed areas as development initiatives have focused largely on irrigation. SWBs are often highly productive because of nutrient release from sediments exposed to the air as they dry out, in spite of limited periods of water for fish culture. These multipurpose SWBs are located in upper watershed areas where they benefit the poor in marginal rain-fed agro-ecosystems. The "invisibility" of these small-scale community / household managed systems contrasts with larger perennial reservoirs that are managed by government agencies.

Conventional hatchery-based seed production is usually promoted for stocking SWBs but the former are mainly located in distant areas with perennial water, a major constraint to timely and cost-effective use of the seed in the latter.

Farmer-managed trials were carried out in India in farm ponds, backyard ponds with women's groups, check dams and open wells; and in Sri Lanka in small-scale tank cascade systems, which are community managed. Availability of seed for stocking was a major constraint in India but tilapia fry and adults, and snakehead fry, were obtained from lower perennial tanks in the cascade system for stocking in Sri Lanka. Poor growth resulted in India, in

A seasonal tank in Sri Lanka. Courtesy Murray and Little part because of lack of feed resources, but 9 out of 24 households harvested 0.5-1.5 kg fish two to three times a week over 2-3 months in seasonal tanks in Sri Lanka.

Cecile Brugere presented "Aquaculture for Poverty Alleviation: Can it also Improve the Position of Women ?" in which she questionnaired, from a theoretical point of view, whether aquaculture can be used for the empowerment of women. While gender is implicit in livelihoods approaches and aquaculture may lead to poverty alleviation, aquaculture interventions may not necessarily challenge women's subordinate position in society. Two kinds of problems arise: women's role in decision-making within the household regarding the uptake of aquaculture as a suitable food and income generating activity; and women's access to, and control over, aquaculture resources and benefits. Based on case studies of the introduction of small-scale cage aquaculture into Bangladesh and Sri Lanka, Cecile presented a "capability improvement framework for women in aquaculture" as well as courses of action and policy recommendations derived from the case studies so that gender, as well as social impacts of the introduction of aquaculture may be taken into account. Improved livelihoods should not be the only goal and women's empowerment should go hand-in-hand. She concluded by stating that rather than "women for aquaculture", it should be "aquaculture for women".

There was only a single presentation on coastal aquaculture, "Role of Mariculture in Securing Food Supply and Reducing Poverty in the Philippines" by W.G. Yap. Wilfredo pointed out that aquaculture in the Philippines is dominated by marine and brackishwater aquaculture, unlike most other countries in Asia. Freshwater aquaculture has a relatively recent history in the Philippines and has not really taken off. With an estimated 75% of Philippine mangroves developed into brackishwater fish and shrimp ponds (which are largely in the hands of the rich), a ban on further development in mangroves, and a dwindling catch from coastal fisheries, mariculture offers the only opportunity for most of the coastal poor, the great majority of whom are landless.

A check dam in India. Courtesy Murray and Little

With a total coastline of 17,480 km, there are many opportunities for the coastal poor to engage in mariculture. Mussels, oysters and seaweeds require low capitalization and are farmed by the poor. Ironically according to Wilfred, it is the culture of high-value fish such as grouper for the lucrative export and restaurant markets that has potential for the poor, providing that constraints of access to capital and markets can be overcome. The rich produce the traditional Philippine food fish, the milkfish. Wilfredo presented convincing economic data to show the comparative advantage for the poor to invest in grouper rather than milkfish.

The final paper in the session, "Tilapias from Different Aquaculture Systems Contain Variable Amounts of w-3 and w-6 Polyunsaturated Fatty Acids: Implications for Human Nutrition" by I.T. Karapanagiotidis, M.V. Bell, D.C. Little and A. Yakupitiyage, followed on nicely from Michael Crawford's plenary lecture. Professor Crawford made the case that the evolution of the human brain depended on polyunsaturated fatty acids (PUFAs) in the diet derived from aquatic food. Ioannis also outlined the beneficial effects of fish in the human diet. The study he reported analyzed the fat content and fatty acid composition of Nile tilapia from various culture systems. Higher levels of w-6 and lower ratios of w-3/w-6 were found in fish fed pelleted feed compared to wild fish and fish cultured mainly on natural food in fertilized ponds. Ioannis concluded that awareness should be raised among change agents and policy markets that the intensive culture of fish can have an adverse effect on fish quality, which may have an adverse impact on human health.

Women managing a cage in Bangladesh. Courtesy Brugere

Seed Production of Mud Crab Scylla spp.

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Crab farming

Mud crab farming is an important source of income for fishfarmers in the Philippines. The expanding export market for mud crab as an alternative for shrimp has led to intensified collection of wild seed for grow-out and has threatened the wild stocks. To ensure the sustainability of crab farming and reduce the fishing pressure on wild stocks, the SEAFDEC Aquaculture Department developed a technology for large-scale production of juvenile mud crabs, *Scylla serrata* (giant mud crab), *S. olivacea* (orange mud crab) and *S. tranquebarica* (purple mud crab). The methods are outlined below.

Fig. 1a: Scylla serrata

Fig. 1b: Scylla olivacea

Fig. 1c: Scylla tranquebarica

Breeding

Pond-grown females of the mud crabs are obtained from crab dealers. The taxonomic identification of species was based on a scheme developed by Keenan et al[1]. The crabs are examined for ovarian maturity by looking through the transparent membrane between the junction of the first abdominal segment and carapace. Mature ovaries are dark orange. Crabs with immature ovaries (light yellow) are ablated on one eyestalk.

The crabs are held in a concrete tank with sand substrate and PVC pipes (20 cm diameter x 30 cm length) as shelters. They are fed mussels, squid and fish at 10-15% of body weight daily and a SEAFDEC-formulated diet[2] at 2%. Live marine annelids are offered to crabs once every 1-2 weeks asa supplement. We maintain water depth in the tanks at about 30 cm. The seawater used for the crab breeders and larvae is pre-treated in a reservoir with 10-20 ppm calcium hypochlorite and then neutralized with sodium thiosulfate after 12-24 h. The water in the tank is changed daily before feeding.

Eggs released by the female become attached to the pleopod hairs of the abdominal flap. Sampling for egg-carrying or berried females is done

Fig. 2. Examination of ovary color between the junction of the first abdominal segment and carapace

when water levels are reduced during the water change. Berried females are then transferred individually to 300-liter or 500-liter tank with aerated sea water at 32 ppt. Berried crabs sometimes lose some or all of their eggs due to fungal infection, failed fertilization, nutritional deficiency, or environmental stress. At longer incubation periods, the eggs may become infected with fungus and filamentous bacteria and infested with protozoans. These infections retard embryonic development and increase the egg mortality due to restricted oxygen exchange across the egg membrane[3,4]. To counteract fungal and ciliate infections we treat berried females with, 0.1 ppm Treflan (44% trifuralin) every three days in the hatching tank. This treatment has no adverse effect on the eggs and newly hatched zoeae.

Each spawning produces 0.8-4 million zoeae in 350-525 g *S. serrata*, 0.7-3 million zoeae in 240-300 g *S. tranquebarica*, and 0.4-2.7 million zoeae in 360-465 g *S. olivacea*. Hatching occurs 7-14 days after spawning at temperatures of 26.5-31°C.

Larval rearing

Zoeae are stocked at a density of 50 individuals per liter in circular concrete tanks (4 m diameter x 1 m height) and fed with the rotifer *Brachionus rotundiformis* at a density of 10-15 rotifers/ml (Table 1). The microalga *Chlorella* sp. is maintained in the rearing tanks at 50,000 cells/ml as food for the rotifers. Brine shrimp *Artemia salina* nauplii are also given at 0.5-3/ml to zoea 3 and larger larvae. *Artemia* densities over 5/ml may not be economical to use in commercial-scale hatcheries.

The zoeae are reared at a salinity of 32-34 ppt and water temperature of 26-30.5°C, and a natural photoperiod of 11-13 hours light and 11-13 hours dark. The rearing water is replaced at a daily rate of 30% starting on day 3 and increasing to 80% as larvae grow bigger or when disease-causing luminescent bacteria are detected in the water and larvae.

Nursery

Megalopa are nursed in concrete tanks or in net cages set in brackishwater ponds. To prevent or reduce cannibalism, the stocking density of 3-5 day old megalopa in nursery tanks is reduced to 1000-2000/ton of water. Black nets are placed at the bottom as substrates and some are suspended in the water column. Food consists of newly hatched and adult *Artemia*. As soon as the megalopa molt to crab stage stage, they are fed minced trash fish, mussel, or small shrimp *Acetes* twice daily ad libitum. About 30-50% of the volume of the rearing water (26-30 ppt) is replaced daily during the first 5 days and every two days thereafter.

Using several hatchery tanks to rear megalopa up to juveniles at low density is not cost-effective because these are better used for rearing the zoea, which have a faster turnover.

Ponds provide a wider surface area for the dispersion of megalopa provided that the ponds are predator-free and have substantial natural food. Nursery net cages (mesh size 1 mm; bottom surface area 20 m^2 are set in ponds for the megalopa. Bamboo poles support the cages and the bottom of the net is buried 3-5 cm into the pond soil. A good growth of natural food is obtained about a week after the application of organic fertilizer at one ton/ha and inorganic fertilizers, urea (45-0-0) at 75 kg/ha and ammonium phosphate 16-20-0) at the ratio of 1:2.

Megalopa to be transferred to net cages are packed in plastic bags at 200-300/liter. Megalopa are stocked at 30/m^2 and fed adult Artemia on the first day in net cages. Food is then changed to minced trash fish and mussel placed in feeding trays. Water depth is maintained at 60-80 cm. About 30% of the water is replaced 3-4 times a month.

Strategies to reduce cannibalism include size-grading, trimming of claws,

Fig. 3. Net cages set in brackiswater pond for the culture of megalopa to crab stage

A

Fig. 4. Mud crab juveniles subjected to trimming of claws (A) & removal of chelipeds (B)

B

removal of chelipeds[5,6], and provision of sufficient shelters. However, chelipeds are not removed from crabs larger than 2.5 cm in carapace width because growth may be affected. Trimming the claws and removal of chelipeds are tedious and are practical only for a small population of crabs.

The survival from zoea 1 to 3-4 day old megalopa is 3-7%. The survival from megalopa to juveniles (1-3 g body weight) after 30 days in hatchery tanks or pond cages is 30-50%. A considerable number of crabs for grow-out can be produced if the megalopa are nursed in net cages in ponds. Crabs that are about 1 g and 2 cm in carapace width can be stocked directly in grow-out ponds (Fig. 3). Hatchery-reared crabs have been grown to marketable size in ponds since late 1999.

The problems that we have encountered in the crab hatchery include: a) egg loss in berried females due to fungal infection, epibiotic fouling, and unfertilized eggs, b) luminescent bacteria, and c) cannibalism among megalopa. The methods described above are being refined to improve the survival from megalopa to crab stage so that the technology would become economically viable.

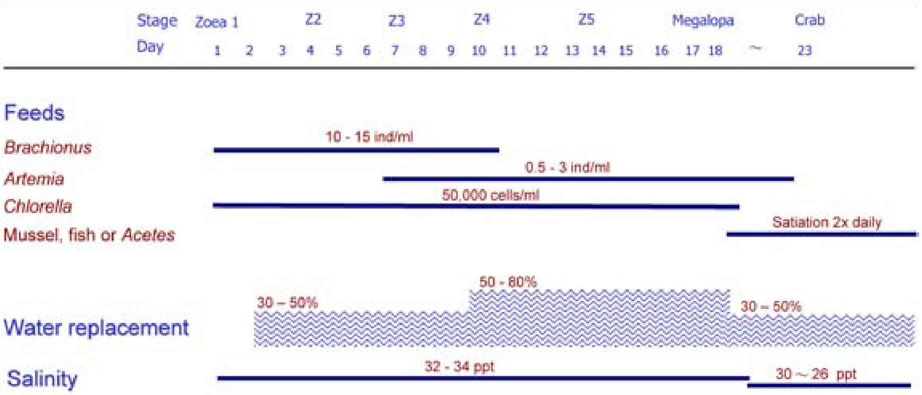
Grow-out

Crab juveniles are grown to marketable size in earthen ponds, or in net or bamboo pens in mangroves or tidal zones. After the application of lime in earthen ponds, pest and predators are eradicated by the application of tobacco dust, tea seed or a combination of hydrated lime and ammonium sulfate. The inner side of pond dikes is enclosed with nets or bamboo mattings with 30-50 cm width plastic sheets along the top of the fence to prevent the escape of crabs.

In both ponds and pens, juveniles are stocked at 0.5-1.5 individuals per square metre[7,8]. Food items are fish, molluscs, crustaceans, waste materials such as animal hides entrails and fish offal at 10% of the crab biomass/day for the 1st month. Feeds are reduced to 8% on the 2nd month and 5% crab biomass/day on the 3rd month until the end of culture period (Triño et al., 1999). Water is maintained at 80 cm depth and is replenished during high tides. In ponds, a pump is used when water change is needed during neap tides. Partial harvesting is done when *S. olivacea* and *S. tranquebarica* reach ^{3}200g and ^{3}350 g for *S. serrata*. Total harvest is done after 4-5 months and a survival rate up to 86% can be achieved.

Fig. 5. Mud crab ponds with net enclosures

Table 1: Feeding and water management used in the culture of Scylla spp. larvae



Acknowledgement

Some results presented in this paper were derived from Project PN9217 funded by the Australian Centre for International Agricultural Research.

