AQUA Culture AsiaPacific

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Focus on shrimp culture

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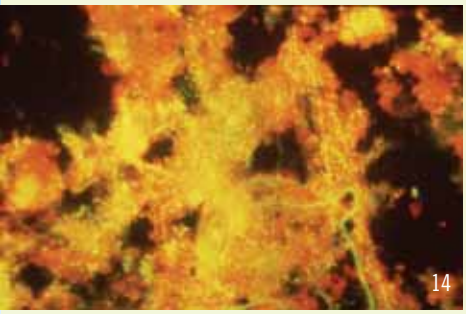

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Letters may be edited prior to publication

From the editor

When survival rate is your KPI*

In this issue, the focus is on shrimp culture management. In any culture system, the main direct costs are feed, utilities and labour in that order. When farmers are approached with the question of cost of production, the answer given is one on a kilogram basis and followed by the quip that costs can be reduced if only feed companies can reduce the feed costs. Admittedly, feed cost is a major component, but cost of production is critically determined by output of shrimp in kilogram. A 50% decrease in output automatically doubles cost of production per kilogram. Hence, should we not be paying greater attention to survival rates?

Any successful farmer knows the factors determining survival rates. These are mainly disease management and water quality. The limited or no water exchange, which is a current practice in Asia, is a paradigm shift from high water exchange previously required for diseased ponds or for improving water quality. In this new era, farmers have to work at controlling water quality *in situ*. This is where the science rather than the art of aquaculture comes into play. We now need to learn more about pond and water chemistry to be able to do this, as explained in an article in this issue (page 12).

Disease experts often emphasise that disease prevention goes hand in hand with good culture practices. Visit any farm and hatchery in many parts of Asia today and farmers are deploying pond probiotics and innovative herbal remedies to improve pond conditions. The future of the industry lies with this ability to manipulate and control conditions to improve survival rates and attain production targets.

These may be achievements that the Asian shrimp farmer can be proud of which has put him ahead of his competition. However, we must not be complacent. With price fluctuations, a competitive advantage means always being a step ahead. We are only looking at the tip of an iceberg. A shrimp farmer may say that he already has a depth of information from his own experience. However should conditions change, his information may no longer be applicable. Through AAP, we would like provide information to expand his breadth of this knowledge.

**KPI=key performance indicator*

What it should have been

In the July/August issue, in the article "New directions in the production of floating feeds", pp 22–24, there were missing lines in the quote on page 24. It should read; 'The state of the industry for floating aquafeeds is good and improving with emphasis on additional profits for both the feed producer and the farmers with the ability to make feeds at higher rates with lower costs and control at time of production'.

On page 38, the second heading should be – Aquaculture feed extrusion nutrition and feed management. We apologise for these errors.

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Growth for seafood company

Siam Canadian Group, the Bangkok based seafood company expects growth of 10-15% this year despite the continued absence of preferential tariffs in Europe and anti-dumping penalties imposed by the United States.

The company was established 17 years ago and has branch offices in Thailand, Vietnam, Burma, China and India. It recently opened an office in Jakarta. It reported a sales turnover of more than USD 150 million in 2004 and has indicated this to increase to USD 165 million in 2005.

The company outsources contract manufacturing to facilities in Vietnam and Myanmar. In Thailand, it has eight to 10 partner factories and works with 5-6 others on a spot basis. The group exports to 50 countries and currently, the United States is its biggest market, followed by Canada, Europe, the Middle East and the Far East. The company sees Japan as a future target market with strong growth opportunities in 2006 and beyond.

James Gulkin, Managing Director said that the market is complicated because of the anti dumping tariffs on Thai shrimp exports and the GSP removal by the EU. However, he has indicated that Thai shrimp exports are expected to grow about 15-20% this year to USD1.97 billion.

The marine shrimp and seafood industry in Thailand have been seeking for a restoration of lower tariffs under its Generalised System of Preferences (GSP). However, the EU again postponed its decision to Jan 1. Added to this, the US Department of Commerce is rethinking the impact of its dumping penalties against Thai shrimp because of the Dec 26 tsunami effects on the industry. A decision is likely to be announced by the end of October.

According to Gulkin, Thailand has a lot of room to move this year despite the US penalties, given the nation's reputation and reliability in processing. It does not compete directly with Vietnam or India, both of which are black tiger prawn producers. Anti-dumping penalties are so high against China that it has been effectively blocked from US markets, and China can compete with Thailand only in Canada.

"Thailand has some disadvantage of higher labour costs in competing with other countries in the same region such as Vietnam, China, India and Indonesia, but it has the advantage of higher efficiency and labour quality," he said. "For certain products that have more quality and require strict quality standards, Thailand can compete better."
(Sources: The Bangkok Post and Nation)

Editor's note: On September 1, the EU Delegation of the European Commission in Bangkok has announced a temporary measure to bring down tariffs on Thai shrimp under the GSP. Import tariffs will drop from 12% to 4.2% for fresh Thai shrimp and from 20% to 7% for prepared shrimp, retroactively from August 1 until December 31.

Success with indoor culture project for lobster rearing

An indoor culture project for the nursery culture of *Penaeus vannamei* and on growing of juveniles of the lobster *Palinurus polyphagus* has been successful in Singapore. The project, initiated by Mr Philip Choong, a specialist consultant with Republic Polytechnic, was conducted from June 2005 and completed in August 2005.

Philip Choong

Together with an industry party, students of the polytechnic designed a 22 tonne culture tank with *in-situ* filtration system and water recirculation technology. The requirements of this indoor culture system are appropriate lighting conditions, ambient and water temperature, flow rate for water recirculation, high dissolve oxygen levels, pH and special *in-situ* structures. The filtration system includes mechanical filters and protein fractionator. No biological filtration was involved and was replaced by a proprietary water treatment system to contain the toxic nitrogen cycle.

An achievement

In this initial trial, 60,000 3-day old postlarva (PL3) of *P. vannamei* were stocked in the tank and cultured for 60 days. In a separate compartment, 22 pieces of juvenile lobsters of 30g average weight were stocked. Postlarvae were fed formulated pellet feed and successfully cultured for 60 days with an average weight of 2 to 3g and size of 3 to 4 inches (7.6 to 10 cm) with low cannibalism rate and a ready healthy batch of juveniles for grow-out farming.

The 22 pieces of lobsters grew rapidly by molting continuously to an average size of 150 grams in 4 weeks. No cannibalism was recorded. They are expected to reach 300g in 8 to 10 weeks of culture. A second trial will be conducted to ensure reproducibility of the results before the commercial potential of the system can be realised.

The catfish fight in the US

The catfish industry in Vietnam is facing another setback as the US Food and Drug Administration (FDA) has found that some samples of Vietnamese catfish (basa) contained residues of the banned antibiotic floroquinolone. Imports into the US were already affected after the US imposed an antidumping tariff of 37% to 64% in 2003 and then recently with the imposition of bonds to the US Custom and Border Protection.

Since the antidumping case, the US market for Vietnam's catfish industry has been reduced from 70% to 20-30% of exports. But it still remains an important one. Currently, the European Union (EU) is a major market and the domestic market is also increasing.

The discovery of the banned antibiotics in samples has set off a series of actions in the US. Louisiana's Department of Agriculture and Forestry imposed a 120 day ban on sales of all imported seafood, according to the report in the Times-Picayune. Its August inventory indicated that this amounted to 349 tonnes of seafood. Alabama followed with a ban only on Vietnamese catfish affecting 113 tonnes of fish. Mississippi has only banned catfish from the two Vietnamese exporters.

Moreover, Louisiana's Department of Agriculture and Forestry is also asking FDA for a nationwide ban. Louisiana together with Arkansas, Mississippi and Alabama are the main producers of catfish with a combined value of USD 457 million in 2004. American catfish importers said that it is this industry that wants to destroy the competition posed by cheaper imports of Vietnamese basa. American catfish is sold at an average of price of USD 2.23/lb (USD 4.9/kg) versus USD 1.01/lb (USD 2.2/kg) for basa.

In the report, Hugh Warren, Vice President of the Catfish Farmers of America, the lobby group for the industry, said that the ban will level the playing field for its members. This is despite reports that sales of basa totalled 9 million pounds (4,090 tonnes) in 2004 as compared to 300 million pounds for the US raised catfish (136,000 tonnes). He also said that barring competitiveness, it is another matter when there are food health and safety issues.

Tracing the problem

In Vietnam, a Foreign Ministry spokesman said that Vietnam is already tough on antibiotic residues in seafood and has complied with food and safety standards. The European Union Committee and the FDA annually inspects Vietnam's aquaculture product safety and hygiene monitoring activities. The last inspection was in May and June 2005, respectively where a clean bill of health was given, according to the spokesman in a report by Thanh Nien News.

The Ministry of Fisheries has issued a list of 17 banned antibiotics covering 10 banned in the EU and 11 in the US and the restricted use of 34 including the antibiotic, fluoroquinolone. The Ministry has also announced another list of 11 antibiotics of the fluoroquinolone group which have been banned in the production of seafood for export to the US and North American markets.

FDA decides

The FDA had the option of issuing an import alert or seizing the products or a combination of both. On August 23, it placed catfish products from the two companies on in its alert list. This means that districts may detain without physical examination the products from firms identified on the alert.

Will prices be affected?

Seafood observers are questioning whether the price for the catfish will rise. John Sackton, editor of Seafood.com said that, "The people who are getting hurt are the regular commercial vendors and sellers and the seafood industry itself. When customers hear of a contaminated seafood product pulled off the market, all they hear is that something is wrong with 'seafood'!"

Study says Vietnam's basa fish tastes better than American catfish

In early August, a survey in America with 300 people has confirmed that Vietnamese basa was better than American catfish. In the survey conducted by a US marketing research company, about 49.5% of participants preferred Vietnamese basa, 46% selected American catfish and 4% saw no difference between the two fish. Fifty-two percent of women and 47% of men preferred the Vietnamese fish, reports the Vietnam news.

In an earlier, more detailed survey, conducted by the University of Mississippi, it was concluded that basa was preferred by three out of four participants. Several catfish associations in the US, as well as members of congress from southern states, protested the result, saying that it was not final, and pushed for further research. But the University of Mississippi, in the US state with the highest number of catfish farmers, defended the research, bolstered by results from the later survey.

GAA questions the ban

In its statement, the non profit organisation, Global Aquaculture Alliance (GAA) has questioned the ban or limits on the sales of all seafood from Vietnam following FDA detention action against two Vietnamese firms whose basa products were found to contain residues of floroquinolone antibiotics.

It said that "Although the Global Aquaculture Alliance is opposed to the use of such unapproved antibiotics, which can result in human health concerns and product detention in the marketplace, it also opposes the use of what may be overly broad emergency rules as an artificial trade barrier to hinder the flow of seafood from certain regions".

GAA President George Chamberlain said, "The states' actions should be more fully targeted toward the offending importers, not the entire Vietnamese seafood sector. They should also be more balanced with similar actions against other protein imports, such as poultry, beef, and pork.'

Floroquinolones are broad-spectrum antibiotics used to treat urinary tract infections, gastrointestinal problems, and other illnesses in humans. They are not approved for use in aquaculture, but were until recently used in the poultry industry to control disease and improve growth.

In an emergency order that is more restrictive than federal guidelines for the antibiotics, the state of Alabama is holding all Vietnamese seafood pending approved testing for fluoroquinolones and may seize adulterated product. Louisiana has stopped the sale of hundreds of tonnes of seafood from Vietnam intended for retail and restaurant sales. Mississippi has ordered retail establishments not to sell basa produced by the companies targeted by FDA.

The National Fisheries Institute (NFI) has indicated Florida also may enact a restrictive emergency ruling due to concerns about the mislabelling of basa as grouper in the state. While the U.S. Congress is out of session, a representative from Arkansas is calling for a nationwide ban on all basa.

NFI does not expect Congress to single out basa for increased testing. However, the increased focus on imported seafood could lead to further emergency rulings in other states.

In cooperation with NFI, the Global Aquaculture Alliance is informing members, affiliates, and international aquaculture producer associations regarding these concerns. It plans to continue alerting producers and others of similar market-related issues in an effort to assure seafood safety and prevent detentions and other trade problems.

Comments from Industry on...

Culturing the white shrimp *Penaeus vannamei* in Malaysia by Liong Pit Chong

Marine shrimp farming in Malaysia has followed closely the pattern of developments in Taiwan and Thailand over the last few decades. Both lead in farmed shrimp production and supposedly with the latest culture technology. Taiwanese shrimp culture technology was brought to Malaysia from the 1970s together with Taiwanese investors and technicians. The technology is still being used.

Thailand, which borders the northern part of peninsula Malaysia has always attracted Malaysian farmers with their technical know how. Study tours are frequently sponsored by some of the larger Thai feed companies. Beside this, many Malaysian shrimp farms employ Thai technicians and farm hands. Hence, it is no surprise that with the culture of tiger shrimp (*Penaeus monodon*) facing serious disease problems (especially with WSSV-white spot syndrome) farmers in Malaysia have decided to follow the foot steps of both the Taiwanese and the Thai farmers and have begun to culture the white shrimp (*P. vannamei*) as an alternate species.

Although there are no official records of when the culture of this species began in the country, it probably started as early as 2001. There has always been a ban on the importation of fry or spawner of exotic fish/shrimp species into the country, but the Fisheries Act is vague on the legality of such culture of exotic species. With no official response from the Department of Fisheries on such culture at its early phase, the culture rapidly spread to many parts of the country. The culture was supposedly based on illegally imported postlarvae/spawners. It is believed that some hatcheries carry out larviculture of the white shrimp using imported spawners or nauplii.

In February, 2003 (21/02/2003), there was a feature article in Nanyang Siang Pau, a leading local paper in the Chinese language, on the pros and cons of culture of white shrimp in Malaysia. It argued that Malaysian farmers would be better off staying with the culture of black tiger shrimp. The white shrimp could be cultured over a much wider geographical area and prices have been on the downward trend with greater worldwide production. This is especially with China and Thailand joining the fray of leading producers.

Malaysia has no competitive edge in the culture of this white shrimp. It was also reported that the newly introduced white shrimp already suffered from the white spot disease, an occurrence dreaded by tiger shrimp farmers. The fear was also that imported postlarvae or spawners may bring in the deadly Taura syndrome disease, not native in the country.

The Department of Fisheries was apparently aware of these culture activities. Consignments of fry have been intercepted and confiscated at the border and airports from time to time and press statements have been issued to such effects that the culture of the exotic shrimp is not encouraged.

A survey was actually carried out by the Department of Fisheries. However, most farmers, when queried officially on such matters, always replied in the negative. Meanwhile harvested white shrimp are sold in wet markets and in the big supermarket chains in increasing amount, with some exported to Singapore. Such productions are however not reflected in the official statistics. Hatchery operators in the country are badly affected by the reduced demand, and lower prices of tiger shrimp postlarvae. Many have been forced to either scale down or even stop operations. Based on guess estimates gathered from different sources such as shrimp farmers, government field workers and feed dealers, possibly 50 to 90% of the farmers have attempted such farming at one time or another.

Joining the ranks of Indonesia and Thailand, it was agreed in March 2005, that the culture of *P. vannamei* shrimp will be allowed in the country. The Department of Fisheries issued guidelines on the culture in early April at a seminar in Manjung, Perak attended by 150 shrimp hatchery operators and farmers. Manjung is an area where the 'illegal' culture of this shrimp has been ongoing for some years.

***P. vannamei* from a Malaysian farm.**
"It would be a real misfortune if the imported white shrimp should prove susceptible to the white spot disease and the native tiger shrimp infected by the deadly Taura syndrome virus brought in by the exotic white shrimp".

Only specific pathogen free (SPF) spawners (the taura syndrome among them) will be imported from Hawaii and Florida and only selected hatcheries with proper quarantine facilities will be allowed to import such spawners for fry production. It is possible for other hatcheries to purchase nauplii from these hatcheries for their larviculture. About a hundred hatcheries in the country should benefit from such a move. Over 7,000 shrimp farmers may have the peace of mind should they choose to culture the exotic white shrimp using local supply of SPF postlarvae.

However it remains to be seen whether such a belated move is adequate to prevent the dreaded Taura syndrome disease from entering the country, given the fact that illegal imports of *P. vannamei* postlarvae have been going on for several years without any check on their disease status. There is the real possibility that the virus is already in the country. Farmers culturing white shrimp just did not seek assistance from the authorities for a proper diagnosis in case of serious disease outbreaks for fear of being punished for the culture. There have been anecdotal reports of Taura syndrome disease in Manjung area, leading to wide spread culture failure. There also remains the possibility that the illegal imports of cheap fry of dubious quality would continue in the near future. Local supply of SPF postlarvae may take time to build up.

Both Taiwan and Thailand took the same precautions well in advance by only permitting imports of SPF spawners. Even then, both failed to prevent the spread of the Taura syndrome (TSV) virus in their countries. Illegal imports of cheap fry and spawners of dubious quality are blamed for such failure. Malaysia may not be in a better position.

Liong Pit Chong is an aquaculture consultant whose main expertise is in the hatchery production and culture of marine fish and shrimp. Liong had been with the Department of Fisheries since 1970 and in 1987 to 2001, was Head of the National Prawn Fry Production & Research Centre. Kedah, Malaysia. Email: liongpc@tm.net.my

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SKRETTING

New abalone farm in Phuket

In Mai Kao Village, Phuket Island, Thailand, Alex Soondarachoti has started to breed the abalone *Haliotis diversicolor* in his second farm on the island.

3 month old spats settle in tanks previously used for the breeding of the marine shrimp

Female abalone

Alex Soondarachoti

The advantage of Phuket for the breeding of the abalone is the pristine water conditions and constant temperature throughout the year. Water temperatures are a constant 28-29°C and salinity is around 32ppt. According to Alex, no ozone or UV filters are required but nevertheless, it is still important to locate the farm near fine sandy areas with better water quality.

After waiting for three months, Alex obtained his broodstock for the initial breeding cycle from South China. The broodstock costs Baht 4,000/kg (USD102/kg). At present, some of these have spawned and settled spats will be sold as seed stock for abalone farms in Taiwan. "Here we use 50 settlement tanks, each of 20.5m^2. With each tank producing around 25,000 spats, the total production may reach 1.25 million spats", said Alex. "In Taiwan alone, the annual demand is around 100 million spats".

During the settling stage, spats are fed the marine algae *Nischia sp* and marine diatom *Navicula sp* and then with artificial feed imported from Taiwan. The cycle takes 3-4.5 months from hatching to settled spat and a year to grow these as broodstock. The spats are sold at 4 baht each (USD 0.1).

Next in line is the setting up of an on growing farm, also in Phuket. This is a joint venture project with Taiwanese investors. The current price for market size *H. diversicolor* is Baht 2,000/kg (USD51/kg).

Four consortiums bid for PT Dipasena Citra Darmaja

PPA (PT Perusahaan Pengelola Aset), the Indonesian agency in charge of the restructuring of the world's largest shrimp farm PT Dipasena Citra Darmaja has named the four consortium groups interested in revitalising the shrimp farm. The government is handling the assets of the farm after the Gadjah Tunggal Group surrendered them in 2002. The debts amounted to Rp 28.4 trillion (USD 2.84 billion).

The four are Fortune, Trans Agro, Reinassance Capital and Laranda. The report dated 22 August 2005 said Charoen Pokphand is linked with the Fortune group. The company has already conducted due diligence on the shrimp farm. Trans Agro comprise of Transpack and Union, from America and Singapore. Groups behind Reinassance Capital and Laranda are still unknown to the PPA, said its director Mohammad Syahrial.

PPA will make assessments on the business plan and financing structure of these consortiums as well as the conditions required by the groups. They will also assess the technical and financial capabilities of the groups.

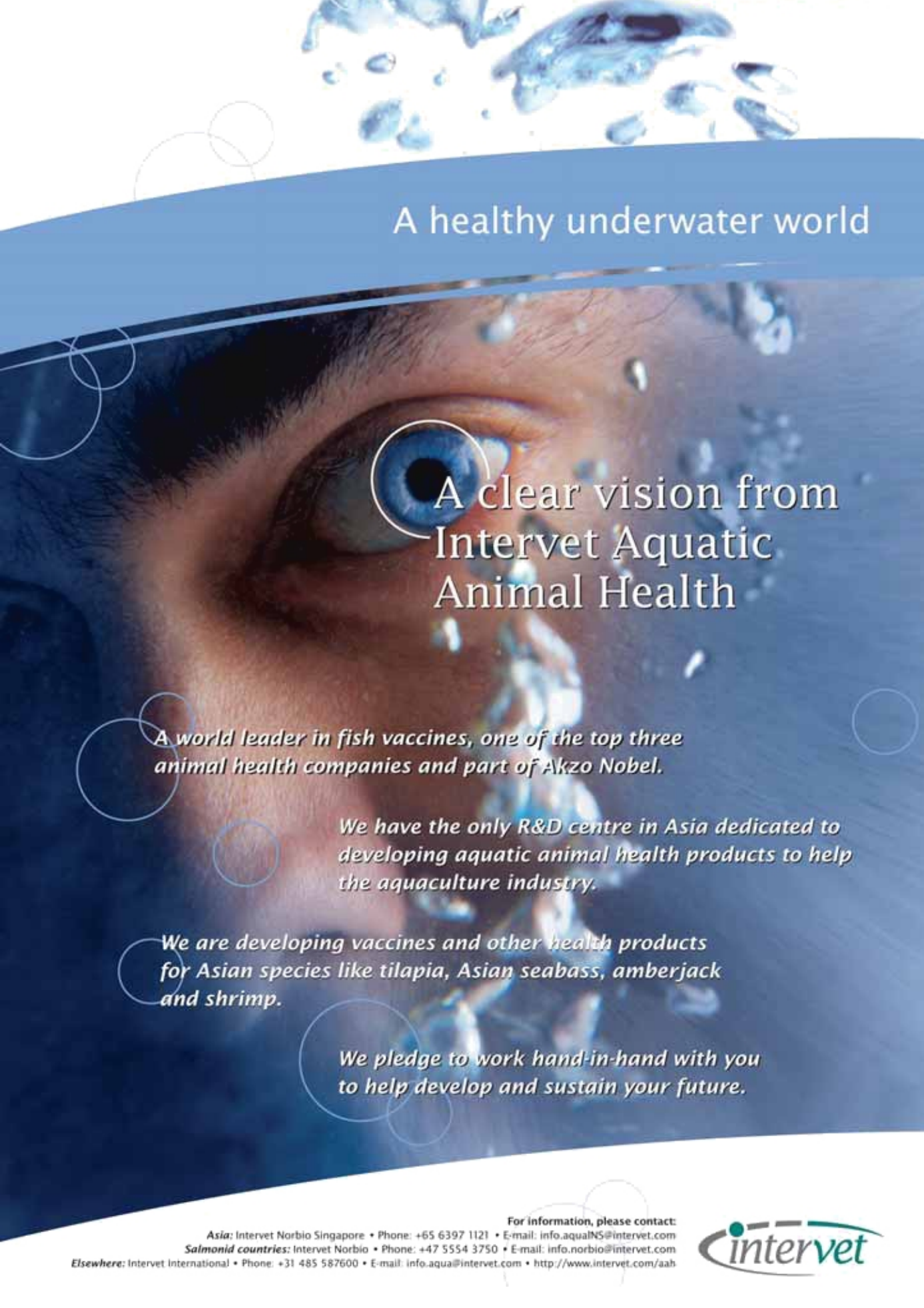
PT Dipasena Citra Darmaja's shrimp farm in Lampung Province, South Sumatra had 18,064 ponds (totalling 3,613 ha), processing and cold storage facilities (set up in 1990) and a shrimp feed mill which it acquired in 1996. It had 11,000 farmers in its plasma farming scheme. The capital expenditure has been USD 150 million for the farm and USD 80 million for the plasma farms.

Vietnam exporter pays USD 6.48 million for bond

Minh Phu Seafood Company, from the Camau Province, has paid this amount to the US Customs and Border Protection (CBP) to allow it to ship 25 containers of shrimp to the US. It is the first company to do so since the requirement was imposed in March. According to a company official, its shrimp exports to the American market totalled USD110 million, reports the Thanh Nien Daily. (related article: Bearish sentiments as catfish and shrimp prices fall, Issue July/August 2005, p8)

Abalone farm to seek Asian investors

Australian land based abalone farm Esperance Abalone Farms will target the Asian aquaculture industry, particularly Taiwan, as a source of funding for the setting up of its facility to produce 100 tonnes of abalone. It had hoped to build the facility by the end of 2005 but was unable to raise the capital of AUD3 (USD 2.28) million from within Australia, according to ABC online. The site at Bandy Creek is licensed and ready for abalone aquaculture with an application to include finfish.



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Focus on shrimp culture management

From artisanal to preventive and therapeutic measures against diseases in Vietnam

By Zuridah Merican

Usually, the measure of the degree of success of a farm is its ability to consistently achieve higher yields from crop to crop. Farmers have individual styles of management which may work well for specific pond and water conditions but not for others. Some examples of the various techniques in pond, water and feed management are given in the following reports from two regions in Vietnam.

A secret recipe and innovations in aeration

Phan Hong Hop and Ninh Kim Hoa have been improving yields from their 32 ponds in Can Gio Province, outside Ho Chi Minh City, Vietnam. To do this, the couple has developed some innovative methods. Using local materials, Ninh has developed an aeration system and Phan said that his secret is in using a garlic based product to clean pond bottom.

Phan Hong Hop and Ninh Kim Hoa

Currently, the ponds which range from 0.6 to 0.8 ha are 6 years old. As the lease on the land with a mangrove fringe is for a total of ten years, they are keen to increase yields as fast as possible. To increase production, they have also increased the stocking rate. Two years ago, the stocking was 40-60 PL /m^2 and currently, it is 62-65 PL/m^2. Phan has unsuccessfully tried stocking 100 PL/ha. Two years ago, some of the ponds were affected by the white spot syndrome (WSSV) and yellow head virus (YHV). Two ponds were affected by white faeces disease.

Currently, out of the 32 ponds, 20 ponds have been stocked in March. For this crop in 2005, Phan said that he will be able to harvest 17 tonnes/ha from ponds stocked with 60 PL/ha and survival of 98%. The target size is 30 pcs/kg. This is an increase from the yield of 11 tonnes/ha obtained in 2003. Back then the harvest size after 4.5 months of culture ranged from 28 to 30 pcs/kg.

Evidently, they are proud to be able to produce such high yields. Relative to other farms in the vicinity, Ninh said that they are targeting a profit as least 25,000 VND/kg per pond, in contrast to the lower margins of 10,000 VND/kg/pond realised by other farmers in the area. The reason, according to Ninh is that they are using more innovative technology in the farm compared with their neighbours.

Soil conditions in the area are acid sulphate. The 1.5 m deep ponds have been constructed by building up bunds of 1m height. Pond dykes are lined with HDPE liners. During pond preparation which lasts 30-45 days, Phan uses water from garlic to clean the ponds. He said that there is a clear difference in the performance of the ponds after this treatment. However, he has declined to reveal more than this. According to Phan, the difference is in shrimp health and growth is evident from the colour of the exoskeleton and from this, he is able to predict the number of days to harvest.

Prior to use, water is treated with chlorine and pH adjusted with calcium carbonate in reservoir ponds. There are two reservoir ponds. Three aeration systems are used in the ponds. The first is a central unit that lifts water up, which Nihn has fabricated locally based on an Australian design. The second works with a compressor to blow air out, similar to equipment being used in Taiwan. In each pond, two to three of these are used in combination with six paddlewheels aerators. Dissolved oxygen levels are maintained at 5 ppm.

Naturally, the recent fall in shrimp prices have affected them, especially since their culture period is only from March to September. In 2003, prices for 30 pcs of shrimp were 120,000 VND/kg (USD 8/kg) and in June 2005, it was 80,000 VND/kg (USD 5.33/kg). Phan has calculated that the minimum price should be VND 90,000/kg (USD 6/kg).

Thus, if prices do not pick up, they will delay harvesting the ponds and market larger shrimp with higher prices. The ponds are already in their 4th month of culture. This is in spite of the fact that even at these prices , profit margins are good, according to a feed supplier. The cost of production is 50,000 VND per ha (USD 3.3/kg). The FCR obtained from Uni President Vietnam's premium feed range (LA One) is 1.2 which is calculated at 40% of costs of production.

Three types of aerators are used. Pictured are the paddlewheel aerators (above) and the innovation fabricated by Ninh.

No expenses spared for preventive measures

Farmers in the Vinh An district of Ben Tre Province only depend on a single crop per year and a continuous improvement of pond and water conditions is critical for good and consistent harvest.

Bentre 1 050- Ho Duc Hung with the owner of the farm. Behind them is a lift used to cross a canal which separates the pond area from the office and stores.

Ho Duc Hung, farm technician/supervisor for two neighbouring farms of 9 ponds and 13 ponds, respectively, has developed pond preparation protocols for each farm. These protocols follow closely the recommendation of the provincial fisheries office. These take into account the different parameters such as salinity and problems faced at the respective farms. The total area of each farm is 12 ha and pond sizes are 0.4m^2.

He allows a total of three months for pond preparation. Pond treatment begins in November and extends into January the following year. Stocking is in February and harvesting in July. After this, as salinity begins to decline, farmers use the ponds for the culture of tilapia as salinity drops with flooding of the adjacent river.

The standard protocol in pond preparation is removal of the sludge and drying for over 2 months. Lime is added. Water preparation takes place in the reservoir, of which there are two for each farm, and includes treatment with chlorine. When the water clarifies, treatment is repeated with chlorine. The water is only used when the right colour is obtained. The whole treatment process lasts for 12–14 days.

Ho monitors water quality for alkalinity once a week, pH twice a day, ammonia, nitrite and nitrate regularly. He also monitors the phytoplankton population and composition. When neighbouring farms report disease problems (which are rare occurrences in the area), Ho uses chlorine to treat water prior to discharge.

More intensive farming methods in Ben Tre

Ben Tre Province in the Mekong Delta is a major shrimp farming area. In 2004, production was 20,000 tonnes, accounting for 10% of the Vietnam's total production. The total area is 36,000 to 50,000ha comprising of 11,000 ponds of 0.4 to 0.5ha in size. The majority of the farms are family owned and some 1,500 ha are 'industrial' farms.