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Topical issues in genetic diversity and breeding

Genes and Fish

Graham Mair

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The dilemmas of strain selection

In this issue I discuss some of the factors behind one of the most basic and cost effective methods of improving the performance of our cultured stocks, namely the selection of the best existing strain for a particular environment. Most of us are aware of the importance of production factors such as nutrition, water quality and general husbandry methods and the advances that have been made in the understanding and management of these factors in recent decades. Very often investments are made in aquaculture technologies and in facilities, which are then applied to whatever fish may be available at the time. Without using the best available stock it clearly will not be possible to optimize yields, whatever technology is applied within aquaculture systems.

For most aquaculture species, there are a large number of domesticated and improved strains in production and the gains achieved by the choice of the best existing strain can be equivalent to the genetic gains that could be achieved from many generations of selective breeding using inferior strains. When selecting strains it is most effective to conduct direct comparisons within the farm environment, measuring all commercially important parameters. Ideally strain selection should include an evaluation of existing local strains by way of a control. Such an approach would then account for what should be positive aspects of any local adaptation affecting the relative performance of the local stock that might have been bred in the "home" environment for several generations.

If the selected (i.e. chosen) strain(s) is intended as a base for a selective breeding program, it is useful also to make some assessment of the levels of genetic variation within the strain(s). This variation, apart from commonly being correlated with general "fitness" parameters, is necessary in order for selection to succeed.

By way of illustration of the potential gains that could come from appropriate strain selection, typically comparisons of growth rate in several different available strains can easily yield differences between the fastest and slowest growing strains of 50% or more. Such differences have been demonstrated in both tilapias and carps for example.

Methods of comparison

There are basically two methods for conducting comparisons of different strains, by stocking strains communally within a common environment or by stocking strains separately in replicated culture units. Test environment should ideally closely resemble the actual production environment to minimize the risk that significant genotype x environment interactions will result in incorrect assumptions being made about the relative superiority of selected strains when extrapolating results from one environment to another.

Communal stocking

Under communal stocking, fish from the different strains are produced and reared separately up to an age and size at which they can be marked. Following marking they are then mixed and reared through the production cycle, being sampled periodically to determine relative growth. In this type of study each individual fish within an environment is considered as a replicate. The main advantages of communal stocking are that it requires relatively few facilities, removes any effect of environmental variance on the growth of the individual fish (as the strains are all in the same environment) and usually enables identification of statistically significant differences.

The main disadvantages are that differences between strains in genetic potential for growth can be modified (usually magnified) by competitive interaction between strains. For example a strain may grow faster because it is more successful at accessing feed ahead of other strains rather than having a better genetic growth potential. Also in communal stocking, differences in initial size at stocking might be exaggerated by competitive interactions during grow-out (although research investigating the predictability of final weight based on initial weight has produced ambiguous results). Competitive interactions are likely to be less significant in fertilization only systems where there is essentially less competition for food resources. There is nevertheless a risk that incorrect assumptions can be drawn from communal stocking experiments due to these interaction factors. This competitive interaction effect can be countered to some extent by utilizing internal reference strains and assessing parameters relative to the reference strain. Also correction factors for differences in initial size can be estimated by deliberately inducing differences in initial size, within strains by multiple pre-nursing of batches under different stocking densities.

Another disadvantage is that certain parameters cannot be measured under communal stocking such as relative food conversion efficiencies or the effects of different sex ratios on the overall growth of populations.

It should be possible to integrate communally stocked trials into the regular production system on the farm with tagged fish followed through to harvest and even processing. This is an ideal situation as we can be confident that our interpretation of the relative performance of strains really does apply to the culture environment of interest.

Separate stocking with replication

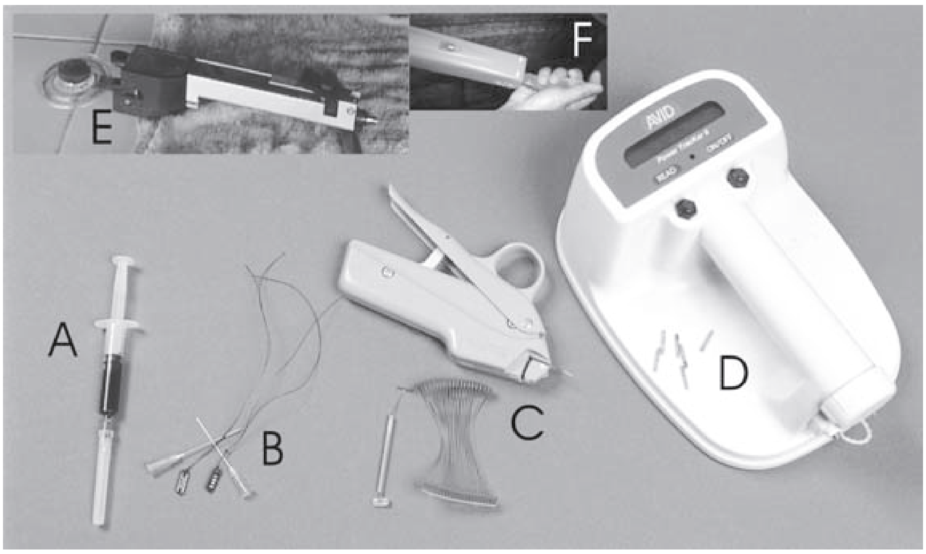
In separate stocking, the strains are stocked separately in discrete units (tanks, cages or ponds). In order to take account of inevitable differences between the individual units (e.g. in water quality, post mortality stocking densities etc.) each unit must be replicated for each strain. The number of replications required depends on the degree of variation between environments. In fairly uniform culture environments (such as cages within the same water body) a minimum of three replications can suffice but in more variable environments, especially ponds in which growth performance can vary widely, five or more replicates may be required. The major disadvantage of separately stocked comparisons is that they require heavy use of facilities and, even with good replication, high variation between culture units can disguise real differences between strains so that they appear statistically insignificant. Due to the requirement for replication, culture units used for separate stocking are often smaller or of a different type than normally used for production and thus representing a different environment increasing risks of incorrect interpretations due to genotype x environment interactions.

The major advantages are that, if environmental differences are effectively minimized, results from successful experiments are more reliable and more parameters can be measured when stocks are reared separately.

Summary

Having myself been involved in many strain evaluations with both communal and separate stocking approaches I perceive significant risk of arriving at incorrect interpretations of data coming from these trials, particularly if the data are not analyzed correctly. Often replicated trials yield differences in mean growth rates and harvest size of strains of considerable magnitude and yet between replicate variance results in differences being statistically non-significant. Also heterogeneity of variance that cannot be corrected by data transformation often invalidates assumptions of ANOVAs. Communal stocking more commonly yields statistically valid and significantly different growth rates between strains. Provided there are not large differences in stocking size, I usually have confidence in the ranking of the strains but how confident can we be that the magnitude of the differences has not been affected by competitive interactions?

Logistical constraints often dictate that communal stocking is the most practical method for strain evaluation and this is likely to be the case for most farm-based evaluations, provided marking options are accessible. Such trials can produce very useful results but attention must be given to the possible effects of competitive interactions between strains. Intelligent use of internal reference strains or multiple pre-nursing to generate different stocking sizes can be used to partially correct/mitigate for interaction effects and thus making for more reliable data.



(Modified from photo by K. Rana.)

Communal stocking of strains requires that fish from different strains be distinguished. Usually this is not possible based on appearance alone and it is necessary to mark the fish. There are many options for marking and tagging fish, some of which are shown in the accompanying photo including dye marking (A), numbered fingerling tags (B), "T-bar" floy tags (C), electronic PIT tags (D – tags and reader) and coded wire tags or CWT (E – applicator; F – detector). For communal stocking individual identification is usually not required so batch marking methods are usually more cost effective. My current preferred marking method is with CWT, which can mark four or five genotypes using different tagging positions. This can be combined with fin clipping for more options.

Molecular methods for rapid and specific detection of pathogens in seafood

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Seafood export are a major source of foreign exchange for many developing countries in Asia. Though generally seafood is considered a safe food, there are a few instances of outbreaks of food poisoning linked to seafood. Since seafood is often going to markets that are highly demanding in quality and safety, the seafood exporting countries need to take extreme care to ensure continued market access. One of the major concerns in seafood is the presence of pathogenic microorganisms. Because of this concern, often seafood processors have to ensure the absence of pathogenic bacteria such as *Salmonella*, *Vibrio cholerae*, *V. parahaemolyticus* and *Listeria monocyotogenes*. Therefore quality assurance programmes require testing of raw material, product, water, ice and equipment for the presence of these pathogens.

Conventional microbiological methods for the detection of these pathogens is very time consuming and laborious. Figure 1 illustrates the general scheme for isolation and identification of pathogens. It takes between 4-5 days to detect pathogens by this method. Further problems arise due to situations such as the following:

Among *V.cholerae bacteria*, only serotypes O1 and O139 cause cholera. Among environmental isolates of serotype O1 non-toxigenic strains also exist.

Among *V. parahaemolyticus* only less than 2% of environmental strains are pathogenic. These are characterized by their ability to produce a thermostable direct hemolysin (TDH) or TDH- related hemolysin (TRH). While the former can be detected using a blood agar medium, Wagatsuma agar, there are quite often false positive reactions in this test. Preparation of this medium requires fresh (less than 24h) human or rabbit blood, which is difficult to obtain in most laboratories. There is no phenotypic test for TRH production.

Figure 1: General scheme for detection of pathogens in seafood

Seafood
↓
Selective enrichment
(minimum 2 broths for *Salmonella*)
↓
Selective plating
(minimum 3 different media for *Salmonella*)
↓
Biochemical testing of typical colonies
(10-15 tests)
↓
Serological confirmation

During recent years, molecular biology based methods have revolutionized pathogen detection. Rapid DNA based methods are facilitating specific detection of pathogens in foods.

Pathogen detection by molecular methods

Molecular methods that are gaining popularity in food safety assurance are (a) polymerase chain reaction (PCR) (b) DNA probe hybridization methods. The former is based on nucleic acid amplification and therefore has very high sensitivity. But it requires special laboratory facilities and can also detect dead bacteria in processed foods. On the other hand, DNA probe hybridization, when performed as colony hybridization, does not require expensive equipment, detects only live bacteria and give quantitative data. The objective of this article is to illustrate the application of PCR and DNA probe hybridization in seafood safety assurance.

DNA probe hybridization is based on the principle that (a) DNA is a double stranded molecule (b) the two strands of DNA can be separated by heating or chemical treatment (c) the two separated strands can reassociate (d) DNA strands from different sources can hybridise, provided there is complementarity of bases (A-T; G-C) between them.

Based on this principle, it is possible to make probes specific different microorganisms. Probes are short stretches of nucleotides that have sequences complementary to the target sequences. To detect probe hybridization, probes are labeled either with a radioactive molecule (p32), enzymes, ligands (eg biotin) or antigenic substrates (eg. digoxygenin). Figure 2 illustrates a typical probe.

Genes that are chosen as targets are those specific for each bacteria. In the case of pathogenic organisms, these are genes that encode virulence factors i.e. factors that make the organism pathogenic. Some examples of these genes are given in Table 1. Pathogenic *V. cholerae* produce a toxin, cholera toxin encoded by ctx gene. The virulence factors in *V. parahaemolyticus* are encoded by tdh and trh genes. The virulence factors in *L. monocytogenes* are encoded by iap and hly genes. In *Salmonella*, there are virulence-associated genes such as inv. Enterohemorrhagic *E.coli* have virulence genes such as stx, eae. Using such specific probes, it is possible to specifically detect the pathogenic strains of bacteria. Figure 3 shows a general protocol for detection of pathogenic bacteria using colony hybridization.

Figure 2: Illustration of the principle of DNA hybridization technique

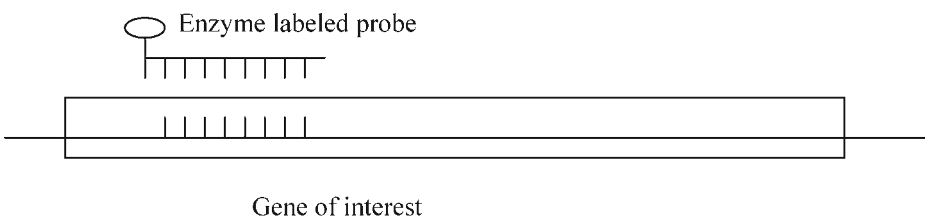
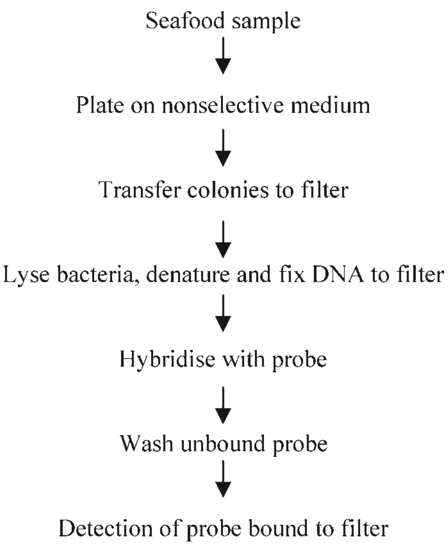


Figure 3: General protocol for pathogen detection by colony hybridization



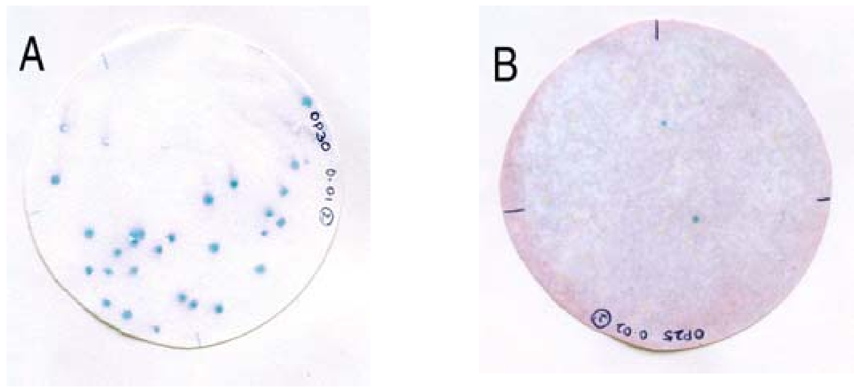
The food sample is homogenized (1:1) in a buffer and plated on a non-selective agar. The plates are incubated at 35°C for 18 h. The colonies appearing on the plate are transferred to a suitable filter. The bacterial cells are lysed by immersion in a lysing solution and the DNA released are denatured and fixed to the filter.