In the last eight years, farms have shifted from extensive farming to intensive or 'industrial farming' but stocking remains low at 25–30 PL/m^2. The largest of these industrial farms are from 300 ha and the smallest, 5 ha. Harvest sizes range 30–40 pcs/kg. The small farms of 1–2 ponds carry out extensive farming using tidal flow and wild stocks of postlarvae shrimp. They produce large shrimp of 10–15 pcs/kg. In the last five years, the fortunes to be gained from shrimp have pushed many farmers to migrate from rice growing to shrimp culture.

Diseases such as WSSV, YHV, MBV and white faeces syndrome have affected farms in the region, the provincial fisheries office have set up 6 PCR-polymerase chain reaction machines for the detection of viral infections. Testing is controlled by the authorities. The first test is carried out two months after stocking and subsequently at intervals of 14 days. No testing by private laboratories is permitted.

Even so, infections from pond to pond have been reported and to date some 300 ponds have had incidences of diseases. The provincial fisheries have developed pond management protocols to improve pond preparation, fry selection and water quality. The use of probiotics is encouraged. They have also introduced methods such as the use of netting material to prevent the entry of disease carriers. Water exchange is not encouraged but is added once every two weeks. In line with the government's export strategy, there are severe penalties for the sale of antibiotics.

Nguyen Xuan Quang Tuyen runs the provincial fisheries office. Although the biggest problem in the area is disease occurrences, farmers remain reluctant to change farming methods. The recent US antidumping action is a main contention for farmers.

Harvested shrimp are sold to five processing plants in Ben Tre as well as those in Cantho. Technical support for farmers is provided by 90 technicians attached to the provincial fisheries offices and 200 technical support staff from companies supplying feed, additives, equipment and pond supplies. Some 60% of the feed is from the three top aquafeed companies – Uni President Vietnam, Grobest and CP.

Ho Duc Hung with technicians from Uni President Vietnam

Black tiger shrimp from one of Ho's pond

During the culture period, Ho uses locally produced zeolite at a rate of 200 kg/ha to improve water quality. He also uses the probiotic Epicin, manufactured by Epicore, USA and Aqualact, manufactured by Biostadt, India. Both are live microbial probiotics. There are added costs but Ho is of the opinion that it provides some stability to the pond water and helps in the build up of microorganisms.

The stocking density was recently reduced from 30 PL/m^2 to 25-27 PL/m^2. The production from these ponds has reached 7 tonnes/kg/crop for 32-40 pcs/kg shrimp. Each crop is 6 months.

In the other farm which he manages, Ho uses zeolite imported from Indonesia instead. The other protocols remain the same. Ho said that the production in this farm is higher at 8 tonnes/ha/crop as the ponds are newer at 2 years. But in 2004, they harvested 52 tonnes, which is calculated as an average of 4.8 tonnes/ha. Both farms use feeds from Uni President. Feeding is carried out five times as day at 0600, 1000, 1400, 1800 and 2200 hrs.

Cost of production is 50,000 VND/kg (USD 3.3/kg) whereas the current ex- farm prices are 75,000 VND/kg (USD 5/kg) (i.e. lower than shrimp sold by farms around Ho Chi Minh City). Ho said that if prices of shrimp continue to fall, they will continue to farm the shrimp but will cut costs by reducing stocking density.

Keeping production up

In the older shrimp farming area of Binh Dai District poor pond and water conditions have given rise to a multitude of problems including diseases. Aside from limiting water exchange, farms have adopted measures such as the additions of immunostimulants into feed and the control of toxic conditions in ponds. These have enabled them to carry on and consistently harvest size 40/kg black tiger shrimp.

The Binh Dai district in Ben Tre province (see box) in the Mekong Delta has 5,000 ha of 0.4–0.5ha ponds. These average 6 years and are mostly used for the intensive culture of the black tiger shrimp. Many farms in the area have faced disease problems from White Spot Syndrome (WSSV), Monodon Baculovirus (MBV), white faeces disease, black and yellow gill and broken tails.

Following the Provincial Fishery Department's new regulations, farmers are now restricted to one crop of shrimp per year alternated with one crop of fish to reduce disease risks and improve sustainability. The culture period for shrimp is between March and October when the temperatures are higher and that for fish, mainly tilapia, from November to February.

For the shrimp crop, farmers follow a strict protocol for pond preparation between harvests. The routine methods of pond preparation include the removal of sludge and sterilization, treatment with lime and drying for 15–30 days. Additionally, they also use probiotics in pond preparation which they usually extend into the culture period. Stocking density is around 30 PL/m^2.

Some 70% of farms in the area have also begun to use feed additives as part of their health management strategy. One such product is Bayer's OliMOS, which contains as the main ingredient, the mannan oligosaccharide Bio-MOS® manufactured by Alltech Biotechnology. The MOS is derived from the cell wall of a specific strain of yeast, *Saccharomyces cerevisiae*[1026]. It has properties such as the ability to adsorb and neutralize certain pathogens and can improve immune responses and gut health.

Farmers add 5g of the product dissolved in water to one kg of feed. Squid liver oil and lecithin are then added to this mixture and used to coat pellets at the farm site prior to feeding. This is used throughout the production cycle. Although starter feeds may be unsuitable for coating, farmers add this, so as to secure protection against diseases to PL as early as possible.

Dang Hoang Hai, Bayer Distributor, Duong Tan Tu, Farm Technician and Vo Thanh Con

According to Mr Vo Thanh Con, Chief of Binh Dai Fishery Promotion Center, this has increased shrimp immunity and helped to reduce significantly farmers problems with white faeces syndrome, a major problem faced by farmers in Vietnam.

"Initially we used the feed without any additives but, as conditions worsened, we needed to find ways to improve growth performance. When we started to use the MOS, the infection rate of shrimp to white

faeces syndrome was reduced from 70% to 30%. We have also observed a more uniform size of shrimp and have been able to harvest sizes up to 40 pcs/kg. We can see the benefits of improved feed conversions in the gut which also reflects the health status of the shrimp".

Water management

As more and more farms were set up in the vicinity, the discharge of untreated water gradually led to poor water quality of the coastal areas. Farms adopted the closed system or limited water exchange to reduce the entry of carriers of diseases into ponds and risks of contamination from other farms. However, better control of water quality within the ponds became vital when farms reported incidences of shrimp coming up to the surface and problems of shrimp mortality.

They attributed this mainly to high levels of ammonia from uneaten feed and faecal waste, although no measurements were made (see box). The pH level is monitored twice a day and range from 7.5 to 9. Dissolved oxygen is monitored weekly.

To maintain water quality and reduce ammonia problems, farmers started to use Deocare A, a product marketed by Bayer. This is a combination of Bio-Mos and De-Odorase. The latter, produced in Mexico by Inyuca, a fully-owned subsidiary of Alltech, is a blend of ingredients aimed at reducing ammonia levels and preventing environmental stress on the shrimps.

"We noticed that the gills of shrimp turned yellow. Ammonia levels were measured and we dosed ponds water with Deocare. Shrimp then recovered," said farm technician, Duong Tan Tu.

In the application program developed by the farmers themselves, the initial dosage is 0.3ppm. This is applied directly into the ponds every two weeks starting from the first month of culture (about 15-20 days after stocking). In the second month, the application rate is 3 times/month and in the third month the dosage is increased to 0.5ppm. From the fourth month onwards, the application is as when required and the dosage is increased to 0.7 to 1ppm.

Bottomline

For these farmers, the benefits of these measures are not only better survival and growth performance but more importantly, a consistent harvest. Vo Thanh Con said, "Naturally, our costs of production have increased with the use of these products but we are compensated with increased survival and larger shrimp. Cost increases are around VND 6 million/ha (USD 400/ha) but our sales in shrimp reach 500 million VND/ha (USD 33,000/ha) from our 50 ponds".

Ammonia problems in ponds

Dan Fegan

According to Dan Fegan, Regional Technical Manager Aquaculture, Alltech Biotechnology, closed, or limited water exchange systems, reduce water exchange to prevent diseases from entering into the pond. Good pond management is critical as the water quality can deteriorate quickly due to the accumulation of organic matter from uneaten feed, faeces, dead shrimp and algal bloom crashes.

All of these can result in an accumulation of ammonia, a by-product of protein metabolism. It has been estimated, for example, that as much as 0.4 ppm ammonia can be added to the system for each 100kg of feed used. Addition of such high amounts of ammonia can overcome the ability of the pond ecosystem to assimilate the ammonia naturally and so excessive ammonia levels can result.

Ammonia is present in water in two forms – a toxic un-ionized ammonia (NH_3) form and a non-toxic ionized ammonia (NH_4^+) form, The relative amounts of these are dependent on the pH of water and, to a lesser extent, water temperature. The percentage of the toxic form increases as pH and temperature rise during the day and can reach critical levels. (Shrimp growth and survival can be reduced with long-term exposure to un-ionised ammonia at 0.1ppm and short term exposure to as low as 0.4 ppm.)

At pH levels below 8, un-ionised ammonia should be less than 10% of the total ammonia measured. However, this proportion rises rapidly and un-ionised ammonia can be 50% of total ammonia at pH9 and over 90% at pH10. Test kits used by farmers generally measure total ammonia so it is necessary to know the pH of the pond water and use conversion tables to estimate the level of un-ionised ammonia in the pond. Thus, a test kit measurement of 4 ppm total ammonia would represent 0.4 ppm un-ionised ammonia at pH 8 but 2 ppm at pH9 .0 and 3.6 ppm or more at pH 10.

Overfeeding, even in one feed, can lead to sudden increases in ammonia, sometimes called ammonia spikes, a few hours later. These spikes can often be missed during daily or weekly sampling of water for ammonia levels but their effect on shrimp growth and performance can be seen in, for example, recirculating systems or high density indoor culture systems.

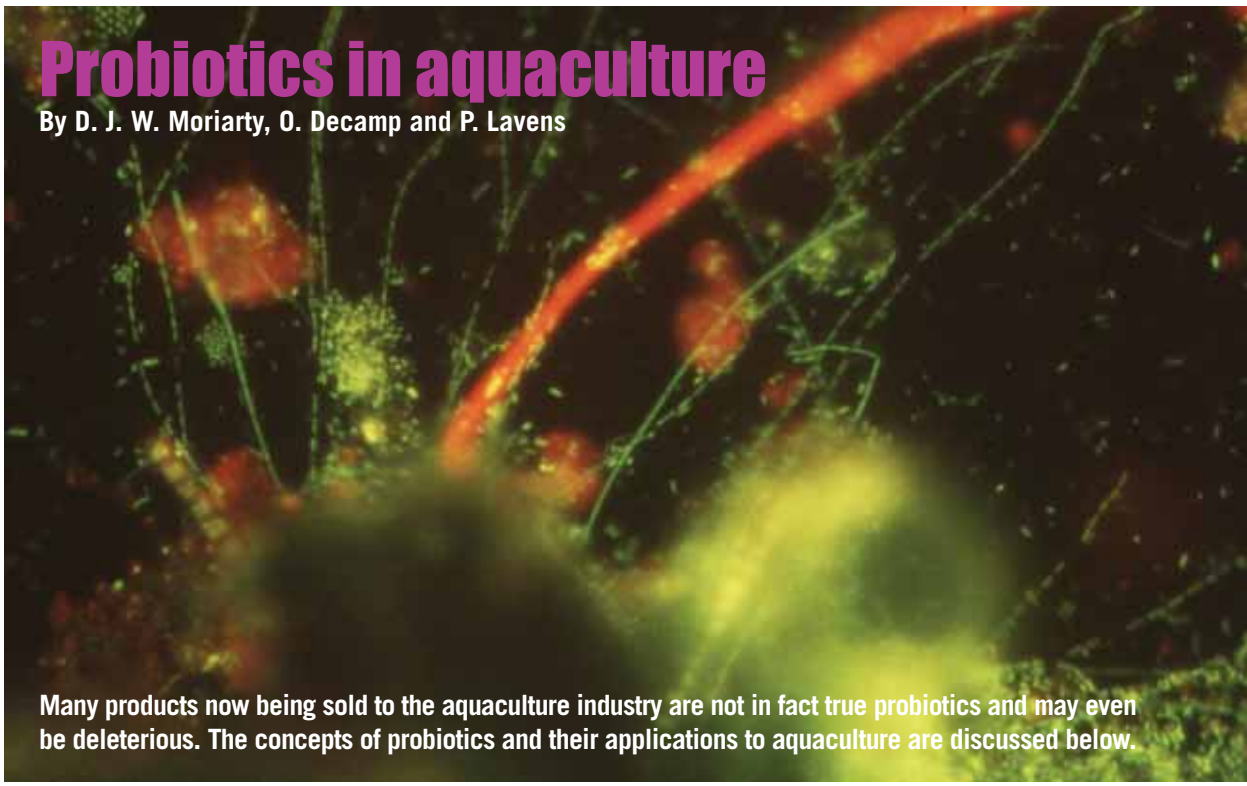
Thus, it is a ***prudent management strategy*** to reduce ammonia in ponds, even at lower pH. Methods used by farmers include water exchange with water of lower ammonia levels, use of probiotics or bacterial amendments, zeolites and products such as De-Odorase and Deo-Care A.

Unfortunately, water exchange is less of an option if low water exchange systems are used. Successful application of probiotics can give inconsistent results due to wide differences between bacteria counts and strains, differences in the environmental conditions in which they are used, and the slow growth of many "probiotic" bacteria strains in ponds. Zeolites, although widely used, have been shown in several studies to be ineffective in reducing ammonia at salinities above 1 ppt due to competition with other ions in salt water such as sodium, potassium, magnesium and calcium.

De-Odorase is a mixture of Yucca extract, bacteria and enzymes. Many trials have shown that this can be used to reduce ammonia levels quickly in water. Unlike zeolites, it works over at a wide range of salinity, temperature and pH and can be used routinely and as an emergency treatment to allow slow-acting probiotics time to develop in the pond.

Probiotics in aquaculture

By D. J. W. Moriarty, O. Decamp and P. Lavens

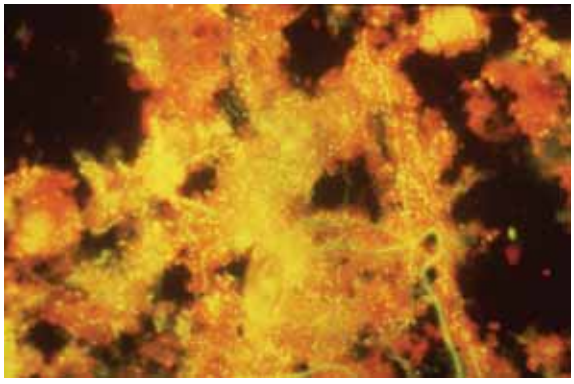


Many products now being sold to the aquaculture industry are not in fact true probiotics and may even be deleterious. The concepts of probiotics and their applications to aquaculture are discussed below.

Probiotics, the natural, beneficial bacteria are now well accepted and widely used in shrimp aquaculture. Potentially, they may have one or more beneficial functions for aquaculture producers:

- Water and pond bottom sediment quality are improved, leading to less stress on shrimp and thus improved health.
- Effluent water is cleaner, thus environmental impact is low.
- Pathogenic bacteria and their virulence can be controlled, and the overall microbial ecosystem can be managed.
- Antibiotics are not used. This stops the increase in virulence and pathogenicity in aquatic bacterial pathogens due to antibiotics. It will also minimise the risk of multiple antibiotic resistance.
- Stimulation of the shrimp immune system.
- Improved gut flora and hence lower disease incidence and increased food assimilation

Hence, productivity and profits are increased when selected probiotics are used.



Bacterial communities in water and sediment are complex with many different species interacting at close quarters. True probiotics are designed to enhance beneficial species and inhibit deleterious ones.

Some concepts in probiotic bacteria

The term *probiotic* has been defined as "a mono- or mixed culture of live microorganisms that when applied to animals or man, affect beneficially the host by improving the properties of the indigenous microflora". Moriarty (1996a, 1998) extended the definition for aquaculture to include the addition of natural bacteria to tanks and ponds in which the animals live.

Probiotic bacteria improve the health of shrimp or fish by controlling pathogens and improving water quality by modifying the microbial community composition of the water and sediment. Probiotic bacteria enter the gut or attach to external surfaces of the animals either directly from the water or via attachment first to food or other ingested particles. Thus, they are used in aquaculture both as water and sediment quality conditioners and as feed supplements.

When we started work with probiotics in commercial shrimp farms, the products that were available had a low number of the important genus: bacteria *Bacillus*. Before use they had to be brewed by the farmer with a nutrient medium to produce a high enough number to be added to a pond to be beneficial (e.g. see Moriarty 1996 a, 1996 b, 1998). Now, we can produce pure strains of *Bacillus* at low cost and market these as powdered mixtures of spores with a long shelf life. The powders are simple for the farmer to use.

"The changing of a bacterial community takes time. It is an ongoing process that requires addition of the beneficial strains of bacteria throughout the culture period".

Many shrimp and fish farmers often think of probiotics as medicines like antibiotics. They expect a quick and decisive effect. They are then discouraged from using probiotics when the results are not immediate or dramatic. The changing of a bacterial community takes time. It is an ongoing process that requires addition of the beneficial strains of bacteria throughout the culture period. The bacteria that are added must be selected for specific functions, added at a high enough population density and under the right environmental conditions to be effective.

Bacillus – the true probiotics for shrimp aquaculture

Gram positive *Bacillus* species are spore formers and produce a wide range of antagonistic compounds. They are suitable as commercial probiotics in aquaculture. Species such as *B. subtilis* and *B. licheniformis* occur naturally in fresh and sea water environments and are found naturally in the intestinal tracts of prawns. They are considered true probiotics for shrimp aquaculture (Moriarty 1998, 1999; Decamp and Moriarty, 2005).

Ineffective products that are sold as probiotics have caused farmers to question the probiotic concept, rather than the nature or mode of action or number of the bacteria in the product. Some contain inappropriate species of bacteria, or population densities that are too low to be effective for aquaculture.

For example, products for crustaceans containing *Lactobacillus* species that were produced for human or land animals are not appropriate for shrimp where these bacteria do not occur naturally. Some products in Asia have labels indicating *Clostridium* species, *Pseudomonas putida, P. aeruginosa, Enterococcus faecium* and *E. faecalis*, which are human and/or fish pathogens. Some products contain purple sulphur bacteria, which require light and hydrogen sulphide under anaerobic conditions. Such conditions would be lethal to shrimp.

The microflora of the sediment and water in which the cultured shrimp or fish live is influenced by the microbes released from faeces of all the animals in their environment. If a pathogen is present, its population density can be magnified through interactions in the intestinal tracts of the animals and in the faeces. When food for aquatic animals is added to the water, it adsorbs or absorbs bacteria from the water before it is eaten.

However, when probiotic bacteria are added to ponds or tank water and are adsorbed to feed, they enter the intestinal tract and compete with pathogens. Thus the farmer can manipulate the species composition by seeding large numbers of desirable strains of bacteria or algae; ***in other words, by giving chance a helping hand.***

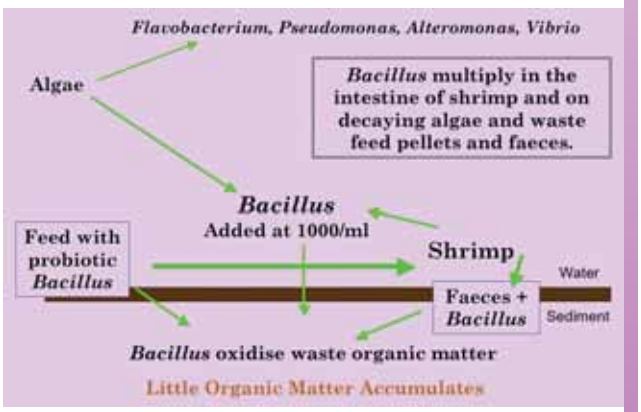
Pond processes mediated by bacteria

Vibrio bacteria often dominate when algal blooms die and shrimp numbers are high. Oxygen diffusion is limited in organic detritus on the pond bottom, especially when the feeding rate is high and thus oxygen is rapidly depleted. Fermenting bacteria, which include *Vibrio*, become active and release organic acids, some of which are toxic to shrimp and which are used by sulphate-reducing bacteria in shrimp ponds.

It is important to ensure that organic detritus and slime do not build up on the pond bottom. All faeces, excess feed and dead algae must be decomposed rapidly. Aeration by itself is not enough. Active bacterial populations must be changed to species that are adapted to rapid degradation of complex organic molecules. The *Bacillus* group produce a wide range of exo-enzymes that are very efficient at breaking down large molecules such as protein and fats.

When selected *Bacillus* strains are added to ponds frequently and at high density, they degrade organic matter faster than in situations where only the natural populations are available. Denitrifying *Bacillus*, which breakdown organic waste and use nitrate when oxygen is depleted, are especially effective on the pond bottom. A product is now available on the market from INVE that contains specially selected bacteria to speed up degradation processes (Figure 1).

Figure 1: Effect of *Bacillus* at high population density in ponds. *Bacillus* compete with other bacteria in the pond for organic matter from algae, feed and animals. Specially selected *Bacillus* displace pathogenic *Vibrio*.

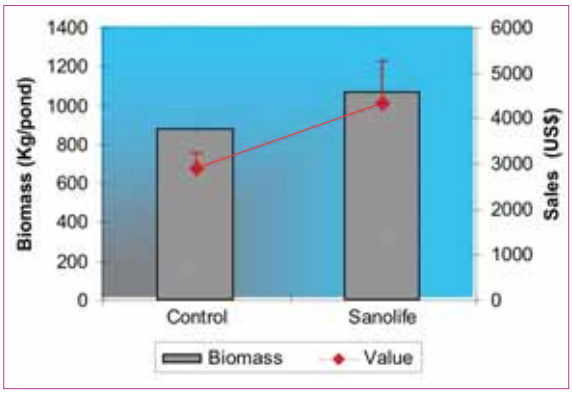


Results of probiotic use in shrimp grow out

Where appropriate and effective products are used, the results are good. For example, in Indonesia and Philippines, Moriarty (1998 and 1999) showed that production was high and consistent in all ponds where probiotics and sound management technology were used, whereas untreated ponds or ponds with antibiotics often collapsed due to disease.

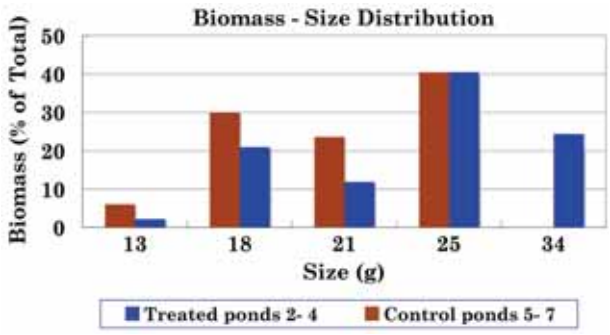
In 2004, at Teknomin farm in Andra Pradesh, India, 25% of black tiger shrimp *Penaeus monodon* reached 34g in the 3 ponds where the probiotics were added to feed (Figure 2). The largest average size of shrimp in the control ponds was only 25g during the same time period (115 days). The net profit was therefore far greater when the probiotics were used (Figure 3). This was achieved by using the respective probiotics

Figure 2: Biomass and size distribution of shrimp on Teknomin farm. Means are for 3 ponds treated with Sanolife® PRO-W in the water and Sanolife® PRO-1 and PRO-2 in feed of *Penaeus monodon* at Teknomin farm in Andra Pradesh, India,and 3 control ponds. Stocking density 10/m^2.



in the water and by incorporating the *Sanolife*® probiotics in all feed, so that the intestinal tract of the shrimp was colonised by *Bacillus* species that competed successfully with the pathogenic *Vibrio* species.

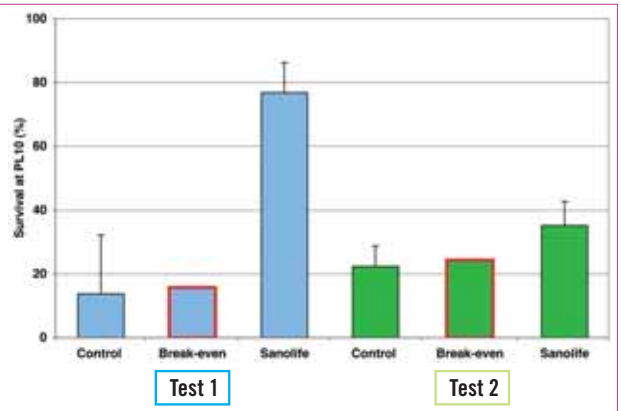
Figure 3: A combination of SANOLIFE® PRO-1, PRO-2 and PRO-W was evaluated in India, with 3 ponds per treatment. Higher survival and harvested shrimp biomass were observed from ponds having been treated with the Sanolife probiotics. Lower FCR was observed in ponds receiving the Sanolife treatments, i.e. 1.52±0.13 compared to 1.6±0.18 for the negative control ponds. Furthermore, bigger sized shrimp were found only in ponds treated with the probiotics. This led to a >10-fold increase in benefits with the Sanolife treatment.



Probiotic use in hatcheries

The main function of probiotic products for hatcheries is to control pathogenic bacteria, especially *Vibrio harveyi* and *V. alginolyticus*. However, results are not always good, because *Vibrios* evolve very quickly, and many very resistant strains are present in some areas, partially in response to antibiotic use. Some of these are also resistant to the probiotics, so probiotic bacterial strains need to be selected that have a wide geographical range. Good results have been reported recently in several different countries for the INVE product for hatcheries (Figure 4).

Figure 4. In 2 separate tests run over a period of 1 year in Thailand, *Penaeus monodon* nauplii were reared until PL10 and fed a combination of *Chaetoceros*, *Artemia* nauplii and Lansy Shrimp (40% live food substitution) INVE larval diet. In these replicated tests, the daily application of SANOLIFE® MIC probiotics at a final concentration of 1-5x10^4 cfu/ml of tank water gave results similar to those observed with prophylactic application of antibiotic and the benefits in term of survival. In both tests, a net profit was realized with the Sanolife® MIC, whereas survivals in the controls were less than the breakeven number.



Following germination in sterile water, the product was added daily to the larval tanks at a concentration of 0.5 ppm until the zoea 2 stage and then 1 ppm from zoea 3 stage to harvest. Its daily application gave results similar to those observed with prophylactic application of antibiotics. The improved survival/biomass compared to negative control outweighed the cost of the probiotics in all tests.

Obviously, minimizing the risk of vibriosis demands a multi-disciplinary approach, including good hygiene and sanitation measures to control the input of potential pathogens, as well as a sound farm management. ***However, probiotics are only cost-effective when they are properly applied together with a suitable farm management.***

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Recent trends in China's aquaculture industry

By Wang Qingyin and Wang Qun*

In 2003, total aquaculture production in China reached 30.28 million tonnes, of which 12.53 million tonnes were from mariculture and 17.74 million tonnes from inland farming. Remarkable developments were in the production of *Penaeus vannamei* which totaled 605,295 tonnes in 2003 as well as in the production of various species of marine fish.

Genetically improved shrimp F. chinensis Huanghai No. 1.

In 2003, aquaculture production in China continued its upward trend and dominated fishery output. It accounted for 64% of the total of 47 million tonnes of fishery production. Total production in 2003 was 3.09% higher than that in 2002. Currently more than 150 aquatic species, including fish, crustacean, molluscs, seaweeds and others are cultured in seawater and/or fresh water. Different farming modes and techniques have been developed or innovated according to local ecological and economic situations (Table 1).

China produced 12,533,000 tonnes of aquatic products from mariculture and 17,742,000 tonnes from inland waters in 2003. This is an increase of 3.34% and 4.74% respectively of the production in 2002. In the mariculture sector, molluscs accounted for 78.6% of the total production. Important cultured species include clam, oyster, abalone, mussel, scallop, razor clam, conch, blood clam, etc. Seaweed production accounted for 11%. Production from the aquaculture of shrimp and crab represented 5.3% and fish accounted for 4.1%. Fresh water aquaculture consisted basically of fish production which accounted for 91.4% of the total fresh water production (Table 2).

In 2003, the area for mariculture was about 1,532,000 ha, an increase of 23% from that in 2000 (1,243,000 ha). The average annual growth rate was 7.67%. From 2000 to 2003, the area for freshwater farming increased slightly at 5.6%. It was 5,571,000 ha in 2003. The average annual growth rate of was 1.9%. (Figure 1)

Table 1. Aquaculture production of China in 2003

	Total production (tonnes)	Category	Production (tonnes)
Overall fishery production	47,060,000		
Aquaculture yield	30,275,000		
Mariculture	12,533,000	Fish	519,000
		Crustacean	661,000
		Molluscs	9,853,000
		Algae	1,383,000
		Others	115,000
Fresh water culture	17,742,000	Fish	16,211,000
		Crustacean	1,065,000
		Molluscss	179,000
		Algae	5,700
		Others	281,000

Table 2. 2003 production in 2003 of main important fish species in China

Category	Species	Production (tonnes)
Marine fish	Sea bass *Lateolabrax japonicas*	78,000
	Yellow croaker *Pseudosciaena crocea*	58,000
	Flounder, turbot etc	36,000
	Groupers, *Epinephelus spp.*	26,000
	Sea breams	42,000
	Cobia *Rachycentron canadum*	16,000
	Red fish *Sciaenops ocellatus*	45,000
	Fugu *Takifugu spp.*	10,000
Fresh water fish	Black carp *Mylopharyngodon piceus*	269,000
	Silver carp *Hypophthalmichthys molitris*	3,382,000
	Bighead carp *Aristichthys nobilis*	1,906,000
	Grass carp *Ctenopharyngodon idellus*	3,492,000
	Common carp *Cyprinus carpio*	2,267,000
	Goldfish *Carassius spp*	1,789,000
	Pingue *Parabramis pekinensis*	525,000
	Tilapia *Oreochromis spp*	805,000
	Eel *Anguilla spp*	161,000

Marine shrimp culture

The most remarkable development in 2003 was in the culture of the white shrimp *P. vannamei*. This shrimp species was introduced into China from North America experimentally in 1988. In the later part of

Figure 1. Aquaculture production and farming area (seawater and freshwater) from 1999 to 2003

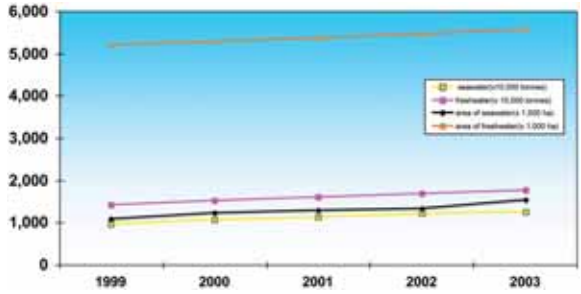
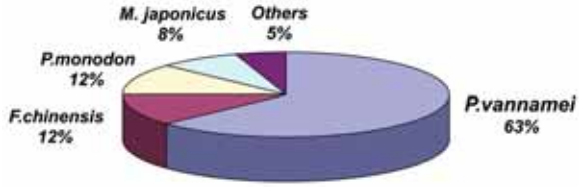


Figure 2. Proportion of marine shrimp species cultured in China in 2003



Cages for the culture of yellow croaker in Fuzhou. Picture courtesy of Dr Chawalit Orachunwong.