The filter is now incubated in a prehybridising solution and then the probe is added. Hybridisation is performed at a temperature appropriate for the probe. After hybridization, the filters are washed at a specified temperature. Probe hybridizing to DNA on the filter is detected depending on the type of label. If radioactive probe is used, detection is by autoradiography, where in the filter is incubated with a X ray film, one can see spots corresponding to colonies to which probe has hybridized.

However, presently a number of non radioactive probe labels are available. Most convenient are enzyme labels which can be detected using the appropriate chromogenic substrate. Figure 4. shows colony hybridization for detection of *V. parahaemolyticus* in seafood using an enzyme labeled probe.

To detect pathogens that may be present in extremely small numbers, the food samples may be enriched before plating. The filters after hybridization can be preserved as a record of analysis. Probe hybridization analysis requires no sophisticated equipment. A hybridization incubator is all that is needed. Therefore this technique can be most conveniently adopted in seafood quality control laboratories. In some situations, DNA probe-based methods are essential to detect pathogenic strains of organisms eg. *Vibrio parahaemolyticus*. This organism is commonly found in coastal and estuarine areas all over the world. 98% of environmental strains are not pathogenic. Hence mere detection of this organism by conventional microbiology is not sufficient to determine the hazard. DNA probe hybridisation methods are getting wide acceptability in quality control laboratories and the US Food and Drug Authority Bacteriological Analytical Manual describes this method indicating acceptance by the regulatory agencies. In the case of bacteria such as *Salmonella* and *Listeria monocytogenes*, DNA probe hybridisation methods have undergone multilaboratory evaluations conducted through AOAC and are accepted as official methods.

Figure 4. Detection of total V. parahaemolyticus *using probe for thermolabile hemolysin and pathogenic* V. parahaemolyticus *using probe for thermostable direct hemolysin (B)*



Polymerase chain reaction and its applications in assessment of seafood safety

PCR is a nucleic acid amplification technique wherein a specific portion of nucleic acid from a target organism is amplified in vitro. This specific amplification is achieved using oligonucleotide primers that are specific for the region flanking portion to be amplified. The amplification requires the enzyme DNA polymerase, and the building blocks of DNA, the deoxyribonucleotides (dATP, dTTP, dGTP, dCTP). The reaction is performed in several cycles, each cycle consisting of three steps (a) DNA denaturation: this is the step in which the target DNA strands are separated by heating to about 95°C. (b) Primer annealing: this is the step in which the primer binds to the target region specifically. This step is carried out at 55-65°C (c) Primer extension: this is the step in which the new DNA strand is synthesized by the DNA polymerase on the template strand. Normally about 30 cycles of reaction are performed. Since each cycle involves denaturation of DNA at 95°C, the DNA polymerase used in the reaction should be thermostable. The discovery of thermostable DNA polymerase from the thermophilic bacterium *Thermus aquaticus* led to rapid application of PCR in diagnostics.

By designing oligonucleotide primers that are specific for an organism, it is possible to design PCR to amplify specifically DNA from any desired organism. In the case of RNA viruses, it is possible to first copy the RNA into DNA using the enzyme reverse

Table 1: Examples of pathogens and target genes

Pathogen	Target genes for probe hybridization
Vibrio cholerae	*ctx*
V. parahaemolyticus	*tdh, trh*
V. vulnificus	*Vvh*
Salmonella	*inv, hns*
Enterohemorrhagic *E.coli*	*stx, eae*
Enterotoxigenic *E.coli*	St, Ct
L. monocytogenes	*iap, hly*

transcriptase. PCR used to detect RNA targets is referred to as RT-PCR.

PCR for detection of pathogenic bacteria in seafoods

PCR technique for detection of most pathogenic bacteria associated with seafood have been described. In most cases the oligonucleotide primers have been designed to specifically amplify virulence associated genes. For example contamination of seafood with toxigenic V.cholerae can be detected using PCR amplifying the ctx gene encoding the production of cholera toxin.

"98% of environmental strains are not pathogenic..."

Contamination of seafood with pathogenic V. *parahaemolyticus* can be detected using PCR amplifying the tdh and trh genes that encode virulence associated hemolysins. In the case of pathogenic *Escherichia coli*, the potential targets for amplification include stx gene encoding the production of shiga-like toxin, eae gene encoding intimin, heat-labile (LT) and heat stable toxins (ST) etc. In the case of *Listeria monocytogenes*, several target genes have been reported. These include the gene encoding the production of the invasion associated protein, iap, listeriolysin, hlyA, and the regulatory protein, prfA.

PCR is a DNA amplification technique and therefore, even if there are dead bacteria, they would showup in PCR. Therefore for determination of seafood safety, it would be important to ensure that only viable pathogens are detected. This can be achieved if PCR is performed after enriching the food sample in suitable broth.

"...using specific probes, it is possible to specifically detect the pathogenic strains of bacteria."

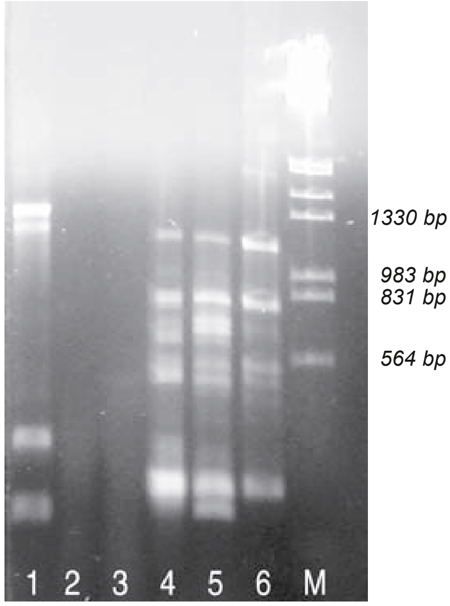
PCR Based techniques for tracing the source of contamination

Traditional methods of identifying bacteria by biochemical tests can identify them up to species level, but cannot differentiate between strains. Techniques such as serotyping and phage typing also have little discriminatory power. PCR based techniques such as Random Amplification of polymorphic DNA (RAPD) can generate DNA fingerprints of organisms. RAPD patterns are helpful in studying similarity or differences in strains. For example, this technique has been used to differentiate strains of *Listeria monocytogenes* isolated from raw fish and from smoked fish and from processing environments. This type of study would help in understanding the source of the strains found in the product, eg cold smoked fish. In this technique single 10 mer oligonucleotide primer is used to perform amplification at low annealing temperature (eg 37°C). The primer is not targeted at any particular region of the genome and therefore, this reaction can be performed even in the case of organisms whose genome sequence is not available. Figure 5 shows an illustration of the application of this technique. In our laboratory, we have been using RAPD to study the source of contamination of pathogenic *Vibrio* spp in seafood.

Conclusion

The safety of products of aquaculture has been a concern and assessment of safety requires detection of pathogenic microorganisms. Conventional methods for detection are time consuming and cannot discriminate between pathogenic and non-pathogenic strains. Molecular techniques such as PCR and colony hybridization are useful for rapid detection of pathogens and specific detection of virulent strains. Since these are rapid, specific and sensitive, they have immense applications in seafood quality control laboratory.

Figure. 5. Discrimination between strains of V. parahaemolyticus *using RAPD*



- Lane 1,2,3 & 6: Farm isolates from Kundapur, Karnataka
- Lane 4: Hatchery isolate from Kumta, Karnataka
- Lane 5: Hatchery isolate from Honnavar, Karnataka
- Lane M: Lambda Hind III/EcoRI digest

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Seed Production of the Crucifix Crab Charybdis feriatus

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Charybdis feriatus, a portunid crab formerly classified as *C. cruciata* and commonly known as the crucifix crab[1], is a commercially important species but is not being cultured commercially. *C. feriatus* is a good potential aquaculture species because of its meat quality, taste, and size. Berried females caught from the wild usually weigh from 150 to 350 g, but the males can grow up to 1 kg in body weight. This species can easily be identified because of its striking red and white color pattern[2]. It is often caught in deeper portions of the sea along with other portunids such as the blue swimming crabs *Portunus pelagicus*, but in much lesser quantities.

Studies directed towards seed production of *C. feriatus* began at SEAFDEC last July 2000 after earlier attempts[3] resulted in massive mortalities during the zoeal stages and megalopa could not be produced. Larval runs conducted last year at the SEAFDEC/ AQD hatchery produced megalopa and crab instar through techniques based on mud crab larval rearing[4]. Berried females caught from the wild were disinfected with 200 ppm formalin for 30 minutes before placing in spawning tanks. The eggs attach to the pleopods of the female and turn from yellow to dark gray then hatch after 5 to 7 days. Zoeae were fed the rotifer *Brachionus*. *Artemia* nauplii were added when the larvae reached the Z4 stage. Among zoeae stocked in tanks, 20 to 26% metamorphosed to the megalopa stage. High mortality was experienced immediately after molting to the megalopa stage and survival at crab instar 1 was 2 to 5% of the original number of zoeae stocked.

C. feriatus has six zoeal stages and one megalopa stage. Its zoeal and megalopa stages have previously been described[3,5]. Based on our larval rearing runs, it takes 18 to 26 days before the zoea 1 (Z1, Fig. 2) metamorphoses to the megalopa stage and another 5-10 days to the crab instar 1 stage when temperature is 26 to 28^{o}C.

Nursery culture

Three days after molting to megalopa stage (Fig. 3), larvae were transported in oxygenated plastic bags and transferred to 5 x 4 m net cages (hapa) installed in ponds. Nets were used for easier retrieval of juveniles. Techniques for nursery rearing were similar to those used for mud crab[6]. Megalopa stocked at 30 individuals/m^2 and fed with mussel meat had a survival of 25% and body weight of 1 to 7g after one month (see Fig. 4). Juveniles were stocked in grow-out ponds but did not survive. Mortality must have been due to the unsuitable salinity levels in the pond which went down to as low as 11 ppt. Laboratory tests conducted after pond stocking showed that survival is significantly lower in juveniles reared in 20 ppt salinity compared to those in full salinity water (32 ppt).

The crucifix crab, Charybdis feriatus

Breeding trials

Breeding of *C. feriatus* is presently being investigated. Adults caught from the wild were held in twelve-ton concrete tanks at a density of 6 to 10 individuals/ tank. Better survival and spawning were achieved when holding tanks were covered and opened only during feeding than when kept open and exposed to ambient lighting (12h light, 12h dark). Cannibalism and shell disease was also more rampant when water depth in the holding tanks was maintained at 0.5 meter than at 1 meter.

Adults were fed mussel meat and the marine annelid *Perinereis*. After 10 to 14 days in the holding tank, females began to spawn even without ablation. However, they produced significantly fewer zoeae (248,357 ± 14,989 Z1 or 867 Z1/ g body weight of the spawner) per spawning compared to females that were already berried when caught from the wild (559,527 ± 107,206 Z1 or 3,259 Z1/ g body weight). The fecundity of this species has been reported to be between 52,350 and 309,250 eggs/ female[7]. In our runs, females that spawned in captivity produced up to 490,000 and wild-caught berried females produced up to 1,200,000 zoea 1. Females that spawned in captivity spawned again 1 to 5 days after their eggs hatched into the zoea stage. A similar number of zoeae are released after this second spawning.

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What's New in Aquaculture

News

NACA launches Shrimp Media Monitoring Service

A regular bi-weekly summary of shrimp-related news and media reports is available for download from the NACA website in PDF format. The release of new summaries will be announced in the NACA electronic newsletter, available through the home page www.enaca.org.

Tougher testing of shrimp for export in Thailand and Vietnam

Vietnam is upgrading quality control of its shrimp exports in response to chemical residue related trade restrictions introduced by major export markets earlier this year. The restrictions were introduced by a number of key markets following the discovery of the antibiotic chloramphenicol, which may be hazardous to human health, in regional shrimp exports.

New testing equipment worth approximately $2 million has been purchased by the government with the first units due to arrive this month. Around 30 Vietnamese shrimp exporting businesses are also investing in rapid testing equipment, worth around $20,000. The local industry has expressed frustration over the short period of time given by the European Union, Canada and the United States for the industry to comply with new and lower maximum residue limits, which have fallen from 0.5 parts per billion to 0.3 parts per billion. Two samples contaminated with chloramphenicol were detected in August by the US Food and Drug Administration.

Thai authorities are also implementing stricter measures, with export bans threatened for shrimp companies found to be selling contaminated chemical residues. Thailand has committed to chemical testing of shrimp and chicken products at different points along the supply chain from harvest to export. In recent months the EU has been inspecting 100% of Thai shipments instead of random consignments. The volume of shrimp exports from Thailand to the EU has fallen by 70% over the first six months of 2002 compared to the same period last year. Sources: Far Eastern Economic Review, Issue 26 September and FIS.com 13 September 02

WAS launches cheap e-subscription for developing countries

The World Aquaculture Society has established an "e-subscription". This subscription is intended to allow people from least developed countries to access some of the benefits of the WAS at a special rate. For more details, visit the WAS web site www.was.org

The e-subscription costs only US$10 per year and includes access to the members area of the WAS web site, inclusion in the WAS membership directory, access to WAS meeting abstracts and members rates in the WAS store. E-subscription does not include members rates for WAS meetings or the right to vote in WAS elections.