Modern storm resistant cages in Hainan. Picture courtesy of Dr Chawalit Orachunwong.

the 1990s, this species became the most important farmed shrimp species, not only in marine farming but also in freshwater culture systems (Figure 2). The total production of *P. vannamei* in 2003 was 605,000 tonnes, of which 51% was from seawater farming, and 49% was from fresh water farming. (Figures 3 and 4)

Industry has predicted that the production of *P. vannamei* will stabilize at present levels, despite its potential in China. The market will be the major constraint of the culture of *P. vannamei* in China.

Guangdong Province has become the most important shrimp producer over the last few years, especially for *P. vannamei* culture. In 2003, the area under shrimp mariculture in Guangdong was about 28,000 ha, with an output of 101,000 tonnes. Another 149,000 tonnes were produced from fresh water ponds in the province.

The production of the indigenous species *Fenneropenaeus chinensis* remained low because of disease problems. Many efforts have been made to revitalize its farming. A recovery of its culture is now present in north China. One of the most important measures was to genetically improve the growth performance of the shrimp. Since 1997, selective breeding has been carried out to improve the growth rate and disease resistance.

By 2003, the average body length of the selected population increased 8.40%, while the average body weight increment was up to 26.86%, compared to the unselected populations. Survival rate also improved substantially. In 2004, selected populations of *F. chinensis* were named "Huanghai No. 1" as a new variety for aquaculture by the Ministry of Agriculture of China. It was popularized in shrimp farming districts in Shandong and Jiangsu Provinces and desirable results were achieved.

Hopefully, the extension of new shrimp farming variety and associated technologies developed after the 1993 shrimp disaster will greatly benefit the shrimp farming industry as a whole.

Mariculture

There have been many developments in the culture of various species of marine fish. The culture of the olive flounder *Paralichthys olivaceus* and turbot *Scophthalmus maximus* is fast developing in north China. In South China, the culture of the turbot is also being developed whilst that of other species such as starry flounder *Platichthys stellatus*, half-smooth tongue-sole *Cynoglossus semilaevis* and southern flounder *Paralichthys lethostigma* are in the research and development stages.

The development of artificial propagation of sea cucumber larvae and its culture technology has popularized its farming in the seas off

Figure 3. Marine fish and shrimp production in 1999 to 2003 in tonnes

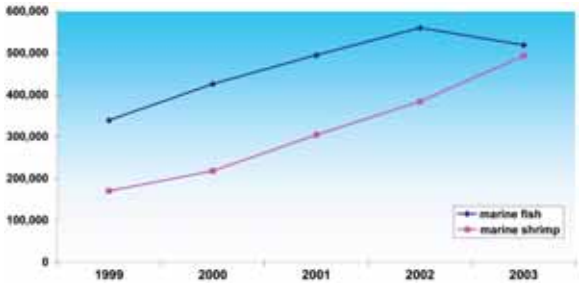


Figure 4 – Marine shrimp production in China (1977-2003)

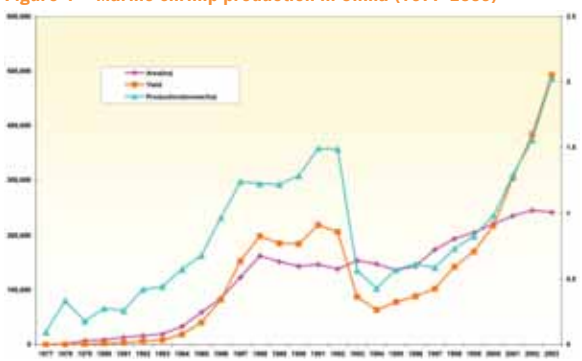
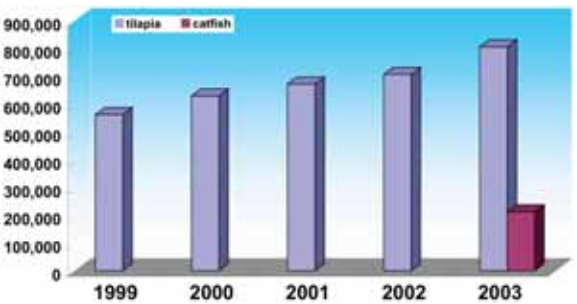
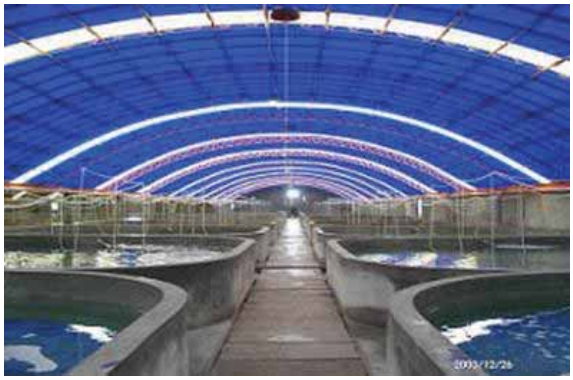


Figure 5 – Production of tilapia and catfish from 1999 to 2003





Indoor fish farming in Shandong Province.

Shrimp ponds in Hainan. Picture courtesy of Dr Chawalit Orachunwong.

north China. At present, the sea cucumber farming area in Shandong province alone is about 16,000 ha.

In marine fish farming, the use of storm-resistant deep water cages has also developed rapidly in China and this has spread from the south (Fujian, Guangdong, Zhejiang) to north China (Shangdong, Liaonimng).

There was also a pattern in industrial farming. This has reached a substantial scale in Shandong, Liaoning, Jiangsu, Zhejiang, Fujian, Hainan, Guangdong, Guangxi, Hunan, Hubei provinces and in Beijing city. The main species are olive flounder, *Paralichthys olivaceus*, turbot, *Scophthalmus maximus*, soft shell turtle, *Pelodiscus sinensis*, sturgeon, *Acipenser sinensis*, abalone, *Haliotis diversicolor* and *Haliotis discus*. Marine fish culture area in the industrial farming pattern in Shandong province alone has reached about 2,600,000 m^2.

Pearl culture is developing in Jiangxi province, and the farming area has reached reach about 5,300 ha. A new pearl culture specie (*Hyriopsis schlegeli*), introduced from Japan, has been popularised in Jiangxi province.

Freshwater fish

Fujian and Guangdong provinces are the two main producers of cultured eel. Production advantages in these two provinces lie in the mild climate, the integrated infrastructure, good management and qualified skilled workers. It was reported that the local fishery authorities will emphasize the building of advanced eel culture facilities in Guangdong and Fujian provinces, and the export volume and value from these two provinces is expected to increase in the near future.

The production of valuable freshwater species such as *Pelodiscus sinensis* in Neimeng region, Chinese mitten-handed crab *Eriocheir sinesis* in Ningxia region and *Salmonidae* in Sichuan, Gansu and Yunnan province are developing rapidly.

Tilapia production in 2003 reached 800,000 tonnes, and main producers are Guangdong, Guangxi and Hainan provinces in southern China. This increased 14% from the production in 2002. The production of the channel catfish *Ictalurus sp* was reported in 2003 as 212,000 tonnes (Figure 5).

Table 3. Shrimp mariculture culture in 2003 in China

Species	Yield (tons)	Farming area (ha)	Unit yield kg/ha
P. vannamei (Mariculture)	308,947	89,334	3,458
P. vannamei (fresh water)	296,312	na	na
P. monodon	51,086	21,203	2,409
F. chinensis	61,685	52,719	1,170
M. japonicus	42,400	58,240	728

R&D

Besides the work on the selective breeding of *F. chinensis*, several projects supported by the National Hi-Tech R & D Program of China are on the genetic improvement of growth performance of other aquaculture organisms. These include work on the scallop, abalone, pearl oyster, flounder, yellow croaker and some fresh water fish species. It is expected that with the progress of technology, the aquaculture industry in China will develop in a healthy, stable and sustainable direction.

Aquaculture development policy and governance

Even though the aquaculture industry in China has made considerable progress and attracts world attention, there exist many problems to be resolved. In order to improve the quality and food safety aspects in the farming of aquatic products, the Chinese government has adopted a series of measures to:

- Strengthen the research capability in the selective breeding of new species and strains.
- Set up stringent standards and regulations to ensure quality and safety and to reduce the social and environmental impact of aquaculture on communities.
- List approved feed additives, pesticides, drugs, antibiotics and other chemicals.
- Specify the approved uses for each compound (regulation no: NY5071-2002) and monitor veterinary drug residues in aquaculture products.
- Develop aquaculture with biosecurity concepts and in a more socially and environmentally responsible manner.
- Focus on disease prevention and cure and develop some rapid and sensitive detection techniques for pathogen detection such as PCR, and gene probe, among others.
- Develop healthy management practices, such as applying quick and sensitive detection techniques to scan pathogens, using water quality reagents, probiotics, high quality feeds as well as preventing the discharge of untreated pond effluents into the environment.

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Advanced shrimp farming technology for white shrimp in Malaysia

As Malaysian shrimp farmers now have the choice of culturing *P. vannamei*, they need to understand the differences in intensification between this species and black tiger shrimp. This was the message by Malaysia's Asia Aquaculture Sdn Bhd, part of the Charoen Pokphand (CPF) group.

Dr Robins McIntosh

At this seminar on 'Advanced shrimp farming technology for the Pacific white shrimp', Dr Robins McIntosh, CPF Thailand shared his experiences and that of CPF at their farms in Lampung, Indonesia and in Thailand on better culture technologies. The seminar was attended by farmers from the area surrounding Manjung, one of the main farmed shrimp producing areas in Peninsula Malaysia. As farmers have been culturing the black tiger shrimp, the main focus of the seminar was to point out the differences in culture techniques when dealing with the white shrimp.

According to Robins, some of the differences are that there is little interaction between density and growth for the white shrimp. At 80–160 PL/m^2, high growth rates have been reported. In Thailand, stocking densities of 100–200 PL/m^2 are common. FCRs vary from 1.3 to1.5 and survival rates are 75% to 85% for a stocking density of 200 PL/m^2. There is a better tolerance to low temperatures and wide tolerance of salinity, although the optimal range is 15–30ppt. As for growth rates, figures quoted were 21g in 118 days in Indonesia.

In the current market scenario, farmers will have to show efficiency through fast growth, high survival rates and high production/unit to survive. Additionally, there is a need to minimize crop failures and show consistent harvests. With declining prices and yields going up in other countries, the challenge for Malaysian producers is to be able to produce at low costs. An average daily growth of 0.18g has been reported in Thailand, with good quality postlarvae stocked at 80–90 PL/m^2 whereas the lowest would be 0.15g and highest, 0.22g.

Farmers from Manjung and the surrounding area attended the half day seminarA

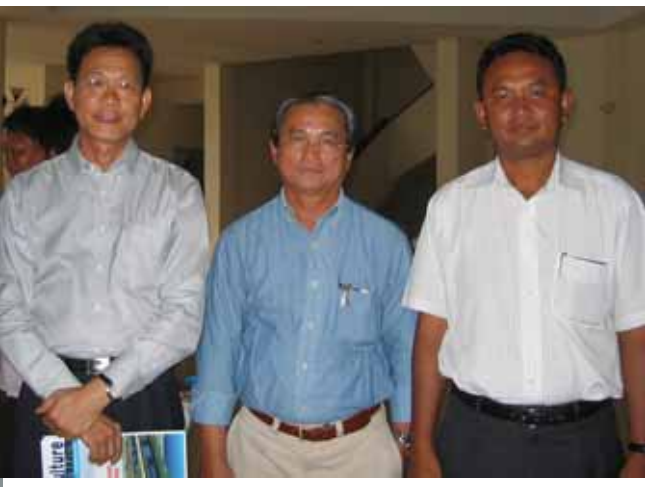
From left Saw Suan Huat, Yu Teow Nee and Tan Beng Hock, farmers from the Manjung district in Northern Peninsula Malaysia

The causes of poor growth were detailed as low surviving genetic stocks, insufficient feed, poor pond bottom conditions, that is, muddy with silt or sludge, poor dissolved oxygen at less than 3.5 mg/l, suboptimal water temperatures of less than 28°C and diseases. Robins said through its broodstock genetic program, CP now understands the importance of characteristics and family. As for the Taura syndrome (TSV), he said that there is a need to understand closely this 'enemy' and when it will manifest.

There are different strains of the Taura virus with different survival rates. The Texas strain has a survival of 99%, Hawaiian, 88%, Belize, 77% and Thailand, 77%. To develop TSV resistant stocks, CP has incorporated these into their genetic selection program. In contrast to the white spot virus (WSSV) where one constructs biosecurity measures to prevent crustacean and bird carriers, Robin said that "the solution for TSV is not only biosecurity but to stock TSV resistant postlarvae".

Prerequisites

In the advanced culture technology proposed by Robins, the first prerequisite is the use of disease free post larvae of PL10 to PL12. The next step is to be able to keep viruses out of the pond system. Water must be free of carriers and infective viruses. This requires the closed system of culture with filtered incoming water and reduced water exchange. Use of reservoirs will reduce the introduction of viral pathogens. A sterilization of pond soil is important as soils may contain Infectious hypodermal and hematopoietic necrosis (IHHNV) and TSV viruses and stay infective for more than 20 days. Reservoirs which are never dried may act to reinfect ponds.



Asia Aquaculture Sdn Bhd's Team. From left Yip Kam Toh, Sommas Soontornkit and Wichit Kongkheaw

Water management

In water management, Robins said that in a typical black tiger shrimp pond, low rpm (revolution per minute) aerators may suffice but those with high rpm are required for *P. vannamei* culture. A common system is the 4 paddle wheel aerators. The newer ones such as the long arm aerators and spiral aerators can circulate oxygen to the pond bottom and apply more efficient aeration.

In general, aeration to achieve more than 4 ppm of dissolved oxygen is related to production targets, stocking density, feed usage and salinity. One horsepower is suggested for 500 kg production and 50 PL/m^2. In Thailand, the norm is one hp for 600–650 kg of production. If stocking is 80 PL/m^2, the suggestion is 16 hp for a production of 8 tonnes. Relative to feed, the guide is 8–12 kg of feed for each hp of aeration. The placement of aerators is important to prevent localized deposition of sludge.

Pond bottoms

A high production of white shrimp (18 tonnes/ha) and an ADG of 0.22g have been reported in Indonesia where ponds are lined with HDPE liners over laterite hard clay pond bottoms. Ponds with soft sludge give poorer yields. However, Robins said that earthen pond bottoms can be improved with oxygenation by the tilling of the pond bottom and followed by sufficient drying and oxidation at least once a year.

To monitor shrimp health, the average daily weight gain is tabulated on a weekly basis. A linear growth pattern means that there may be no problems whereas a decrease in growth signifies problems.

Culture fundamentals

Overall, it is important to know how much shrimp can be supported by the pond environment. This is dependent on the oxygenation levels, carbon dioxide and the condition of pond bottoms. The rule of thumb is that the higher stocking density means lower harvest sizes. For example, at 125 PL/m^2, harvest size is 10g and the production can be 15 tonnes/ha in 80 days.

However, partial harvesting can be used to maximize carrying capacity. Although the ideal carrying capacity can be low, the farmer can achieve higher production volumes by partial harvesting more than once.

The use of hydrolysed soybean meal in feeds for juvenile freshwater fish

By Aruneepong Srisathaporn, Jowaman Khajarern, Pornchai Jaruratjamorn, Sarote Khajarern, Winai Jaikan and Adilak Lebnark

Juvenile hybrid catfish *Clarias garieppinus x Clarias macrocephalus* and tilapia *Oreochromis niloticus* fed diets with dehulled soybean meal hydrolysed with proteolytic enzymes showed good growth and feed conversion. A 10% substitution of the soybean component with this meal was sufficient to improve growth performance by 25% in hybrid catfish and 40% in tilapia.

The basic nutritive properties of various soybean products for fish are well documented. It has long been realized that heating of raw soybeans increases its nutritional value and palatability (Osborn & Mendel, 1917). Raw soybeans contain anti-nutritional substances which decreases animal growth and performance. The predominant anti-nutritional substance is trypsin inhibitor (TI) (Kunitz, 1945; Birk et al., 1963) which may also cause pancreatic hypertrophy with excessive endogenous protein losses (Booth et al., 1960; Rackis, 1972).

Several less studied anti-nutritional substances have also been identified (Rackis, 1972; Liener, 1975). It has been well documented that heat treatment of raw soybeans improves its utilization. Heat treatment primarily inactivates the heat liable TI (Rackis, 1972; Liener, 1981) and denatures the soy protein making them more digestible (Kakade et al., 1973). However, excessive heating may be undesirable because of the Millard reaction; the formation of unavailable sugar-amine complexes (Maynard et al., 1979) and the destruction of heat sensitive amino acids ie. lysine, cystine. (Smith and Circle, 1972).

The use of biotechnology by using beneficial bacterials and enzymes in pre-processing dehulled soybean meal offers some advantages such as

- enhanced and more constant nutritional characteristics of the product
- predigestion of the ingredient which will provide a better digestibility and,
- production of organic acidifier (lactic acid) for enhancing digestion enzyme and inactivating the antinutritional compounds in the intestinal of the animal.

In this study, four different sources of dehulled soybean meal fermented by bacterial *(Lactobacillus)* with or without enzyme phytase or hydrolysis with proteolytic enzymes replaced 10% of soybean meal in basal hybrid catfish diets. Weight gain, feed conversion and survival of fingerling hybrid catfish and sex reversed tilapia *Oreochromis niloticus* were measured.

Experimental diets

Five isonitrogenous and isocaloric diets were prepared to contain 36% protein and 3016 kcal kg-1 metabolizable energy (ME). The main protein sources were fish meal, soybean meal and wheat flour. In the treatment diets (T2 to T5), four types of pre-processing dehulled soybean meal replaced 10% of the soybean meal (Table 1). The diets were prepared and stored as described by Khajarern and Khajarern (1997).

Table 1: Composition of the experimental diets.

Ingredients	T1 Control	T2 VSL	T3 VSLP	T4 VSH	T5 DSBMF
Fish meal (60% CP)	37.00	37.00	37.00	37.00	37.00
Soybean meal (44% CP)	23.00	12.00	12.00	12.00	12.00
Broken rice (7.5%CP)	8.00	8.00	8.00	8.00	8.00
Corn (7.8% CP)	7.00	7.00	7.00	7.00	7.00
Rice bran (12.5% CP)	5.00	6.00	6.00	6.00	6.00
Wheat flour (13% CP)	15.00	15.00	15.00	15.00	15.00
Rice bran oil	2.00	2.00	2.00	2.00	2.00
Vet Soy-Lac (VSL)*	-	10.00	-	-	-
Vet Soy-LacP (VSLP)*	-	-	10.00	-	-
Vet Soy Hydrolyse (VSH)*	-	-	-	10.00	-
DSBMF**	-	-	-	-	10.00
Vitamin-mineral premixes[a]	2.00	2.00	2.00	2.00	2.00
Monocalcium phosphate (P21%)	1.00	1.00	1.00	1.00	1.00
Calculated composition					
Crude protein, %	36.04	36.13	36.13	36.13	36.13
ME, kcal / kg	3016	3019	3069	3019	3019

[a] *National Research Council (1983)*

* *Dehulled soybean meal fermented with bacterial Lactobacillus, Vet Soy-Lac (VSL), with enzymes phytase, Vet Soy-LacP (VSLP) and hydrolysis with proteolytic enzymes, Vet Soy Hydrolyse (VSH). All are from Vet Superior Consultant Co., Ltd, Thailand*

** *Dehulled fermented soybean meal from Taiwan*

Figure 1: Effects of diets containing different sources of pre-process dehulled soybean meal on growth performance of hybrid catfish fed for 4 weeks

Table 2: Summary on the effects of four different sources of pre-processing dehulled soybean meal supplementation in fingerling hybrid catfish for 4 weeks feeding a

Diets no	Body weight (g)	Weight gain (g)		Feed conversion (Feed: gain)	Survival rate (%)
		Average	Total		
T1 (Control)	6.130[b]	4.630[b]	74.080[b]	1.990	80
T2 (VSL)	6.980[ab]	5.480[ab]	87.680[ab]	1.823	80
T3 (VSLP)	7.120[ab]	5.620[ab]	89.920[ab]	1.775	80
T4 (VSH)	8.030[a]	6.525[a]	114.188[a]	1.693	87.5
T5 (DSBMF)	6.840[ab]	5.335[ab]	85.360[ab]	1.875	80

[a] *Values reported are means of two replicates.*
[a-c] *Means with different letters in the same column are significantly different (P<0.05)*

Table 3: Summary on the effects of different sources of pre-processing dehulled soybean meal on performance of tilapia fed for 4 weeks

Diets	Body weight (g)	Weight gain, (g)		Length gain (cm)	Feed conversion (Feed: gain)	Survival rate (%)
		Average	Total			
T1 (Control)	7.160[b]	4.925[b]	98.50[b]	2.505c	1.890[a]	100
T2 (VSL)	8.460[a]	6.290[a]	125.80[a]	3.055[a]	1.480[bc]	100
T3 (VSLP)	8.415[a]	6.280[a]	125.60[a]	2.885[b]	1.415[bc]	100
T4 (VSH)	9.030[a]	6.897[a]	137.20[a]	3.185[a]	1.355[c]	100
T5 (DSBMF)	8.155[ab]	5.897[ab]	117.93[ab]	2.785[b]	1.560[b]	100

[a] *Values reported are means of two replicates.*
[a-c] *Means with different letters in the same column are significantly different (P<0.05)*

Growth effects on juvenile hybrid catfish

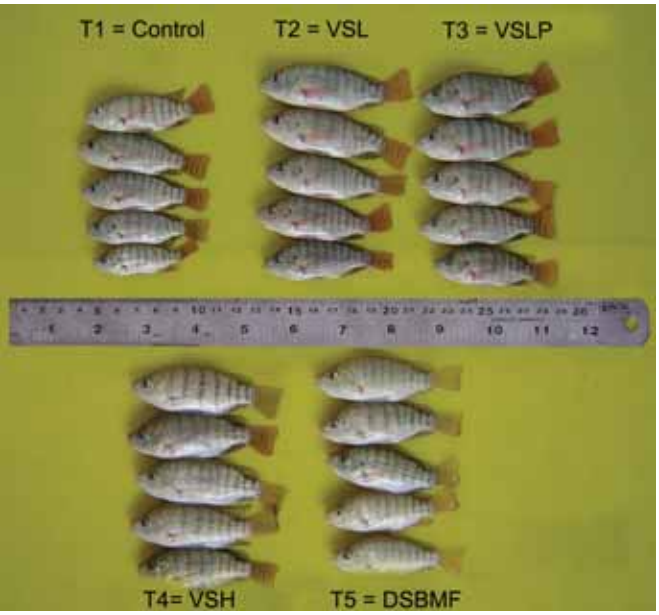
Fingerlings of hybrid catfish (*Clarias gariepinus x Clarias macrocephalus*) obtained from a commercial fish farm were acclimated to laboratorys condition for 3 days and fed a commercial feed six times daily. After acclimatization, fish with an average initial weight of 1.5± 0.05 g were selected and stocked into 28-litres glass aquaria at a stocking density of 20 fish each. There were two replicates for each treatment. Each aquarium contained 20 litres of water.

Each diet was fed to fish (average weight 1.5±0.05g) six times daily for 4 weeks. The average final weight gain, feed conversion and survival rate of fish fed diets containing different sources pre-processing dehulled soybean meal are presented in Table 2.

Hybrid catfish fed diet T4 had the highest weight gain and lowest feed conversion than those of fish receiving the other diets. The average weight gain of fish fed diet T3 was second, followed by diet T2. However, this weight gain was not significantly different (P>0.05) than of fish fed diet T5.

No significant differences were found in feed conversion of fish receiving the four different sources of pre-processed dehulled soybean meal and the control diet. Fish fed the control diet with soybean meal (T1) had the lowest weight gain and the highest feed conversion or the poorest feed efficiency.

Figure 2: Effects of diets containing different sources of pre-process dehulled soybean meal on growth performance of sex reversed nile tilapia fed for 4 weeks



Growth effects on juvenile tilapia

In this study, fingerlings of sex reversal tilapia obtained from a commercial fish farm were acclimated to the laboratory conditions for 3 days and fed a commercial feed six times daily. After acclimatization, fish with an average initial weight of 2.24± 0.2 g were selected and stocked into 28-litres glass aquaria at a stocking density of 20 fish each.

Each diet was fed to fish (2.24±0.2 g average weight) in two replicatess aquaria six times daily for 4 weeks. The gain in weight and length and feed conversion ratios were best for tilapia fed the diet T4 and followed by fish fed diet T2, diet T3 and diet T5.

The weight gain (average and total), feed conversion, length gain and survival rate of fish fed diets containing different sources pre-processing dehulled soybean meal are presented in Table 3. Tilapia fish fed diet T4 had the highest weight gain for both average and total and lowest feed conversion (the best feed efficiency) which were significantly higher (P<0.05) than those of fish fed the control diets. The weight gain of fish fed diet T1, T2 and diet T3 were comparable and were not significantly different (P<0.05) from fish fed diet T5. Survival was 100% in all treatment groups.

Conclusion

This suggested that it is necessary to pre-processe soybean meal to remove or inactivate the antinutritional compounds and digest fiber of the hull and improved palatability before the meal can be used in fingerling stage of hybrid catfish and tilapia feeds. It was also indicated that the effects of a 10% substitution of soybean meal with various types of hydrolysed soybean meal depend on the hydrolysis method. In both types of fish, the addition of soybean meal hydrolysed with proteolytic enzymes was most effective in increasing growth performance.

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Jowaman Khajarern *Sarote Khajarern*

The role of de-oiled soy lecithin in shrimp nutrition

By Yuyun Mu

Aquaculture has emerged as a fast-growing food producing sector since the 1990s. This expansion was led by the production of shrimp which showed an annual growth rate of 15%. According to FAO, shrimp aquaculture produced 1.3 million tonnes of shrimp and comprised only 3.3% of the total global aquaculture production in 2002, but it was valued at USD7.3 billion and represented 13.6% of the value of aquaculture production.

This growth of shrimp aquaculture, mainly of the black tiger shrimp *P. monodon* and white shrimp *P. vannamei*, will continue to strengthen into the future. A better understanding of the nutritional needs of specific shrimp has contributed to the fast expansion of shrimp aquaculture worldwide. In terms of nutrition, specific fatty acids, cholesterol and phospholipids are of great importance to shrimp. It has been well documented that shrimp have unique requirements of phospholipids for development, growth, reproduction and survival.

Biological functions of phospholipids

The membrane component

Phospholipids are the major lipid components of biological membranes. Within cell membranes, phospholipids are organized in the form of bilayers which ensure constant renewal and regeneration of cell materials. The level and type of phospholipids determine functional properties, physical uniformity and fluidity of the membrane.

Generally, phosphatidylcholine is the most active component owing to its specific role as the major component of polar lipids in membranes as well as lipoproteins. Without phospholipids in membranes, there is neither cell respiration occurring in the mitochondria nor mobility of the membranes. During the larval and juvenile stages, shrimp are not capable of *de novo* synthesis of phospholipids at a rate sufficient to meet the requirement for the formation and mobility of new cell membranes.

Emulsification of dietary lipids

Phospholipids have hydrophilic and hydrophobic properties. Such properties enable it to emulsify and disperse homogeneously dietary lipids in the intestine. In the early stage of shrimp, phospholipids are required for efficient emulsification and digestion of dietary lipids such as triglycerides and cholesterol. This is because of undeveloped digestive organs and limited secretion of bile acids in shrimp.

Role in lipid transport

Exogenous and endogenous lipids are incorporated into chylomicrons or lipoproteins for the transportation via the blood or lymphatic system in shrimp. Phospholipids are not only the important components of the above lipid transport vehicles but also have the influence on the assembly and stability of lipoproteins. In crustaceans, phospholipids accelerate mobilization of triglycerides and cholesterol from the midgut gland or gut into the haemolymph and between various tissues and organs, thus enhancing the utilization of dietary lipids and cholesterol.

What is de-oiled soy lecithin

De-oiled soy lecithin is the high concentration form of phospholipids that are natural occurring components of soy beans. Soy lecithin is defined as a complex of so-called "polar" and "neutral" lipids, consisting of phospholipids, glycolipids, triglycerides, sterols and small quantity of fatty acids, carbohydrates and sphingolipids.

Phospholipids contain two fatty acids esterified to glycerol and a phosphate group that is esterified to an alcohol. Common alcohols are choline, ethanolamine, glycerol, serine and inositol. The respective phospholipids are called phosphatidylcholine, phosphatidylethanolamine, phosphatidylglycerol, phosphatidylserine and phosphatidylinositol. In soy lecithin, phosphatidylcholine, phosphatidylethanolamine and phosphatidylinositol are major components of phospholipids.

De-oiled soy lecithin contains 96% phosphotides as acetone insolubles.

A comparison of de oiled soylecithin and with crude soy lecithin (right).