STREAM launches Virtual Library

The STREAM virtual library has been upgraded. Please browse the book shelves! There is lots to read and many downloads and useful contacts. There are three ways to locate publications, documents and materials:

- You can look through Periodicals, Countries and Themes.
- You can look in the Virtual Library by typing key words into the search engine.
- You can connect to other websites through links maintained by STREAM.

The website is available through http://www.streaminitiative.org/newvirtual/VirtualLibrary.html

Coral trout spawning achieved in Philippines

The Bureau of Fisheries and Aquatic Resources (BFAR) has succeeded in spawning one of the world's most sought-after grouper, the coral trout (*Plectropomus leopardus*), known locally as suno, in its Palawan hatchery last month. Coral trout is primarily a reef-dwelling species. Destructive and illegal fishing methods such as cyanide and explosives are often used to catch this fish resulting in damage to adjacent reef habitat. High demand has made it one of the most expensive fishes in the region and it is a staple for the live fish restaurant trade. BFAR researchers were able to collect 77,000 eggs during the spawning on 9 August. The fingerlings (usually wild caught) are reared in floating cages. Source: Manila Business World

US shrimp industry accuses Asia and Latin America of dumping

US Shrimp fishers are planning possible lawsuits against up to 16 countries accused of dumping shrimp at below-market prices and damaging the US industry. The US is considering action against China, Vietnam, Thailand and several Central and South American countries for allegedly dumping shrimp in the United States and damaging the domestic shrimp industry.

Shrimp industry representatives from Alabama, Florida, Texas, South Carolina, North Carolina, Georgia, Mississippi and Louisiana attended the meeting in New Orleans, along with government officials from several US states. A steering committee has been formed for the action, which will meet in the next two weeks to decide if court action will be pursued.

If successful, the lawsuits could result in new tariffs being imposed on imported shrimp and possibly result in the introduction of import quotas. Source: Associated Press, 11 September 2002.

New system detects nodavirus in seabass

A new study on nodavirus by the French institute IFREMER has shown that ELISA (Enzyme-Linked Immunosorbent Assay) methods may be used to detect nodavirus infection in farms and to select virus-free broodstock. Nodaviruses cause a degenerative disease affecting the brain and retina of some fish species, notably grouper and sea bass, although it affects a wide range of others. ELISA allows early virus detection without harming fish by detecting specific antibodies in the blood. The epidemiological study of infection was performed on both wild and farmed seabass to assess the feasibility of using the serological test for detecting the virus. The results show that the system could be used to monitor infection in fish farms and for selecting uninfected individuals to serve as broodstock. The experiments performed with the ELISA method complement the currently internation standards recognized by the International Office for Epizootic Diseases (OIE). Source: FIS Latino, September 9

Mexico hosts workshop on capacity and awareness building on import risk analysis for aquatic animals

The Second Training/Workshop of the APEC Fisheries Working Group project was held from 12-17 August in Mazatlan with the assistance of Mexican authorities, NACA, the FAO and the OIE Fish Disease Commission. 61 regulatory authorities and administrators responsible for trade of live aquatic animals and aquatic animal health specialists came together to share experience, raise awareness, build capacity and contribute to the development of a practical manual for risk analysis in aquatic animal movements. Five APEC economies in the Americas (i.e. Canada, Chile, Mexico, Peru and USA) along with 2 economies in Asia (i.e. Australia and Thailand) with an additional representation from 12 countries in Latin America (i.e., Belize, Brazil, Costa Rica, Colombia, Cuba, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panama, and Venezuela). With the completion of the Mazatlan workshop, we expect a networking of people with certain skills and increased level of awareness on IRA on aquatic animals in 40 countries in the Asia-Pacific and the Americas.

Meeting recommends establishing a formal mechanism for regional aquaculture cooperation in the Americas

Participants from 18 countries agreed at an informal meeting in Mazatlan, Mexico, on 18 August, that a formal regional co-operation is imperative for sustainable development of aquaculture in the Americas. The success story of NACA and its support to Asia regional aquaculture should be considered as an example for exploring viable mechanisms for the Americas. Such mechanisms should support overall development of the aquaculture sector in the Americas, while addressing the issues of major concerns to the region on timely and priority basis; build on existing networks and agreements and should be complementary and should strengthen regional and inter-regional cooperation. An Ad-hoc Working Committee, consisting of members from FAO, NACA, APEC, United States of America, Ecuador and Chile, was established with the view to move the initiative forward. Participants represented Australia, Belise, Brasil, Canada, Costa Rica, Colombia, Cuba, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Peru, Panama, Thailand, USA, and Venezuela. The meeting was organized by FAO, NACA, APEC Fisheries Working Group and the Comision Nacional de Acuaculturay Pesca (CONAPESCA) of Mexico.

Thailand warns farmers against use of banned chemicals

Thai farmers have been warned against the use of the banned veterinary drugs chloramphenicol, dimetridazol, ronidazole, furaltadone, furazolidone, nitrofurantoin, nitrofurazone and nitrovin, by Thailand's Public Health Ministry, who are worried about losing access to major overseas markets such as the EU. The EU now insists on testing for these drugs, which have in the past been found in Thai products. Products from Vietnam and Myanmar are also tested. Positive results could result in a ban as happened with China. Frozen chicken and shrimp exports are worth around US$ 2.4 billion to Thailand annually. Farmers now risk fines of around US$ 500 and two years in jail. A recent crackdown by Thai authorities recently found six tonnes of chemicals but more is thought to be stockpiled. *Source: Associated Press, August 22, 2002.*

Vietnam-US catfish battle may continue for some time

Vietnam producers of basa and tra catfish have announced they intend to fight US producers in court despite the potential length of the case (up to one year). The Vietnam Association of Seafood Exporters and Processors (VASEP) are disputing US catfish producers' claims to the US International Trade Commission (ITC) that Vietnamese are deliberately dumping (exporting and selling products in the US at a price below the cost to produce in an effort to undermine US producers). VASEP state they are fully prepared to face the lawsuit and claims their product is low in cost due to low labour and production costs and it is sold at low prices globally, not just in the US. They also claim that while only 14 businesses supply the US, they are suing 53. They also have the academic support of US economists who state that the fall in US catfish prices is due to a general economic slump throughout the US. A win for US catfish farmers would be disastrous for the 300,000-400,000 farmers in southern Mekong Delta provinces. VASEP has also asked the ITC and the ministry to make objective decisions in line with bilateral trade ties to bring benefits to both the US and Vietnam. The ITC ruled that here was "reasonable indication" that a rise in low-priced imports of "certain frozen fish fillets" from Vietnam threatened to injure the domestic industry. The vote now allows the Commerce Department to continue the investigation into whether anti-dumping is occurring. This has been described by the Vietnamese foreign ministry as "an unreasonable petition based on totally groundless allegations". The Commerce Department could impose a preliminary duty in December after the completion of its investigation. Vietnam has further accused the US International Trade Commission (ITC) of being biased in allowing US catfish farmers to proceed with anti-dumping action. *Source: Agence France Presse, August 9, August*

15, 2002; Associated Press, August 8, 2002; Associated Press Online August 8, August 15, 2002; National Post, August 9, 2002; Pittsburgh Post-Gazette, August 18, 2002; Vietnam Investment Review, July 29, 2002; Saigon Times Daily, August 12, 2002.

Malaysian aquaculture zone planned

Rivers in the Gelang Patah zone of Malaysia are planned to be turned into an aquaculture zone following the application to the Rural Development Ministry two years ago by the Johor Baharu Selatan Farmers Organisation (PPJBS). Twenty-five operators are expected to take part in the project operating on the Sungai Simpang Arang, Sungai Pulai and Sungai Redang rivers. Already, 19 fish breeding ponds exist, capable of producing 1.5 million fry annually such as merah (red snapper), gerung belang (striped trevally), senangin (threadfin) and siakap (sea perch). *Source: BERNAMA, Malaysian National News Agency, August 14, 2002*

Philippine plan to develop more lobster farms

Following the success of its mariculture park and to further develop food security, the Island Garden City of Samal (Igacos) is to develop lobster farms in Babak. Although still in the early stages, the plan is to install cages in a mariculture park. The 10 million Peso park will be developed with the assistance of the Bureau of Fisheries and Aquatic Resources (BFAR) and the Asian Development Bank (ADB). Other mariculture parks have recently given Samal the Best Practices Award by the League of Cities of the Philippines (LCP) for innovative schemes for job creation, food security, sustainable development and the protection of marine resources. *Source: Business World Publishing Corporation, August 5, 2002.*

US funds Vietnamese shrimp breeding project

Work has begun on a US$ 5 million shrimp breeding project in Hai Phong, Vietnam. The ten-year project is intended to create 1,000 jobs and over 2,000 tonnes of shrimp per year. Funded by American Technologies Inc (ATI), the project will encompass all life stages from breeding to exporting to American markets. The 846 ha project will be conducted in two stages, building the initial ponds and infrastructure then later expanding. However, not all local farmers are happy, stating that compensation for land was less than their initial investment in it. (Source: Asia Pulse, August 15, 2002)

New publications

Fisheries Subsidies

Australian Bureau of Agriculture and Resource Economics

This report reviews the issues surrounding subsidization of the fishing industry throughout the world and also in an Australian context. The report reviews the type and level of subsidies employed and current activity and issues in relation to disciplining subsidies. The report is available as a free download (PDF 43 pages 97KB) from http://www.abareconomics.com/htdocs/pages/freepubs/free_fisheries.htm

Import competitiveness

Australian Bureau of Agriculture and Resource Economics

This report provides a profile of edible fisheries products imports into Australia, the role of imports in domestic seafood consumption and the competitiveness of commodities such as live and plate fish, white fillet fish and crustaceans against Australian wild-caught product. The report also examines the profitability of selected aquaculture species including salmonids, Asian seabass, shrimp, mussels and some native freshwater fishes. It contains some very useful statistics and trends on these areas. Available as a free download (PDF 49 pages, 336KB from http://www.abareconomics.com/htdocs/pages/freepubs/free_fisheries.htm

STREAM Workshop on Process Monitoring and Significant Change Report

The aim of the STREAM programme is to offer support to the livelihoods of poor people who manage aquatic resources through an inclusive approach. The aim of the workshop was to familiarize participants with the work being done in process monitoring and significant change; discussion and development of a practical information system that enables monitoring of development processes and significant changes occurring within the STREAM initiative; and learning to inform STREAM implementation and other stakeholders; and to explore how this will work in practice. Available as a free download from the NACA website www.enaca.org/publications.htm (PDF 327 KB, 53 pages), or order through the NACA Secretariat (contact publications@enaca.org).

First STREAM Regional Conference Report

This report describes the proceedings and outcomes of the first regional conference of the Support to Regional Aquatic Resource Management program (STREAM). Issues covered include strategies, processes and practices; livelihoods; policy and institutional development; and communications aspects of the program. Available as a free download from the NACA website www.enaca.org/publications.htm, (PDF 766 KB, 25 pages) or order through the NACA Secretariat (contact publications@enaca.org).

Report on the formalization of an Asia-Pacific Marine Finfish Aquaculture Network

This is the report of a sub-section of ‘Collaborative APEC-NACA Grouper Aquaculture Network’ project on “Formalization of an Asia-Pacific Marine Finfish Aquaculture Network”. The aims of the formalization are to create a strong network of research institutes and experts that are actively involve in grouper and other marine finfish R & D in the region; resources sharing through cooperation in order to make maximum use of limited resources; and improve information exchange and dissemination. Available as a free download from the NACA website www.enaca.org/publications.htm (PDF 260 KB, 45 pages), or order through the NACA Secretariat (publications@enaca.org).

The Asia-Pacific Marine Finfish Aquaculture Network Website CD-ROM

The entire Marine Finfish Aquaculture Network website has been put on a CD-ROM, featuring two newly-released proceeding of previous network meetings and other associated publications. To order, contact publications@enaca.org. If you want to see what you get visit the website itself, www.enaca.org/grouper

Sustainable Sea farming & Grouper Aquaculture

The proceedings of the Grouper Network workshop in Medan, 2000. This report contains the recommendations of the working groups and research papers presented by participants. Available for free download from the www.enaca.org/publications.htm (234 Pages, PDF 2.15 MB)

5th Edition of the International Aquatic Animal Health Code released

The fifth edition of the Code is now available in English, French and Spanish. The Code covers all diseases listed as ‘notifiable’ and ‘other significant’ by the OIE (the Office International des Epizooties, otherwise known as the World Organization for Animal Health). The Code complements the OIE Diagnostic manual for Aquatic Animal Diseases (currently in its third edition published in 2000). Together these two documents comprise the internationally recognized standards for aquatic animal diagnosis and trade certification. Both cost 40 Euros. You can view the OIE Publications Catalogue from www.oie.int.

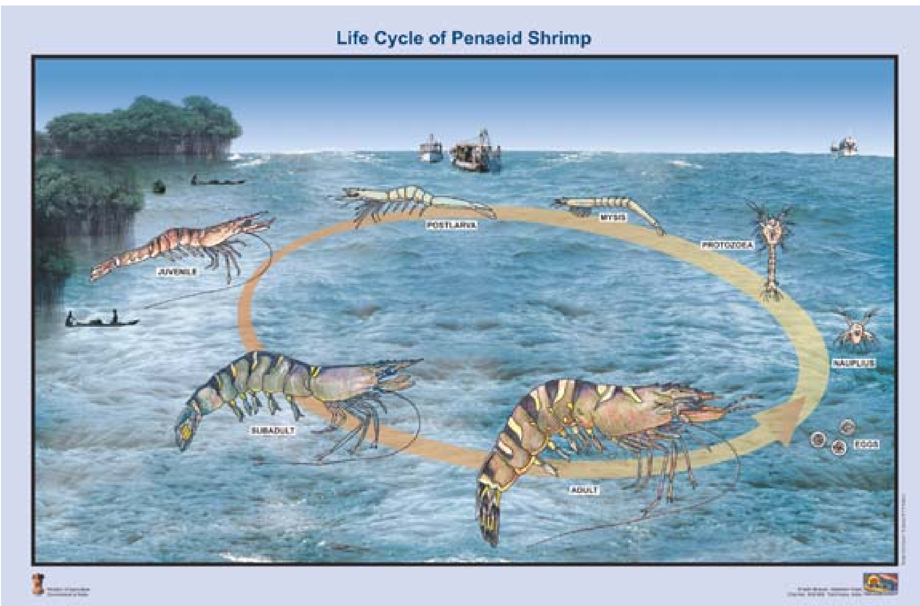
Production and Marketing of Shrimp: Trends & Outlook

S. Subasinghe and Tarlochan Singh (eds.)

This is the Proceedings of Shrimp 2001 Chennai, the Fourth World Conference on the Shrimp Industry and Trade and Buyer-Seller Meet, held 27-29 September 2001 in India. 34 papers are divided into four sections: I Global overview, II Industry situation and outlook, III Markets and marketing and IV Technological aspects of production, processing and quality assurance. It includes a list of participants and their contact details. The 239 page proceedings are published in black and white and well presented. A price was unavailable at time of publication, visit www.infofish.org for updates.

Sustainable Shrimp Farming Posters and Guidelines available

The Aquaculture Authority of the Government of India has prepared a series of four full colour posters promoting sustainable shrimp farming practices. These have been developed to popularize the concepts of sustainable shrimp farming and raise awareness among small-scale shrimp farmers. The posters are free. The Aquaculture Authority also publishes Guidelines on Effluent Treatment System in Shrimp Farms; and on Adopting Improved Technology for Increasing Production and Productivity in Traditional andImproved Traditional Systems of Shrimp Farming. To obtain copies of these publications please contact Mr Yugraj Yadava, Member Secretary of the Aquaculture Authority, Shastri Bhavan Annexe 26, Haddows Road, Chennai 600 006, Tamil Nadu, India, Tel (044) 8234683, fax (044) 8216552, email aquaauth@vsnl.net.



One of the four Sustainable Shrimp Farming Posters available. This one covers the life cycle but the others address management and husbandry practices relevant to the environment.

PRACTICAL APPROACHES TO HEALTH MANAGEMENT FOR CAGE CULTURED MARINE FISHES

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The need for health management

Large numbers of diseased fish dying is seldom observed in the natural environment unless environmental conditions have recently deteriorated. In the natural environment, fish lead a less stressful life and are free to move, and mortality is not easily observed. However, in the confined area of the net cages, fish are subjected to a large variety of stresses, such as handling in grading and net changing and it is easier to observe when there are mortalities due to one cause or another. The fish farmers usually observe the occurrence of disease soon after the fish are placed in the net cages. The newly placed fish often have hemorrhages and lesions on the body, indicating some bacterial infections, and die within a few days.

Initially only wild juvenile fish caught from the surrounding coastal region were farmed in floating cages, but now many species of fish can be produced in the hatcheries, particularly in Taiwan R.O.C. The majority of the tropical marine fish species found in the region belong to three families, namely Centropomidae (Asian seabass), Lutjanidae (snappers) and Serranidae (grouper). Of the three families, both snappers and groupers have the most number of species farmed in captivity. Most net cage fish farms in Southeast Asia are into multi-species fish farming, which complicates the process of fish health management, particularly in the control of disease.

The severity and greater frequencies of diseases in farmed fish have increased in recently years with the rapid expansion and greater concentration of fish farms as well as the larger number of fish species in farms. The large-scale international movement and importation of hatchery-produced fingerlings/juveniles is a major factor contributing to the emergence of new and serious diseases observed in cultured marine fish. Some of these new fish species are more susceptible than others resulting in greater frequency and severity of disease.

Diseases do not occur with consistent incidence throughout the culture period. Most outbreaks occur during the first 2 - 12 weeks after initial placement in the net cages. The severity depends on the condition of the fish on arrival, their size and fish species involved. For example, 5-8cm Asian seabass fingerlings are very susceptible to tail-rot disease soon after placement in the net cages, but other fish species are not usually affected. Recently (2001/2002), it was observed that large number of newly introduced 5cm red snapper were also readily affected by tail-rot disease that has not been observed in previous years. This caused about 5-10% mortality. Early recognition of the disease and immediate treatment are important to reduce mortality.

Most diseases occurring in the grow-out phase of the culture cycle are caused by multiple pathogens, namely bacteria (*Vibrio* spp. and *Flexibacter maritimus*), protozoans (*Cryptocaryon irritans* and *Trichodina* spp.) and monogeneans (*Benedenia* spp., *Neobenedenia* spp., *Diplectanum* spp., *Pseudorhabdosynochus* spp., and *Haliotrema* spp.). Recently, large number of imported hatchery-produced juvenile grouper suddenly died off in net cages in China with a virus identified as the pathogen causing the disease. Such symptoms have also been observed in imported juvenile grouper in Malaysia where a virus is suspected to have caused mass mortalities.

Very often, the densities of the monogenean parasites in diseased cultured fish are found to be higher than in the healthy cultured ones, which in turn are higher than in the wild ones. The bacterial flora is present naturally in the aquatic environment, as well as in the digestive system of the fish, but protozoans and monogeneans are introduced along with the fish host. Once they are introduced into the farm, it is impossible to eliminate them from the system.

Benedenia spp., a common parasite

The routine maintenance activities in a floating net cage farm (net changing, net washing, handling and grading of fish) along with poor quality of trash fish are major contributing stress factors and contradict good animal husbandry management. Furthermore, multi-species farming and overlapping batches of farmed fish in closed proximity results in the floating net cage farm acting as a reservoir of pathogens. There is not usually a break in the culture cycle in the floating net cage system that would allow a reduction in the population of pathogens. Juvenile fish are continuously introduced in the net cages and are exposed to a pool of pathogens in the culture environment.

Given a general understanding of multi-species fish farming, the diseases and their occurrence in the floating net cage culture system, a practical approach to prevention and control of diseases could be developed and integrated into the routine fish farm activities. The chemicals and drugs used, where possible should not be hazardous to human or animal health, acceptable to end markets, easily available and importantly, their correct use must be understood. Chemicals and drugs reported to be effective in treating diseases in the laboratory may not be effective in the farm environment.

Before one can implement a strategy to control and treat diseases, a number of steps must be taken. The most important ones are the human resource development of the farm workers, particularly the foreman/manager by providing some technical training on various aspects of fish farm management, in the general recognition of various disease symptoms and in the appropriate use of treatments including chemical. It is very important that practical hand on experience be undertaken at the farm with the participation of the farm workers. Experienced farm workers generally know when the fish are not well in a particular cage. It must be emphasized in the training course that in such a situation, **immediate** action must be taken to treat the affected fish in that cage **without delay**. A delay in treatment results in higher losses and possibly the total loss of all the fish in the cage. This is to ensure that the farm workers know how to carry out the required task properly and quickly, especially in immediate response to an emergency situation, like disease outbreak.

A simple study should be undertaken to determine the type of pathogens on the farm

The second step is to undertake a simple epidemiological study of pathogens among the various species of cultured fish in the farm, noting particularly the types and density of monogeneans. Data obtained provide an insight into the extensiveness of infestation among the cultured fish in that farm. This technical support should be provided by the government to assist fish farmers. The technical support team from the government should regularly visit fish farms and to discuss any problems that have been encountered in the farm. Also they should make sure that the fish farmers implement a code of aquaculture practice. This is very important to the fish farm community, especially if the fish are farmed for export overseas.

In most, if not all cases, fish farmers will encounter disease within the first 8 weeks when fingerlings and juveniles are placed in the net cages. Some species of fish are more susceptible to disease than others. It is impossible for fish farmers to determine if the newly imported fish harbor any particular pathogens or not, as they do not have the facilities to do so. Besides, the fish can arrive at the farm at odd hours and in large number. Even if the imported fish were certified as pathogens free, the 'healthy' fish would immediately be exposed to a reservoir of pathogens in the net cage system.

A routine prophylactic treatment should be incorporated into the farm management activities. One would ask what should we used to treat the newly arrive fish with, given that there are so many pathogens in the cage culture system? Many studies on diseases involving marine fish cultured in the tropical region indicated these diseases

Farm hands need to be given some technical training on health management are caused by infection with multiple pathogens. Fortunately, most of the pathogens found associated with these diseases in these newly placed fish were vibrio bacteria, protozoans and monogeneans. Therefore at this stage of the culture circle, the treatment chosen should be those with a wide spectrum application. Protozoans and monogeneans are ectoparasites, ie they are found on the body surface, either on the gills or on and under the scales. These pathogens on the body surface can easily be treated with freshwater, although this is not very effective for treating the gills. Formalin is an effective chemical that could be used to treat protozoans and monogeneans on the gills. One has to be very careful when one uses formalin because too strong a concentration could kill the fish and low concentration would not be effective in removing the pathogens [NB: Formalin is hazardous to humans, so avoid skin contact, avoid breathing the vapor and use appropriate safety equipment – ed.]. Fortunately, the monogeneans on the gills are not as pathogenic as those under the scales. Very often, fish are injured in the process of grading, packaging and transportation and do not show any external signs of injury. These can result in secondary bacterial infection when the packed fish reach their destination.

During this initial period of the fish adaptation to the new farm environment, they should be treated regularly with freshwater with or without the addition of formalin, methylene blue and possibly appropriate antibiotics. The duration and frequency of treatment would depend on the condition, size and species of fish. Generally treatment should not be more than 15 - 30 minutes. The newly placed fish should be treated with freshwater and 100ppm formalin on the second day for 30 minutes with aeration. This treatment is repeated on the fourth day, each time watching the fish closely to see signs of any stress on the fish. During the second week, it is best not to treat the fish, but this would depend on the condition of the fish. If the fish are healthy and actively feeding, then discontinue any prophylactic treatment. If treatment should continue, this is usually treated on a weekly or longer time interval. The newly placed fish would have adapted to the new farm environment by the 4th

A routine prophylactic treatment should be incorporated into farm management activities

week. This treatment is used not only to remove any pathogens in the fish, but more important also to condition the fish for adaptation to the rough handling in the cultured environment. **NOT** all fish species required prophylactic treatment on arrival. The prophylactic treatment as described above has been found to be effective for grouper and red snapper, particularly in farms that have large population of capsulid monogeneans.

The named chemicals could be used singly or in combination with one or more. At times, even after these treatments, the fish may also prove to be infected with bacteria, particularly with ulcers/lesions on the body, especially in grouper and begin to die after a few days. In such situations, it is best to inject a sulfur drug to all the fish in that cage. This is a very simple prophylactic treatment of newly placed fish and it should be carried by all fish farmers if they want to reduce mortality of fish in their farm.

An experienced farm worker should be able to detect the onset of disease in a cage throughout the grow-out stage of the culture cycle. The first sign of disease occurring in a net cage is when the fish are not actively feeding and some fish are swimming sluggishly at the surface. Appropriate action(s) must be immediately taken. All the affected fish in that cage must be immediately treated with freshwater with or without formalin or methylene blue. If affected fish have red boils or lesions on the body, they should be injected with a sulphur drug. The freshwater treatment is to eliminate and or reduce the density

Injecting a sulfur drug

of protozoans and monogeneans, while the injection of drug is to treat the systemic bacteria vibrio infection. This freshwater treatment and injection of drugs have been successfully used in many farms in Malaysia and have been incorporated into routine activities in some fish farms with very satisfactory reduction of mortality.

These treatments as described in the previous paragraph are effective against most diseases except for scale drop disease in seabass and ulcerative disease in mangrove snapper. They do not assist in treating viral infections. Seabass juveniles are very susceptible to tail-rot disease in Southeast Asia. The symptom of this disease is the rotting of the tail and the breaking down of the muscle at the base of the tail. All seabass in that net cage should be immediately treated with freshwater.

Should fish be vaccinated against disease? Unfortunately, we know very little about the types of disease in cultured marine fish in Southeast Asia. Most of the cultured fish are affected by vibriosis, particularly grouper. Vaccine for vibriosis is commercially available in Europe and USA. The results of vaccination against vibriosis in greasy grouper are fairly encouraging and vaccinated grouper were less susceptible to vibriosis during the grow-out cycle period. For the vaccination to be effective the grouper should be at least 10cm in length and after vaccination, fish should be given prophylactic treatment as described in the previous section. It takes between 10-14 days post vaccination for the fish to develop some immunity to vibrio bacterial infection. During this period the fish may be affected by other pathogens, as most diseases are caused by multi-species pathogens infection, reducing the effectiveness of the vaccination. It is important that the vaccination programme be carried out in the farm with participation of the fish farmers. Other fish farmers will adapt the vaccination programme once they find out that less fish are dying from disease. The vibrio vaccine has not been used to determine its effectiveness against vibriosis in other fish species. With the availability of vibrio vaccine, an active field research vaccination programme should be undertaken to determine its effectiveness against vibriosis in various fish species.