The neurotransmitter precursor

Phosphatidylcholine provides a bio-available and time-released source of choline. Choline is the precursor of acetylcholine, the most important neurotransmitter. Without supplementary phosphatidylcholine, the formation of acetylcholine is limited in shrimp as in mammals. This may lead to serious disorders.

Effect on body lipid composition

Phospholipids affect lipid deposition in tissues of shrimp owing to their functions in lipid transport. With phospholipid supplementation, larvae and juveniles of shrimp increase the retention and levels of polar and neutral lipids in hemolymph, muscles and tissues, in particular phosphatidylcholine, cholesterol and n-3 highly unsaturated fatty acids (HUFA). The type of dietary phospholipids influences the proportions of n-3 HUFA in the tissues of larval and juvenile shrimp.

Benefits of dietary phospholipids in shrimp

Provision of energy, phosphate, EFA, choline and inositol

Phospholipids are highly digestible in aquatic animals. Dietary phospholipids serve as the effective and direct source of metabolic energy, available phosphate, choline and inositol for larvae and juvenile shrimp.

Crustaceans including shrimp have a limited capability to synthesize the linoleic and linolenic group of fatty acids and possess little or no ability to chain-elongate and desaturate n-3 and n-6 polyunsaturated fatty acids (PUFA) into the n-3 and n-6 HUFA. Therefore, in shrimp, the need for essential fatty acids (EFA) must be met by dietary sources of linoleic, linolenic, eicosapentaenoic and docosahexaenoic acids. Phospholipids are superior sources of energy and EFA for growth and survival of larval shrimp. This is also for post-larval and juvenile shrimp.

Choline and inositol in the presence of phospholipids are more effective than synthetic choline and inositol for aquatic animals. For example, dietary choline is not as effective as soy lecithin in reducing molt death syndrome in juvenile lobsters. The beneficial effects of phosphatidylcholine and phosphatidylinositol on growth and survival in shrimp are not replicated by supplementing equal levels of synthetic choline and inositol, respectively.

Interactions with cholesterol

Cholesterol is an important sterol which is present per se or in combination with fatty acids in cells and blood. It serves as a component of cell membranes and lipoprotein complex and as a precursor of adrenal, reproductive and molting hormones vitamin D and bile acids for satisfactory molting, growth and reproduction. But crustaceans have been found to be incapable of *de novo* synthesis of cholesterol. Therefore, cholesterol is considered as an essential nutrient for crustaceans.

Phospholipids seem to improve the mobilization and availability of cholesterol in other trials with lobsters and shrimps although several studies failed to demonstrate an interaction between phospholipids and cholesterol requirements in some species of shrimp.

The dietary requirement for cholesterol in shrimp diets is between 0.5 and 1.0%. The complement effect on growth and survival of P. vannamei was observed by combination of supplementary cholesterol and phospholipids. For example, for the optimal growth of juvenile P. vannamei, cholesterol requirement could be 0.4% when the diet was deficient in phospholipids. It was 0.2% when 1.5 or 3.0% de-oiled lecithin was included in the diet, and 0.1% when 5% de-oiled lecithin was supplemented. The decreased requirement of cholesterol may be due to the fact that supplementary phospholipids or lecithin in feeds increases absorption, transport and utilization of cholesterol in shrimp.

Improvements in growth, feed conversion and survival

Many experiments have demonstrated that feeding soy lecithin in shrimp results in significant improvements in growth, feed conversion and survival. Phospholipid deficiency may lead to a difficulty in larval development of crustaceans. Dietary phospholipid inclusion is able to improve tolerance to osmotic shock and salinity and to prevent incomplete molting and molt death syndrome in larvae and post-larvae of some species. Such inclusion is also beneficial in improving the efficiency of dietary EFA and in increasing the retention of n-3 highly unsaturated fatty acids (HUFA) in tissues. The improvements in the utilization of energy and essential nutrients like EFA and cholesterol contribute to better growth and higher survival of shrimp fed soy lecithin.

Effects on reproduction of broodstock

A supplementation of soy lecithin has been found to be effective in improving reproductive performances of parent shrimp. This is shown by high nauplii production, better hatch ratio, high sperm counts and better sperm mobility. Lecithin is reported to be suitable for successful maturation and spawning of pond reared shrimp.

Requirements and application of phospholipids in shrimp

Shrimp have a dietary requirement of phospholipids for growth and survival. The requirements of the main cultured shrimp species are shown in Table 1.

The optimal levels of phospholipids are dependent on the species, age and phospholipid fraction. In general, the phospholipid requirement decreases with age or developmental stage of shrimp. Larval stages are very sensitive to dietary phospholipid deficiency. For juvenile shrimp, the requirements are mostly within the range of 1.2-1.5% of active phospholipids. Phosphatidylcholine and phosphatidylinositol are more effective in promoting growth and survival of larval and juvenile shrimp and are regarded as active phospholipid fractions.

Table 1: Requirements of phospholipids in shrimp

Species, stage, wet weight	Phospholipid source (purity)	Optimal level (%)	Reference
Penaeus japonicus,			
Larvae, Zoea I/II	SL: PC 24%, PE 30%, PI 18% and other PLs.	3.0	Teshima et al. (1983)
Juveniles 1g	SL: 35% PC, 18% PI	3.0	Teshima et al (1986)
Juveniles, 5g	Soy PC: 95% PC	1.5	Gamara (1994)
Penaeus chinensis	SL: 42% PC, 20% PI,	2.0	Kanazawa (1993)
Juveniles, 0.71 g	6% PE, 4% LPC and others		
Penaeus monodon			
Juveniles, 0.09 g	SL: 63% PL	2.0	Piedad-Pascual (1986)
Juveniles, 0.45 g	Soy PC: 80% PC, 20% LPC	1.25	Chen (1993)
Penaeus vannamei	Soy PC: 95% PC	1.5	Coutteau et al (1996)
Juveniles, 2 mg	SL: 86% PL	6.5	Coutteau et al (1996)
Penaeus penicillatus Juveniles, 1 g	Soy PC: 80% PC, 20% LPC	1.25	Chen and Jenn (1991)
Penaeus merguiensis	SL: 60% PL	1–2	Thongrod and Boonyaratpalin (1998)
Penaeus stylirostris	SL (ICN Biochemicals)	1.5	Bray et al. (1990)

PL, phospholipids; SL, soy lecithin; PC, phosphatidylcholine; PI, Phosphatidylinositol; PE, phosphatidylethanolamine; LPC, lysophosphatidylcholine; PS, phosphatidylserine

Inclusion of soy lecithin in commercial feeds

As the most important commercial source of phospholipids, soy lecithin is used in shrimp feeds to meet the phospholipid requirement. The younger the shrimp, the more soy lecithin has to be included in the feeds. In commercial feeds, crude soy lecithin is often added at 1 to 2 % of the diet. Such an inclusion rate may be not able to provide the adequate amount of phospholipids to shrimps, especially that of phosphatidylcholine or that in larval and juvenile shrimp.

Formulating with de-oiled soy lecithin

For maximum growth and survival of shrimp, feeds should be balanced in terms of lipid nutrition, ie dietary levels of crude lipids, all EFA, phospholipids (particularly phosphatidylcholine), cholesterol and the ratio of n-3 to n-6 fatty acids. However, the optimal levels of dietary lipids in shrimp feeds are between 5 and 8%. This is likely due to more mortality and reduced growth caused by higher lipid levels in feeds.

Compared with crude soy lecithin, de-oiled soy lecithin contains less lipid content and more phospholipids and phosphatidylcholine. Thus, an inclusion of de-oiled lecithin in shrimp feeds will allow the formulation of diets which takes into consideration the actual requirement levels and optimal ratios of dietary EFA, phospholipids and cholesterol. When considering the cost-effectiveness, de-oiled soy lecithin is recommended to be supplemented in shrimp feeds at between 0.5 and 1.0%.

Cost-saving effects of de-oiled soy lecithin

De-oiled soy lecithin provides more biologically-active sources of linoleic acid, linolenic acid, choline and inositol as compared with neutral lipids, synthetic choline and inositol. Supplementation of de-oiled soy lecithin is used in combination with neutral lipids to meet EFA requirements. Synthetic choline has poor availability owing to the high solubility in water. Inositol is also very expensive. Dietary inclusion at 1.0 kg de-oiled soy lecithin/tonne of feed contributes dietary choline by about 36 mg/kg feed and dietary inositol by about 38 mg /kg feed, respectively. This inclusion saves costs and increases availability of choline and inositol.

Improvement in shrimp feed properties

De-oiled soy lecithin is easily handled, accurately dosed and homogeneously mixed during feed processing as compared with crude soy lecithin. Dietary inclusion of de-oiled soy lecithin is effective in improving the water stability of shrimp feeds, decreasing the leaching of water-soluble nutrients (B vitamins and trace minerals) and other feed additives (amino acids and attractants). Phospholipids are able to protect vitamins A and E from oxidation during the processing and storage of feeds, stimulate feed consumption and increase utilization of dietary nutrients. These properties of phospholipids are crucial for larval and juvenile feeds.

Summary

Shrimp is incapable of de novo synthesis of phospholipids to meet requirements. The published requirements of phospholipids are variable and depends on shrimp species and age, test conditions and the composition and purity of phospholipid sources. The phospholipid requirements during the various stages of shrimp are mostly in the range of 1-3% in diets. As de-oiled soy lecithin has a higher concentration of phosphatidylcholine and phosphatidylinositol, its supplementation in the diet offers better options to formulate a balanced feed which takes into account the optimal levels and ratio of lipid, EFAs, cholesterol and phospholipids required by the shrimp.

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At Vietfish 2005

Showcase of quality and more value added seafood products

The annual exhibition of Vietnam's seafood industry was held from June 14 to 16 in Ho Chi Minh City. There were more than 150 domestic and foreign businesses showcasing their products in 210 booths. These included companies from the US, China, Japan, Denmark, Canada, France, Thailand, Norway, UK and Singapore.

Alongside the seafood processing industry, were companies displaying feed additives and feed manufacturing equipment for the expanding aquaculture industry in Vietnam.

Vietfish is an annual exhibition organized by VASEP – Vietnam's Association of Seafood Exporters and Processors. It is the rendez-vous for Vietnam's 332 seafood processing companies, 100 of which are qualified to export to the European Union (EU) in 2004. Vietnam's annual value of seafood exports reached USD2.4 billion in 2004. Japan was the leading export market at 31.4% of total exports, followed by the US, EU, Asean countries and China/Hong Kong in 2004. The target for 2006 is USD2.6 billion in exports. (Viefish, 2005).

Similar to the previous shows, the main attractions were leading exporters such as Camimex, Amanda Seafoods, Agifish and Cafatex. Nevertheless smaller companies attracted businesses with professional

Team at AquaService Vietnam

From left.Amparo Lafuente Andres, Luong Xuan Lieu, Zi-Techasia Vietnam Ltd and Javier Miguel Fernandez, General Manager

displays of their products. Most seafood processors have their own farms to supply the raw material.

QD fish specializes in *tra* and *basa* catfish and has the largest farming system with a production of 1,000 tonnes/year. Because of its upstream and downstream activities, QD assures full traceability from raw material for feed to fish processing. Supplies are only from its own farms to assure this traceability. The company exports 50% of its products to the US.

Another leading company, QVD Food Co Ltd is involved in the farming, processing and exporting of *Pangasius* catfish. The 35ha farm in An Giang Province supplies 35% of the raw materials and the rest are from its strong association with large producers. Products from Cuulong Fish Co Ltd are marketed under the brand CL Fish. According to the company, in the farming process they have programs that can control diseases, odour and colour of the fish and which allows it to produce fish as white as the market demands. Fish are cultured in floating cages and ponds.

Others such as Prime Sea from Korea buys its supplies of *Pangasius* fish and tilapia from Vietnam and *Ictalurus* catfish and vannamei shrimp from China for processing and export to the EU and other markets.

A significant development in recent years is the production of value-added products. Agifish said that it has set up a new factory in 2004 for producing value added items from *Pangasius* (basa). These include basa skewer, basa fish with lemon leaf, satay basa and tempura. The new range includes dim sum varieties such as 'shaomai, haukau, shuikau, basa spring roll and wanton basa'.

The main seafood item for Camimex and CP Vietnam Livestock Co Ltd is the black tiger shrimp. Camimex, established in 1977 processes 10,000 tonnes of seafood whereas a relative newcomer, CP Vietnam Livestock's plant was set up in 2002. At their respective booths, they showed their range of value added products, such as sushi ebi, breaded shrimp, nobashi ebi, tempura shrimp and shrimp rings. Camimex, located in Camau, the shrimp culture centre of Vietnam has been certified to process organic shrimp for export to the Swiss market since 2002.

Insurance programs

At the pavilion of the French Chamber of Commerce, Benoit Fisse explained the agro- industry insurance programs offered by Gras Savoye Vietnam for seafood processing and aquaculture industries in the region. Gras Savoye, is a leading insurance provider in France and in 1993, it established an office in Vietnam. Their clients in the seafood industry include those in processing, warehousing, transportation and trading. Their focus is not only on large foreign owned companies but also the medium market and private Vietnamese companies to self employed individuals. As the industry is fast expanding, Benoit who studied marine environmental biology in France and Holland is encouraging risk management and insurance for the processing line to downstream activities. (email: info@grassavoye-vn.com)

Product enhancers

New to the Asian market is Spanish company, Fish Tech Laboratorio. Last November, the company presented its products at the China seafood show in Qingdao, China. The company offers new products and techniques to enhance the organoleptic, texture and coloration properties of seafood.

"As Spain is a large market for seafood from Asia, it is appropriate that Asian seafood processors present these as closely as possible to products in Spain", said Amparo Lafuente Andres, Technical Director.

The products include glazers to prevent the break up of the glaze, enhance shine and avoid oxidation. Black spot inhibitors under the Melatech and Fish Fresh range avoid the darkening of the cephalothoraxes of crustaceans which is linked to stress situations. The company also has a range of products to act as moisture retainers and tenderisers under its Hidratech, Hidrafish and Crustech range for the basa fillet. In Vietnam, the marketing is through Zi-Techasia Vietnam Ltd. (www.fishandtech.com).

Feed production and ingredients

Jointly exhibiting at the show were Taiwanese companies, Idah Machinery Ltd, SuChiang Chemicals and Da Bomb Protein Company. Idah,

Philippe Serene from AquaService Vietnam, with Harry Sunogo, PT Pangan Lestari and Gary Lim, Taiwan Seafood & Fish Corp, USA.

From Left: Danny Huang, Teddy Liao, Foster Huang and Jim Kuo, Consultant SuChiang. Taiwan

established in 1973 is one of the top three manufacturers of feed processing equipment for fish and shrimp in Asia. It provides turnkey projects in the sector whilst Su Chiang has expertise in feed formulation.

According to Danny Huang, Business Representative, "Idah is expanding into Vietnam because we have the machines to satisfy the requirements in fish and shrimp feed production. We have been working on increasing capacity of our machinery in accordance to demands by feed companies".

Teddy Liao of Da Bomb Protein Company introduced a product of partial hydrolysis with 30-40% peptides of small molecular weight called DaBomb-P. He said that the properties of the product is due to the hydrophilic peptides and amino acids which renders it more soluble and digestible as well as with better emulsification properties. Among its uses, the company has listed it as a medium for chelating minerals and binder in feeds for the eel and shrimp and marine fish at 5-15% inclusion rates. (www.dabombprotein.com.tw).