Aquaculture Fundamentals

Simon Wilkinson, NACA

A general approach to disease treatment and control

In the context of aquaculture, disease may be broadly defined as any condition that leads to sub-optimal production[1]. The aetiology of disease involves an often complex interaction between three main factors: The status of the host organism, the environment and pathogens[2]. When one or more of these factors is unfavourable the host must adapt its physiology and/or behaviour to compensate. These adaptive responses, stress, impair normal physiological functioning and reduce the hosts chance of survival[3]. In particular, chronic stress lowers the resistance of fishes to infectious agents. This is caused by depression of the immune response and progressive leukopenia resulting from the release of corticosteroid hormones[2,3]. The relationship between disease and stress highlights the link between disease and poor management practices in aquaculture[4].

The essential principles of disease treatment and control[1] are to:

- Establish an accurate diagnosis;
- select an appropriate and environmentally responsible treatment;
- evaluate management practices within the farm and determine if future outbreaks could be prevented by changes in procedure or design.

1. Establish an accurate diagnosis

An accurate diagnosis is an essential first step in disease control since it is fundamental to the selection of an appropriate treatment[1,2]. Investigations should commence as soon as a disease problem is detected[5]. This can reduce losses by facilitating early treatment and allowing infected populations to be isolated. It can also assist diagnosis through by allowing the selection of fresh specimens.

Diagnosis requires a systematic approach considering all possible factors to determine the cause or causes of the disease. Ideally, investigations should include the following the following studies[2]:

- Investigation of environmental factors, water quality and stress related factors;
- investigation for pathogens; and
- histopathology (investigation of the host).

Unfortunately, few farms have the facilities or expertise to carry out detailed investigation of pathogens or histopathology[4]. If the farm has the resources (and if one is available) then an appropriate fish health specialist should be consulted to provide a professional diagnosis in addition to on-farm investigations.

Laboratory investigations

A range of clinically affected individuals at various stages of disease should be collected along with some apparently healthy specimens for comparison[5,6]. Sampled fishes should be sent to the laboratory live if at all possible since autolytic changes occur rapidly in fish and freezing destroys or inactivates some pathogens[7]. Anaesthetics should not be used on specimen fish since they kill ecto-parasites and make them more difficult to observe[6]. A comprehensive account of the clinical signs and losses, recent records of environmental parameters, stocking densities, feed and management practices should accompany the sample, along with a sample of the water supply[2].

Strategies for on-farm investigations

On-farm investigations and treatment of disease should focus on identifying and reducing sources of stress[2]. Two approaches to on-farm disease investigations are[1]:

1. Examine the major components of the culture system (fish, water, containment facilities and diet) with reference to the

requirements of the cultured species, looking for ways to improve the management;
2. assess the entire production system for faults that could cause unusual disease and mortality rates from beginning to end, starting with the water intake and finishing with the end product.

A combination of these approaches provides a thorough framework for the investigation of disease, particularly when considered in the context of environmental, pathogen and host related factors.

Environment

The major environmental components of culture systems are the water and containment facilities. One or more environmental parameters may be unsuitable, particularly if the species is exotic and being cultured outside its natural range. Water temperature may be of particular concern in marginal climates or under unusual extremes.

From a production system perspective, critical production points that warrant investigation include any physical, biological and chemical filtration systems, pumps, aerators and water circulation infrastructure[1]. This can be achieved through:

- Examination of current and historical farm-records of physio-chemical water properties to see if they have deviated from preferred levels and may have contributed to the disease outbreak[8]. Records should also be examined for any rapid changes in environmental factors since this can also result in stress[2] even if the changes occur within ranges normally tolerated by the species[9,10];
- supplementary investigations to assess parameters that are not routinely monitored such as the possibility of chemical contamination of the water supply[2]; and
- physical examination of water management and containment infrastructure for proper function and its safety/suitability as a habitat for the cultured species[1].

Pathogens

Affected fish should be examined for pathogens as far as the facilities and expertise of the farm permit, even if this just involves external examination of the fish. The water supply, introduction of new stock, live feeds, contact with wild animals, quarantine and hygiene procedures are critical points in the production process where a pathogen could enter[2,11]. Farm records should be examined to determine if the disease could be traced to these factors.

Many of the organisms that cause disease in aquatic animals are facultative pathogens in that they are a normal part of the host's microflora and will cause disease only when the host is under stress[2,8,12,13]. Epidemiological studies must therefore take into account post-infection events[3] and consider interactions with environmental and host-related factors[2].

Host

Key host related considerations include nutritional factors and behavioural interactions between the host species.

Nutritional deficiencies can arise from the use of new or inappropriate feeds[2]. However, most deficiencies are caused by inappropriate storage or feeding regimes rather than by inadequate formulation[1]. Some vitamins and macronutrients, particularly fats, are not stable and may quickly degrade with lengthy or inappropriate storage and handling[14,15]. Nutritional deficiencies can be diagnosed through histology[2], further highlighting the need to submit specimens to fish health laboratories for professional diagnosis.

Feed delivery, in terms of ration size, frequency, timing and distribution is also a critical point in the production system[14]. Records of feed regimes and feed type should be evaluated to see if they are appropriate for the species under culture and if there have been any recent alterations that might have contributed to the disease outbreak. Ideally, feed should periodically be analysed to test for contaminants and to verify composition[1].

High stocking densities are recognised to contribute to the risk of disease outbreaks by having a detrimental effect on water reducing environmental quality and facilitating the transmission of pathogens[11,16]. High stocking densities or inadequate provision of shelter can also encourage fighting and aggression between fish[1] leading to wounds and subsequent infection. Stocking densities should be reviewed in light of the suitability of the prevailing environmental conditions. If conditions are poor, consider reducing stocking density.

2. Select an appropriate and environmentally responsible treatment

A holistic approach should be adopted to treatment that considers the interaction between the host, the environment and pathogens[4]. Clearly the most appropriate treatment for the disease will depend on the diagnosis determined by a fish health specialist and also on the specific management practices and resources of the farm. However, even where a reliable diagnosis is not available the farm should adopt a precautionary approach to try and minimise losses. Precautionary measures should be aimed at reducing stress, particularly as part of the initial on-farm investigation of disease[2].

Five general principles must be considered in the selection of a treatment[16]:

- What is the likely outcome if the treatment is or is not given ?
- Is the treatment economically viable relative to the value of the fish ?
- Will the fish withstand the treatment ?
- Does the loss rate and the particular disease justify the treatment ?
- Is the treatment acceptable in terms of risk to human health or the environment, or market acceptance of product ?

Under some circumstances the most appropriate response may be to simply harvest the fish before additional losses occur, or to destroy them.

Environment

Poor water quality can be alleviated through water exchange assuming that the water intake of farm is of a higher quality than that in the culture system. This will reduce organic loads that boost populations of fungi, bacteria, and protozoans[1] and assist to flush out the larval stages of ectoparasites[2]. In closed systems, filtration of water down to 1um to remove organic solids is an alternative means of reducing organic loads[1]. Supplementary aeration should also be provided to reduce stress[2].

Pathogens

Strategies for the control of pathogens include:
- reducing stress (considered elsewhere);
- use of chemotherapeutants;
- eradication; and
- a combination of the above.

Usage of chemotherapeutants may be warranted to treat a presumptive microbial infection (subject to diagnosis), or in some cases as a prophylaxis against infection. However, it should be stressed that antibiotics will not remedy poor management and the underlying causes of disease also need to be addressed.

Factors that need to be considered prior to use of a chemotherapeutant include[16]:
- the properties of the chemical and its impact on non-target species, toxicities, effective doses, and spectrum of activity;
- the tolerance of the culture species to the chemotherapeutant;
- the tolerances of the disease agent;
- the volume and properties of the water in the culture facilities - this may affect dose rates and tolerance of the chemotherapeutant;
- human health, market and environmental considerations.

Inappropriate use of antibiotics can lead to the development of resistant strains that may be difficult to treat[11,17]. Many countries, such as the USA, set maximum residue limits and withdrawal periods for antibiotics used in food for human consumption[18]. Consideration should be given to the constraints that will be imposed on harvesting by the withdrawal periods and residue standards of the intended market.

The USFDA has developed a code of practice for the use of antibiotics that includes additional guidelines for farmers[1]:
- antibiotics should be used only as last resort;
- a definitive diagnosis (including antibiotic sensitivity) is required to effectively target a pathogen;
- less expensive and environmentally friendly chemotherapeutants, eg. salt, are preferred.

In some circumstances, such as the occurrence of a serious or persistent pathogen it may be necessary to attempt eradication. Eradication involves the removal of all susceptible or potentially susceptible species, drying out and liming of ponds and disinfection of contaminated equipment[19].

Host

The nutritional state of fish influences the production, maintenance and repair of tissues[3]. It may be desirable to obtain a fresh supply of feed from a different manufacturer if possible and mild vitamin and mineral supplementation may be considered until a definitive diagnosis can be made. These measures will reduce the risk of further damage to the fish in the event that the feed is contaminated or spoiled, or that it does not meet nutritional requirements. In particular, supplementary levels of vitamin C have been shown to confer additional protection against disease in fish apparently by boosting both specific and non-specific immunological defence mechanisms[19].

Reducing the population density of the host is an effective means of reducing stress and may be sufficient to lead to recovery in some circumstances[3].

3. Prevention - Controlling disease through effective management

Disease in fishes is often secondary to environmental insult[16] and an expression of poor nutrition and/or environmental quality[19]. The most important approach to disease control is managing the culture unit to reduce disease predisposing conditions[16]. This is best achieved by through the use of realistic stocking densities, preventing the introduction of pathogens, maintenance of good water quality, avoiding stress and through the provision of adequate nutrition[16,20]. Elements of a preventative approach are:
- Continuous evaluation and improvement of management techniques.
- Awareness of disease and of the requirements of the cultured species;
- A systematic approach to health monitoring and record keeping;
- Hygiene and quarantine; and
- Contingency planning;
- Continuous evaluation of management practices

An essential component of treating a disease outbreak is to evaluate management procedures to determine if they contributed to the condition and if they can be improved. Farm records and management processes should be reviewed and adjusted accordingly. Similarly, any experiences or lessons learned in the response to the disease should be incorporated into the farm's contingency plans to facilitate future responses to disease. The systematic approach to the on-farm investigation of health problems suggested above could also be usefully applied in a pro-active manner to the production system to identify potential hazards prior to the occurrence of disease.

Awareness

An understanding of the environmental, nutritional and behavioural requirements of the cultured species is fundamental to the provision of an adequate diet, environment and habitat. Farm staff need to be adequately trained in the recognition, life cycle and aetiology of disease in order to detect predisposing factors and early signs[11].

Monitoring

A systematic approach to monitoring of the behaviour and condition of fish and of the culture facility are essential for effective management of the system and for the early detection of disease[2,4,11,19,22]. Fish tissues should be regularly examined[4,11]. However, it should be recognised that the value of screening to exclude disease is limited for those of low prevalence[23]. Similarly, equipment and should be regularly inspected and serviced and staff should be able to identify malfunctions in critical equipment such as pumps and filters.

Accurate and comprehensive records of environmental parameters, observations and all activities should be maintained[2,11]. Historical records provide a base-line that allow perturbations in the system to be detected and acted upon before they result in disease. Records can also help to retrospectively identify factors contributing to the outbreak of disease and to subsequently improve management practices. Records should preferably be kept on computer to facilitate analysis and a variety of pond and tank management software is now available.

Hygiene and quarantine

Good health in hatcheries and farms is best achieved through efficient hygiene. This includes regular disinfection or drying of equipment and culture facilities and hygiene of staff, prevention of aerosols and cross contamination between facilities, the use of anaesthetics during handling procedures to reduce stress and wounds, and the use of prophylactic treatments where appropriate[11,19].

Newly arrived stock and live feeds such as forage fish should be quarantined for a period and examined for signs of disease[11]. Prophylactic treatments may be judiciously applied in quarantine[24] or when host resistance is low[11]. If possible, stock should be purchased from specific pathogen free sources[2]. This is particularly important for broodstock.

Similarly, the water supply in ponds and hatcheries should be screened to prevent the entry of larval pathogens or of animals that may carry disease[11,19]. In problem areas, water should be obtained from well or bore sources, or stored in a fish-free reservoir for an appropriate time prior to use[19].

Contingency planning

Contingency plans for disease investigation and control should be established as part of the farms general preparation for a disease emergency. Plans should outline mechanisms for identifying diseases and treating outbreaks of disease, as well as procedures for isolating affected culture facilities, collecting and dispatching specimens and contacts for fish health specialists and relevant government authorities.

Conclusion

A holistic approach should be adopted to the diagnosis, treatment and prevention of disease. This should consider the interaction of the environment, pathogens and host-related factors. An accurate diagnosis is fundamental to the selection of an appropriate treatment and consultation with a fish health specialist should be an integral part of any investigation where circumstances allow. The economics, possible side-effects and environmental impacts of treatments should be considered prior to application. Preventative management is the most important step in disease control since a systematic and thorough approach to health management can reduce the incidence of disease and associated production losses.

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The role of rural extension in the sustainable development of Chinese aquaculture

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The need for extension

The improvement of farming systems, the enhancement of farming technologies and the input of research findings are key factors in increasing aquaculture production. However, application of these factors demands effective extension methodologies that bridge the gap between researchers and farmers, thus converting the research outputs into production power at the farmers' level and sustaining the development of aquaculture.

Establishment of the Extension Institutions on the Sustainable Development of Aquaculture

Many institutions are capable of carrying out effective extension with farmers. In China the following institutions are the key bodies with this responsibility:

Government extension

In the early 1990s, the Chinese government launched the "Harvesting" and "Sparkling" programs in fish farming areas. These were highly successful extension programs that brought about a great use of new species, new technologies, new outputs and promoted great economical growth for communities and farmers. It is clear that the projects from the government have a strong power in organizing the communities and the farmers, but the projects should keep in line with the national development programs without any contradictions, the beneficiaries have the least risks.

Research Institutions, Universities and Colleges as Extension Services

In many cases, the research and teaching sectors directly transfer their research findings to the farmers without any intermediate links through teaching and demonstrations. For example, the Freshwater Fisheries Research Center (FFRC) of the Chinese Academy of Fishery Sciences, Wuxi successfully produced a new common carp *C. carpio* var.jian with almost 20 years research. The scientists conducted various combinations for crossings and gynogensis with the new technologies and techniques to produce, finally, a variety with stable genetic characters, good body shape and fast growth rate. A number of seed supply/training centers were constructed in various places in Chinese rural areas. The fish was highly accepted and utilized in rural areas within three years and considered as a major and first choice for polyculture.

Civil Institutions and Associations as Extension Services

In order to sustain and facilitate the development of the aquaculture in a large scale of fish farming zones, Chinese farmers have organized local associations and societies addressing issues such as fish disease, culture associations and seed supply clubs to solve the critical problems that farmers have encountered. These organizations have regular meetings and workshops and encourage mutual assistance between farmers. The farmers in East Lake region in Hunan Province have these activities for years. They not only solve the problems for the members themselves but also for the farmers in adjacent areas.

There are also a good number of specialist extension services for particular types of aquatic animals. The national aquaculture extension service has organized a number of research institutions, provincial and municipal extensions services to form associations for eels, shrimps and crabs, ice fishes and others. These also have regular workshops and meetings to discuss the farmers' problems, deliver the leaflets and newsletters. The farmers gain a lot through such media.

Business and Companies as Extension Services

These sectors have a specific target for extension based on the products that they sell to the farmers. They invite customers for workshops and meetings held at regular intervals to obtain the feedback so that they can adjust to meet the needs of the farmers. Presently there are good extension services in this regard for fish feeds and medicines.

Effects of the Extension Projects on the Sustainable Development of Aquaculture

The national government establishes specific programs and the guidelines for the local development. In the resource-poor, less developed areas with difficult terrain the local government establishes site specific development programs tailored to meet local conditions. For example, in the Central part of Sichuan province where there are hills and mountains, water wells, tanks, reservoirs and cage culture are recommended. In southern parts of China dominated by plains, paddy field culture is recommended. In the northern part of China, where the climate is very cool, thermal groundwater is used so as to extend the culture period.

Our experience is that extension projects should be in line with the local development needs and environmental conditions before the will be accepted by the farmers. There is a need to balancing the relations between economical returns and environmental impacts, between the use and conservation of biodiversity and between traditional and modern farming practices.

Relations Between the Economic Returns and Environmental Impacts

Most types of water bodies such as reservoirs, lakes, ponds and water wells can provide a good economic return. However, in developing the fish farming industry for economic purposes, environmental considerations should be placed in an equal position, so that the business can be successfully operated sustainable and indefinitely.

As an example, Taihu Lake is one of the four largest freshwater lakes in China. In the early 1980s protein-rich food was in short supply. The farmers around the lake adopted cage culture, pen culture and other types of enclosures as some of the local areas had a large-scale external waste input for natural food production. However, due to accumulation of various wastes the lake became highly eutrophic. This illustrates that unsustainable short-term economic growth can lead to losses in the long term. Therefore it is necessary to consider the economic, social and environmental consequences of a project proposal so as to ensure long term success.

Relations Between the Use and the Conservation of the Biodiversity

Biodiversity is a base for human existence and development. It both provides amount of indispensable necessities for live existences, increase the living quality and formulates a biocycle of human development. Fishery biodiversity is also a base for the development of aquaculture activity. Use and conservation of biodiversity are one of the important tasks for extension services. There are 3,826 fish species in China, 770 of which occur primarily in freshwater. 200 of these are currently considered to have direct economic potential and farmers have already successfully domesticated 50 species, which play a vital role in aquaculture.

Jiangxi province has protected the "Three Red Common Carps" - *C. carpio* var. xinguonese; *C. carpio* var. wuyuanese and *C. carpio* var, wananese, which are quality fishes in freshwater culture. They have unique external features, red in color, and have excellent genetic characters. In early 1970s, the cross-bred "Feng common carp" and in 1980s, the cross-bred "Yiyu crucian carp" all had strong hybridity in production, but their one of the parental line is either *C. carpio* var. xinguonese or C. carpio var. wuyuanese. In order to maintain these pure genes for crossing and studies local government officials isolate fish farms in a remote hilly areas. They have built 'gene reservoirs' away from the cities and business centers and easy access to the transportation. They use water sources from the mountainous leakages or reservoirs without any external disturbances. In some cases, farmers have even requested that strains of common carps should not be allowed within 15 km of these gene reservoirs to avoid accidental crossing affecting these valuable genetic resources.

Further Efforts in Extension Science Studies

Practical training needs to be developed for extension officers so as to fit the Chinese rural situations and the farmers. Thus trained, the extension personnel will be better able to help farmers select appropriate projects addressing the needs of the individual farmers, local communities and social and environment impacts.

The knowledge of the extension personnel should be upgraded. At present the most of the extension personnel from the central, provincial and municipal government are well equipped with sufficient subject matter knowledge as they are the graduates from the universities. However, extension is a science of teaching, knowledge conversion related to pedagogy, psychology and methodology. If one obtains a successful extension of a specific project, the subject matter knowledge is important, the extension skill and knowledge are equally important as the use of the dialects, good gestures, pleasant motivation and local customs. This will help establish good rapport with the farmers.

Strengthening Extension Teams

The success of project extension demands a good quality extension team, which is always available for the farmers. However, those who are working in this area should be equipped with the additional knowledge to make extension better: Those who work with the extension should regularly upgrade their knowledge of the subject matters. Most of these technical people have acquired the knowledge from books; they need to follow the farmers' new trends. The farmers know what products are in most demand by the consumers; therefore, the extensionists who will offer services and guides for the farmers have to understand the technical know-how. In rural extension officers have less access to fresh knowledge. Moreover, these extension people are not only assigned to wok with the extension but have to carry out more other activities to earn the money for their daily expenses and even salaries. They have to divert their efforts and attention for something else which is not necessary for the farmers' purposes. This can sour relations between village-level extension officers and farmers. Municipal extension services are the important linking between the national and village-level extensions, they often have to work as a bridge between these two.

Strengthening Input of the Extension Services

Various levels of the government in China have a good amount of input for the extension services in terms of structural setup, staffing, fund allocation and office facilities.

The output of the extension services is mainly dependant on funding input. Although quite many local extension institutions provide paid services, this limited amount of the income can not satisfy the needs of the necessary daily expenditures of many extension people. Circumstances are much more difficult in rural areas where the system suffers from funding constraints. The extension service in the fisheries sector is quite poor in terms of equipment supply and staffing compared with other sectors in agricultural fields. It has only quite recently been established with limited funding. In light of the requirements from the Central Extension Authority, there should be available with service structure, staff teams, training facilities and the pilot test farms. However, the insufficient supply of the staffing and facilities will certainly handicap technical progress. In the early 1980s, the contribution from technical progress in the aquaculture sector accounted for 16% of the increase in production. However, the contribution to the improvement reached 48% in the 1990s. Undoubtedly, the research output is a powerful source in enhancing and developing fisheries, but the extension services are equally important.

The development of the aquaculture needs technical progress while the extension services demand good systems. Effective extension is always welcome by the farmers. The extension services should develop themselves by carrying out business, trading and consultations for the farmers. The extension services in the years to come will play an increasingly more important role in developing the aquaculture sector and enhancing the technical contribution to the aquaculture production.

Aquaculture calendar

Regional Workshop on Sustainable Marine Finfish Aquaculture for the Asia-Pacific, 30 September-4 October, Halong City, Vietnam

A Regional Workshop on Sustainable Marine Finfish Aquaculture for the Asia-Pacific is to be held in Halong City, Vietnam, from 30 September to 4 October 2002. The workshop is one in a series undertaken by the Asia-Pacific Marine Finfish Aquaculture Network. This workshop will concentrate on recent improvements in production technology for marine finfish aquaculture, and will incorporate the end-of-project workshop for ACIAR project Improved hatchery and grow-out technology for grouper aquaculture in the Asia-Pacific region. For further information please contact mike.rimmer@dpi.qld.gov.au.

Aquaculture Europe 2002, Trieste, Italy 16-19 October 2002

The theme is Seafarming – Today and Tomorrow. Three workshops will be held in conjunction to encourage interactive discussion on future perspectives with industry. The workshops will address 1) applied solutions to health management in Mediterranean aquaculture; 2) new technologies for Mediterranean aquaculture; and 3) certification in aquaculture – HACCP, ISO Standards, Eco-labeling and organic. *More detailed information is available from the European Aquaculture Society website* www.easonline.org *or Email ae2002@aquaculture.cc*

Workshop on Health Management, 16 October, Trieste, Italy

Organized in cooperation with the European Fish Pathologists (EAFP). *Contact: EAS, Slijkensesteenweg 4, B-8400 Oostende, Belgium, Tel: +32- 59-32-38-59, Fax: +32- 59-32-10-05, E-mail: ae2002@aquaculture.cc*

Workshop on Certification in European Aquaculture, 16 October, Trieste, Italy

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Tel: +32- 59-32-38-59, Fax: +32- 59-32-10-05, E-mail: ae2002@aquaculture.cc

Offshore Mariculture, October 29-31 2002, Bali, Indonesia

Contact: Jean Pritchard, Society for Underwater Technology Innovation Centre, Offshore Technology Park, Bridge of Don Aberdeen AB23 8GX, Scotland, Tel: +44.0.1224.823637, Email: jeansut@sstg.demon.co.uk or visit http://www.sut.org.uk/pdf/ maricultureflyer.pdf for more information.

ExpoPesca and Acuicultura 2002, 20-23 November 2002, Santiago, Chile

Email Sue Hill for more information on sue.hill@informa.com

Mega Aquarium Shanghai 2002, 21-24 November 2002, China

Contact National Development Ltd. Room 3, 4th Floor, Albion Plaza 206 Granville Road, Tsimshatsui, Kowloon, Hong Kong. Tel +852 2369 1766, fax +852-2369 1799 or email info@megaaquarium.com.

5th Symposium on Diseases in Asian Aquaculture, 25-28 November 2002, Gold Coast, Australia

The Fish Health Section of the Asian Fisheries Society will host the 5th Triennial Symposium on Diseases in Asian Aquaculture (DAA5) from 25 – 28 November 2002 at the Gold Coast International Hotel, Australia. Two satellite workshops will follow the Symposium: Epidemiology and Risk Assessment 29-30 November 2002, and the Asia-Pacific Regional Molluscan Health Management Training Program Phase II 2-6 December 2002. For more information about the symposium contact OzAccom Conference Services, ph +61 7 3854 1611, or you can inquire at email daa5@ozaccom.com.au. *For more information about the workshops, contact Dr Chris Baldock - ph +61 7 3255 1712 (Epidemiology and Risk Assessment), email chris@ausvet.com.au and Dr Rob Allard - ph +61 7 3840 7723 (Molluscan Health).*

Second International Tropical Marine Ecosystems Management Symposium, 25-28 November 2002, Manila, Philippines

Tropical marine ecosystems are under increasing pressure from many sources, including coastal land use and development, pollution, unsustainable fishing and tourism and the impacts of global climate change.

The 2nd International Tropical Marine Ecosystems Management Symposium (2nd ITMEMS) will provide an opportunity for managers to engage in multidisciplinary discussions and sharing of experiences and lessons learned to identify gaps and priorities for future management action. The output and recommendations from the symposium will be disseminated through the partners of ICRI (including member countries, the International Coral Reef Action Network, IUCN, UNEP, WWF, the World Bank, donor agenices) and considered in the implementation of management programs for tropical ecosystems at local, national, regional and global levels.

The 2nd ITMEMS will be conducted through a number of concurrent workshops that address the topics listed below. Each workshop will start with presentations of exemplary case studies that illustrate relevant experiences and lessons learned either by their successes or, equally important, their inadequacies. These will form as bases for subsequent facilitated discussions that aim to achieve clear recommendations and priorities for the management of tropical ecosystems in the future. The results of each workshop will then be reported to all participants and discussed in plenary sessions. The number of participants in each workshop group will be limited to approximately 20. Preliminary topics for workshop sessions include co-management and social impacts of marine and coastal management; economic benefits of conservation and sustainable use; the role of the private sector in protection and management; the role of protected areas and management; monitoring to facilitate successful management; management to mitigate the effects of climate change; dissemination of information for coastal and marine management; targeted research for management support; securing sustainable funding for management; restoration and rehabilitation of damaged ecosystems; and achieving sustainable fisheries.

Contact the ICRI Secretariat: +63 2 928 1225 / +63 2 926 2693 or e-mail to: secretariat@icriforum.org or olof.linden@cordio.org. Organized by the International Coral Reef Initiative (ICRI), Joint Philippine-Sweden Secretariat, 2nd/F FASPO Bldg., Department of Environment and Natural Resources (DENR), Visayas Ave., Diliman, Quezon City, 1101, Philippines.

International Symposium on the Management of Large Rivers for Fisheries: Sustaining Livelihoods and Biodiversity in the New Millennium, 11-14 February 2003, Phnom Penh, Cambodia

The symposium are will review and synthesize the current status, management and development of large rivers systems including their ecology, fisheries, environmental impact assessments, multiple uses of resources and associated socio-economic considerations. The symposium will also raise the political, public and scientific awareness of the importance of river systems, the living aquatic resources they support and the people that depend upon them and contribute to better management, conservation and restoration of the living aquatic resources of large rivers. It is organized by the Mekong River Commission, the Cambodian Department of Fisheries and the FAO. *Visit http://www.lars2.org for more information.*

Accessing and Meeting Requirements of Markets for Aquaculture Products, Regional Seminar 11-14 February 2003, Manila, Phillipines

We invite you to a seminar of fish farmers, fishery product traders, entrepreneurs, prospective investors, suppliers, technical service support providers, industry analysts, experts, advisers, technologists, researchers and government policy makers from more than 25 countries from Asia- Pacific, Europe and North America.

Interact with co- participants and with resource persons from various UN specialized agencies and other international organizations including ADB, ESCAP, ICLARM, INFOFISH, FAO, IBRD, ITC, OIE, UNCTAD, WHO, WTO and others. The topics: various issues and policy approaches relating to access and competitiveness in markets for aquaculture products and impacts of certain trade issues on poverty and environment.

Work Boat World Asia, 18-20 February 2003

Contact Baird Publications, 135 Sturt St, Southbank, Melbourne 3006, Australia, Tel +61 (3) 964 50475, fax +61 (3) 9645 0475, or email marinfo@baird.com.au.

Advanced Fish Medicine course, Florida USA, 25-28 March 2003

Advanced Fish Medicine is an intensive six-day course that will provide instruction in the most recent and advanced procedures associated with clinical fish health management. The course will emphasize a "hands-on" approach to many of the latest techniques including anesthesia, hematology, nutritional therapy, imaging, histopathology and surgery. The primary goal is to encourage practitioners to increase their expertise in clinical fish medicine. The course is intended for the advanced student who has prior education in fish diagnostics and health management. Acceptance into this course is by permission of the faculty. The course will start and end in Orlando, Florida with behind-the-scenes workshops at Walt Disney World and Sea World Orlando, respectively. Lectures and laboratory exercises will be conducted at the University of Florida College of Veterinary Medicine in Gainesville, Florida. *Visit http:// conference.ifas.ufl.edu/fishmed/ for more information or contact Dr. Ruth Francis-Floyd, Department of Fisheries and Aquatic Sciences , University of Florida/IFAS, PO Box 110600, 7922 NW 71st St., Gainesville, FL 32653 - 3071, USA, tel: +1-352-392-9617 ext. 229, fax: +1-352-392-3672 or email: rff@mail.ifas.ufl.edu*

Farmers as Scientists

This is a series anchored by M.C. Nandeesha. It describes farmer-driven innovations and experiences.

Diversity enhances profitability and sustainability

Dr. M.C.Nandeesha has taken up a new position as Professor and Head of the Department of Aquaculture, College of Fisheries, Central Agricultural University, PO Box No. 120, Agartala-799001, Tripura, India. This is a four-year old institution established to cater to the manpower and research requirements of the Northeastern part of the country in the fisheries sector. He has nearly two decades of experience in teaching, research and development and has worked with Universities, NGOs and multilateral organizations within and outside the country. Email address: mcnraju@yahoo.com.

The Indian Council for Agricultural Research has instituted an award in the name of late Professor N.G. Ranga, a well-known parliamentarian who contributed significantly to uphold the interest of farmers and initiated a number of farmer-centered developmental activities in the country. The criteria fixed for the award include i) generation of new knowledge of practices and management strategies, ii) increased yield and income from the activity with efficient use of resources and inputs, iii) breaking of technology transfer barriers, iv) disease prevention strategies evolved, among others. Through the countrywide competitive selection process, the first award for the year 2001 has been given to Mr. Haricharan Das, a progressive fish farmer from the Tripura State located in the Northeastern part of the country. Mr. Das was chosen for the award as he has made several accomplishments in terms of diversification of activities, a number of innovations in regard to aquaculture and other agricultural activities like poultry farming, mushroom cultivation, forestry, vegetable and paddy cultivation and increased income through the wise use of resources. In this article, developments that have been made by this farmer in the area of aquaculture, which have relevance to the region are emphasized.

The professional accomplishment of Mr. Das, who is now 74 years old is a noteworthy for all those interested in taking up aquaculture as a profession and an example of the benefits of determination. Traditionally, his family occupation being fishing, Mr Das' desire to be educated helped him secure higher education in commerce. He worked as a railway employee and taught students before venturing into fisheries business. He left the government job and took up independent work as a fish auctioneer. Following his success as an auctioneer, Mr Das moved into fish culture activity by buying land, wherein he could build a pond of less than 0.5 ha. Using the ponds for seed rearing and selling, his activities expanded from that small piece of land to his current holdings of 25 ha. The farm not only has diversity of agricultural activities like horticulture, animal husbandry, forestry and fisheries, but also a good example of how agricultural activities can be integrated and developed in hilly terrain. Apart from his technical accomplishments, on the social side Mr Das has built excellent community bondage,

Mr Haricharan Das, a progressive fish farmer from Tripura recieves the N.G. Ranga award for innovation

Chinese hatcheries are now popular for the production of carps in Kolkata

which provides an example of how commerce can be combined with the motto of community service.

Development of hatchery systems

In the early stages, glass jar hatcheries developed based on the Hungarian models were popular in India. Mr. Das installed a jar hatchery system and even today, he recalls that jar hatchery as his most lucky project. With the introduction of Chinese hatcheries in Kolkata for the first time, the system became most popular throughout the country with medium and large-scale seed producers both in the Government and the private sectors. Mr. Das immediately adopted the system and has brought changes to suit local conditions. By evolving some of the simple management strategies, he has been able to achieve maximum breeding response, hatching and survival of the hatchlings.

Pituitary gland is still the best and most economical method

Though synthetic hormones have invaded the market, Mr. Das continues to depend on pituitary for breeding owing to cost factor as well its organic nature. The seed produced from his farm is the major source of seed to the large part of Tripura State and also to other parts of the Northeast. Fish seed nursing activities being undertaken by other groups of entrepreneurs, the farm largely concentrates on spawn production. This has enabled the farm to use the facilities for the production of table fish as well as fish seed with good efficiency.

Integration

Diversification of activities and their integration wherever technically and economically viable are the major accomplishments that can be seen in this farm. The farm houses nearly 6,000 parent birds for the production of chicks and nearly 30,000 birds for the production of broilers. This has led to the generation of huge amounts of waste from the poultry unit, which is efficiently recycled through fish culture ponds. In addition to poultry, there is also cattle farm consisting about 30 cows for milk production purpose. The grass and other vegetation on the farm provide fodder to cattle. There is also mushroom seed production unit and mushroom cultivation unit. Vegetable production is also undertaken in suitable areas. Coconut trees and other horticultural fruit crops also form an important component on the farm. Tree plantations are widespread on the farm with more than 22 cm annual rainfall, the climate provides good environment for the growth of high value timber trees like teak, mahagony and neem.

Biogas slurry and fishpond integration

The most significant innovation made by Mr. Das is in the efficient utilization of poultry, cattle and kitchen waste in aquaculture after passage through a biogas digester. As there was a problem of regular electricity supply and also difficulties in regulating fish pond water quality by using fresh cow dung, he took advantage of the Department of Non-Conventional Energy special program implemented through the Science and technology Department to install a biogas production unit on the farm. So far he has established eight biogas plants of varying capacity and a special biogas unit based on human excreta. The design changes he has brought in the digestion chamber is reported to have been appreciated by the Ministry and emphasis is now laid on

Carp pituitary gland is still more economical than synthetic hormones for induced spawning

Efficient recycling: Poultry, cattle and kitchen waste is passed through a biogas digester to produce energy, then the residual slurry is used to fertilize ponds, boosting fish production

promoting the new version in rural areas. Currently the entire farm is using the digested slurry for fishpond fertilization as well as for agricultural crops. The usage of biogas slurry for fish culture has given a good boost to fish production with productions obtained being always higher than 5,000 kg/ha/year.

Fish Culture Techniques Innovated

Because of the locational difficulties, drying of ponds is not a common phenomenon. Application of lime at 400-500 kg/ha as the initial dose is generally adopted. If the ponds are dried, lime is mixed with the dried soil. Following the application of lime, ponds are filled with water and plankton culture is introduced via water from other ponds. To enrich the plankton growth, mustard oil cake is used at the rate of about 200 kg/ha. The quantity is split in to six portions and each portion is applied on daily basis after ensuring that the cake is soaked with water at least for 3-4 days. Plankton enrichment in the pond generally reaches a good level by the time the fourth portion is applied and at this point of time, depending on the plankton density, application of rest of the two portions is decided. Once the pond is rich in plankton, fingerlings consisting of a mixture of Indian carps, Chinese carps, silver barb and tilapia are stocked with a total stocking density of about 15,000-20,000 fish seed /ha. The pond is fertilized regularly with biogas slurry at the rate of about 1,000 kg /ha. The frequency and quantity applied is regulated based on the water color and water quality. During the rainy season and summer, biogas slurry usage would be higher and during winter period dosage is reduced.
weighing more than 150-200 g are taken and replaced with the same number of fish fingerlings. During each harvest, about 25% of the fish are taken out and replaced with same number of fingerlings / yearlings. Year end harvest would also result in fish weighing more than one kilogram. Through this cyclic culture and harvest method, the annual production obtained is reported to be not less than 5000 kg /ha/year with the usage of biogas slurry as pond manure and fed with least cost feed

Profitability

Feed still constitutes major cost of production. The food conversion ratio is reported to vary between 1.5 and 2.00. With the local market value of fish being about USD 1.5 for carps, the profitability obtained is very good. The market demand for tilapia and silver barb being higher these species are mixed with Indian major carps and Chinese carps and cultured. Probably, this is the first farm in India wherein biogas slurry is widely used for fishpond fertilization on a regular basis and on a commercial scale. There is opportunity to enhance the productivity further through further research.

Biogas slurry research in India

The biogas plants are spreading in India rapidly with the increasing fuel crisis. The Department of Non-Conventional Energy is promoting biogas plants of different types and dimensions to suit the different categories of farmers. Early


Production of biogas onsite has solved some of the problems of an irregular electricity supply

research conducted at the College of Fisheries, Mangalore by a postgraduate student demonstrated the immense benefits of biogas slurry in carp culture. With the application of 3,000 kg /ha, in a short-term study, extrapolated values showed that a production of 2,900 kg / ha/year of fish can be obtained. Further research carried out at the Central Institute of Freshwater Aquaculture, Bhubaneswar in Orissa using cow dung and water hyacinth as the basis for the production of slurry have demonstrated the benefit of using the digested components in fish culture. Application of biogas slurry at 15 to 30 tons/ ha/ year has given fish yields which are more than 60% higher as compared to the application of undigested cow dung. Experimental results have also shown the possibility of incorporating biogas slurry in the feed mixture of rice bran – oil cake to the extent of 50%, by taking advantage of the existence of coprophagy in carps. Cultivation of duckweed like Azolla, Wolfia and Lemna has been found to be far more efficient on the slurry. In another study conducted at the Madurai Kamaraj University, results have shown that growth of carps was nearly ten times higher in biogas slurry treated ponds as compared to those treated with conventional methods of chemical fertilizers applications.

Spirulina, which is now considered as an important health food not only for fish, but also for people, has been successfully produced using biogas slurry by the Center of Science for Villages located in Datapur of Wardha. The yield obtained using the slurry was comparable to the one obtained using chemical fertilizers.

Mr. Das is not aware of these research results. He has developed the technique using slurry to meet his requirements. However, he is looking forward to explore ways to further improve production strategies using the available scientific information or generate new information with the facilities available at his farm.

Education to other farmers

Recognizing his entrepreneurial skills, state Department has used his experience to train other farmers and unemployed youth in the State on fish culture. So far three batches of trainings have been organized and there are plans to start regular training programs for the youth. The facilities have also been used to provide hands on training to the students of the Fisheries College by placing them on the farm as part of their work experience program. Mr. Das is an institution by himself who has built a farm and providing livelihood to about 200 families directly and several others indirectly.

Mr Das is now training other farmers and unemployed youth in fish culture

What next

Mr. Das who has not only played a key role in stimulating aquaculture development in Trpura State, but also contributed for the spread of technology through his commercial seed production activity in the region. The northeastern part of India is called the “dark continent”. Though the region is well known for rich biodiversity and culture, it has remained poorly developed for varieties of reasons. Insurgency continues to be a major a constraint in several parts of the region and strategies need to be evolved to reach farmers under these complex situations, wherein the biggest sufferers are again the poor.

Mr. Das has not only been honored with this prestigious award, but also has received Central Institute of Fisheries Education Award for being the best farmer in the year 2000. While he has been able to produce good amount of fish and maintain healthy community relationship, his empirical knowledge should be documented and investigated further to improve productivity and sustainability. The information generated from this type of actual farming conditions in the “field set up”, would help in the generation of ready to use information of other farmers. Mr. Das is willing to cooperate with research institutions to undertake further studies on his farm and allow the information for the benefit of other farmers. The College of Fisheries being located in the area is looking forward to undertake research in partnership with other interested institutions. We hope to report the progress of research in the future.

Regional seminar consultation and exhibition

3-7 February 2003

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Accessing and Meeting Requirements of Markets for Aquaculture Products Regional Seminar, 3-5 February 2003

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Interact with co- participants and with resource persons from various UN specialized agencies and other international organizations including ADB, ESCAP, ICLARM, INFOFISH, FAO, IBRD, ITC, OIE, UNCTAD, WHO, WTO and others. The topics: Various issues and policy approaches relating to access and competitiveness in markets for aquaculture products and impacts of certain trade issues on poverty and environment. Join the panel discussions on specific marketing related issues on the following themes:

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Be a part of the search for strategies for action on accessing markets and on meeting market requirements.

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