Also present at the show were feed equipment manufacturers, Jiangsu Zhengchang and Jiangsu Muyang from China. JS Feed & Biotech Company, also from China introduced its YK3 effective bacteria which mineralizes the water to accelerate the decomposition of organic waste and keeps algal growth under control. This is a lactic acid and yeast combination. Thailand's Vet Superior Aquaculture also displayed soybean based hydrolysed products (see article on page 24).

Cobia farming and marine stewardship

Two seminars were held by Aqua Service Vietnam Co Ltd. Gregoire Poisson presented information on the Marine Stewardship Council (MSC) which promotes well- managed fisheries to consumers. The MSC is based on the FAO Code of Conduct for Responsible Fisheries. A test case in Vietnam was also presented at the seminar. In another seminar, Philippe Serene presented details on a project on cobia farming, initiated by Marine Farms AS. To expand production, there were calls for investments from local entrepreneurs.

Next year's Vietfish will be held from 14 to 16 June 2006 in Ho Chi Minh City.

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Tran Vu Khanh, QD Fish, Vietnam

At Huu Tin's booth. From left Nguyen Tan Phong and Phan Si Luu Truong, Huu Tin and Huynh Man Khoi, DSM Vietnam

Part 1-Culture and nutrition

The feeding and nutrition of the tilapia

By David Creswell

Tilapia is now a major aquaculture commodity worldwide. In this two-part article, the author looks at current culture and feeding practices in tilapia, nutritional requirements and the differences in requirements between stages of tilapia culture.

Tilapia *Oreochromis spp* has many desirable traits that suit their culture, processing and value added marketing. Well suited to warm and tropical temperatures, they are generally resistant to diseases and tolerant to stress. Different varieties have been adapted for commercial culture in either freshwater or brackish water systems.

Tilapia grows on a wide variety of nutrient sources from pond algae and bacteria to high quality feedstuffs such as grains, oilseeds and fishmeal. Commercial grow out is also possible on all-vegetable diets using high levels of soybean meal as the protein source. Final fillet product, taste and quality depend on nutrient sources as well as culture conditions.

Presently, red tilapia and hybrids are cultured in China, Thailand, Malaysia, Indonesia, Singapore and Vietnam as the market preference is for the red colouration. With a relatively low price in comparison with marine finfish, tilapia is an alternative aquatic product for seafood species. The commercial tilapia market, in particular for the red tilapia, requires products of good quality, that is, without off-flavour.

Pond Culture

Ponds are the primary ecosystems for tilapia culture and account for >95% of world production. In China, this is the main system and ponds are usually 0.2 to 0.5ha in size and contain freshwater or brackishwater. One to two paddlewheel aerators per ha of surface area are used. Stocking density is 30,000 to 37,500 fingerlings/ha.

One of the more popular concepts practised in many countries is the 80:20 system. Here, the aim is to culture crops of fish in ponds where approximately 80% of the harvest weight is from only one feed taking high value species with high consumer demand. Approximately 20% is composed of "service species" such as filter feeders that help clean the water and predaceous fishes that control wild fish and other competitors. This typically provides higher yields and higher profit than monoculture.

In intensive feed based tilapia ponds (>10,000 fish/ha), feed supplies all nutritional requirements. Feeds should be fresh, clean and have a water stability of greater than 10 minutes. The addition of wastes such as fish scraps, vegetable scraps, oilseed cakes, cooked or raw cassava or corn is strongly discouraged during grow out. Any nutritional benefit is outweighed by increased fish stress, disease incidence and pollution. In addition, adding such wastes may negatively impact the acceptability of the final product in the market.

As a general rule, fish production will increase linearly with feeding rate while water quality deteriorates exponentially with feeding rate. Management techniques to prevent and control water quality deterioration resulting from feed wastes are based on limiting the feeding amount to a safe level. This level will counter formation of toxic phytoplankton and low dissolved oxygen.

Tilapia should be fed pelleted sinking feed or an extruded floating feed to 90% satiation. To do this, determine 100% satiation on day one and measure the amount fed. Then feed this amount for the next 10 days. By day 10 the rate will be down to 80% satiation with an overall average of about 90% satiation. Repeat this every ten days. Tilapia from 25 to 100g should be fed 3 times/day and tilapia from 100g to market size (500g to 1 kg) twice a day. Increased daily feedings may increase growth rate but can degrade conversion and profitability especially since there is a tendency to overfeed.

Cement tanks are used to culture tilapia at the PKPS Fish Mart farm in Malaysia.

Tilapia reared in cages in Vietnam

Cage Culture

Intensive tilapia culture in low volume (1 to 4 m^3) cages at high fish densities (up to 500 individuals or 200kg of fish/m^3) is becoming an important way of expanding production in lakes, reservoirs, rivers or ponds. In contrast, cage culture such as in China uses 6x4x3m cages with stocking densities of 150 fish/m^2.

Small cages are preferred over the traditional larger cages in intensive culture as more fish can be raised per unit volume. Small cages have greater surface area per volume which enhances water exchange. They can also hold more fish per unit volume and as a result cost less per weight of fish raised. Low volume high density (LVHD) design requires that cages be placed individually with no adjacent common sides of any two cages.

Intensive cage-in-pond culture of red tilapia is also being practiced in brackish water (10–20 ppt) ponds previously used for black tiger shrimp culture in Thailand. Cages holding tilapia facilitate harvest, feeding, fish uniformity and overall management. Filter feeders can be placed in the pond at large to help condition the water. In one totally closed production system, two units of 5 cages each were placed several metres from each of two corners of 40m x 40m x 1.5m deep (1,600m^2) ponds. The five cage units were in series with adjacent sides. Each individual cage was 3m x 6m x 1m deep and each cage held 720 red tilapia (40 fish/m^3). Fish were cultured from 100 to 600g. Electrically operated paddle wheels were placed near each cage unit to aerate and move the water in a circular pattern around the pond. Floating feed was used exclusively. This totally closed system yielded 25–27 tonnes/ha (45,000 fish) with a final FCR of 1.5.

Higher productivity per area of cage and water area is common in open reservoirs, lakes and rivers but in many cases this is not sustainable due to a lack of carrying capacity of the water body. This has led to high nutrient turnover, low dissolved oxygen syndrome and routine fish kills. Problems with fish kills in open mesotrophic water bodies (80-200 cm visibility) can be avoided by limiting feed input in the total water body to 8 kg/ha/day. Limits in the area where fish are growing should also be imposed. For a one ha cage area, a limit of 500 kg/day would be a good starting point. In a 10ha intensive cage area the limit should be 1,500 kg/day.

Generally cage culture requires much lower capital investments and lower operating cost than pond and tank culture. Typically, fish are stocked at high density and fed complete feeds. The maximum density is limited by the availability of oxygen. In a study conducted in Thailand and reported by Orachuwong et al., (2000), the average yield from five 12m^3 cages located in the Ratchburi River, was 58.4kg/m^3/cage. The stocking density ranged from 1,200 fingerlings with initial weight of 75g to 1,900 fingerlings of initial weight of 58.3. Fish were fed commercial feed of 20 to 32% crude protein. In this case, tilapia can be raised to 650-700g in a period of 120 days. Similar results have been obtained for tilapia grown in mining pools (Malaysia) and cages (Jatiluhur Reservoir, Indonesia).

Tilapia nutrition

Tilapia is generally classified as herbivorous and detritivorous. Nevertheless, they exhibit their best growth rates when they are fed a balanced diet providing a proper mix of protein, carbohydrates, lipids, vitamins, mineral and fibre. The nutritional requirements vary with life stages. Fry and fingerling fish require a diet higher in protein, lipids, vitamins and minerals and lower in carbohydrates. Sub-adult fish need more calories from fat and carbohydrates for basal metabolism and a smaller percentage of protein for growth. Adult fish need even less protein. Brood fish may require elevated protein and fat levels to increase reproductive efficiency.

Protein and amino acids

The requirement for protein and amino acids are mainly supplied by ingredients such as soybean meal, fishmeal, and corn gluten meal and to a lesser extent wheat. The level of protein required for maximum growth has been estimated to be between 25 and 40% depending on species, size and age of fish, ingredient digestibility and the level of dependence on natural food.

Tilapia requires the same 10 essential amino acids as other fish species. Tilapia of 1-10g require 34 to 36% crude protein; 10-100 g, 28-30% and >100g, 20-25%. About 20% protein diet is considered enough for fish before harvest (500-600g). Replacing all or partially of fishmeal with both animal and plant protein sources have been studied widely. Among the alternative animal proteins that have been used in tilapia feeds are blood meal, meat and bone meal, hydrolysed feather meal, poultry meal, fermented fish silage, shrimp meal, krill meal and live maggots. The most commonly used plant proteins by feed manufacturers are soybean meal, peanut meal, cottonseed meal, sunflower seed meal, rapeseed meal and *Leucaena sp.* leaf meal.

Protein levels for tilapia grow-out

A significant differences in daily weight gain when red tilapia were fed extruded diets containing 20% and 25% protein has been reported by Orachuwong et al.,2000 (Table 1). The cost in Thailand of 20% and 25% protein commercial extruded feed was USD 0.39 and USD 0.32 per kg, respectively. With the same food conversion ratio, production cost of fish associated with feed use was relatively low for 20% protein feed. As a consequence, the feed cost was reduced by 17%.

Lipids and fatty acids

The essential fatty acid requirements of tilapia are similar to those of poultry in that they require around 1% of either linoleic (18:2n-6) or linolenic (18:3n-3) acids in their diet. Unlike the marine species, tilapia do not have a requirement for unsaturated fatty acids longer than 18 carbons (EPA or DHA) that must be supplied by fish oil in marine species. While not required for growth, the lipids in fish oil may however be beneficial in stimulating the immune system.

In general, the lipid requirements for fish under 2g represent 10% of the diet. This decreases to 6-8% from 2g to harvest. The fibre component is usually the reciprocal of the lipid content. That is starting at 6-8% in small fish up to 35g and increasing to 10% above 35g.

Carbohydrates

These usually represent less than 25% of the diet for fish under a gram and increases to 25-30% for fish greater than a gram up to harvest. Tilapia digest carbohydrate better than common carp and African catfish. Dextrin and starch have some protein sparing action in tilapia hybrids. Raw and extruded corn can be utilised at high levels (50% of the diet) by hybrid tilapia. Carbohydrates are often supplied by the least expensive ingredients in the diet. Corn, wheat, rice and a number of agricultural by-products are typical carbohydrate sources.

Intestinal carbohydrate absorption by tilapia is low and influenced negatively by the level of fibre in the diet. Inclusion of high fibre feed ingredients such as wheat bran at levels up to 60% caused only slight impairment of growth. Complex carbohydrates such as starch are better utilized than disaccharides and monosaccharides. Thus, it would appear that high dietary fibre only affects absorption of the more simple carbohydrates.

High starch ingredients such as corn are often restricted or limited in tilapia diets. This is mainly due to suspicion over contamination with aflatoxins. Other mycotoxins may also be a concern. Warm water fish such as channel catfish are known to be more sensitive to the mycotoxin cyclopiazonic acid than aflatoxin and tilapia have been shown to have significantly lower growth and higher metabolic disturbances when fed 75 ppm fumonisin B1, a fusarium toxin. T-2 toxin has also been implicated as highly toxic to tilapia at levels as low as .02 ppm. Thus, tilapia producers must be vigilant against aflatoxins and other known mycotoxins.

Vitamins and minerals

These are critical to proper nutrition in tilapia. Commercial premixes are available which allow feed makers to purchase a whole group of micronutrients rather than attempting to determine how much is available from the productivity of the system and the other ingredients.

Of particular importance is ascorbic acid as this vitamin is heat and time sensitive especially in extruded feeds. Several forms are available that are more stable than the parent free acid. These include coated products and phosphate esters such as L-ascorbyl-2-monophosphate-sodium, L-ascorbyl-2-monophosphate-magnesium and L-ascorbyl-2-sulfate and L-ascorbyl-2-polyphosphate. The phosphate forms are more available than the sulphate form. Of the monophosphates, the magnesium form appears to be more stable but is only around 85% available as the sodium form for tilapia.

Phosphate is an important nutrient that must be supplied in tilapia feeds. Tilapia produce acid gastric juice and therefore are able to utilize bone phosphorus to a greater degree than the carp. Plant phosphorus

Table 1: Performance of fish fed 20 % and 25% protein extruded feed for 144 days

Item	20% protein	25 % protein
Percent Protein in feeds	20	25
Stocking density of 80g fingerlings	5,000	5,000
Survival rate (%)	97	92
Harvest mean body weight (g)	548.3	606
Harvest biomass (kg)	2,654	2,800
Average daily gain (g/fish/day)	3.26	3.65
Food conversion ratio (FCR)	1.4	1.39

Water parameters were 15-18 ppt salinity, min DO_2 -3.5ppm, 28-32°C. Aeration with 2 long-armed paddle wheels (18 paddles and 3hp electric motor each). Days of culture 144 days.

Table 2. Composition of experimental diets (g/kg diet)

Ingredients	Commercial[1]	Fishmeal[2]		Meat and Bone Meal (MBM)	
Added soy oil		-	+	-	+
Corn gluten meal		204.9	203.8	204.1	203
Corn		400.1	361.3	385.1	344.6
MBM		-	-	62.3	62
Fishmeal		59.9	59.6	-	-
Soy oil		-	35.1	-	36.5
Soy grits[3]		289.7	295	300.4	306
Vitamins & Minerals		45.4	45.2	48.1	47.9
Total		1000	1000	1000	1000
Nutrients					
Protein, %	40.9	38.1	39	39.1	39.1
Fat, %	5.5	3.1	5.5	2.9	7.3
Ash, %	9.1	6.3	6.3	6.8	6.9
Lysine[4], %	5.9	6.7	6.6	6.8	6.7
Tryptophan[4], %	1.2	1.5	1.5	1.4	1.5
Threonine[4], %	3.8	3.9	3.9	3.9	3.8
MethCyst[4], %	3.3	4	3.7	3.6	3.4

[1]Purina 5144 Catfish Cage Chow [2]Selected Menhaden fishmeal [3]Assumed to be soybean meal [4]Percent of protein

sources are low in availability to tilapia. Thus, when animal meals are substituted by oilseed protein meals, phosphorus deficiency will occur unless inorganic phosphate is supplied in the feed. Mono-and di calcium phosphates are more available than defluorinated rock phosphate (tri calcium phosphate) in tilapia. There is some indication that phytase enzyme supplements may improve phytin phosphorus utilization experimentally, but concerns over stability during feed processing and storage may limit application of this and other enzyme products in tilapia feeds.

Ingredient usage

A large range of ingredient is used in feeds for tilapia, although only a few have ever been fully evaluated. Most commonly commercial tilapia feeds will be based on soybean meal as the major protein source, and corn, rice bran, wheat bran and cassava as major carbohydrate components. Fishmeal or MBM is commonly included as an animal protein source. Other ingredients that have been tested or are used are rapeseed meal, copra meal, cottonseed meal, leaf meals, poultry meal, corn gluten meal and wheat. Table 2 suggests the range of ingredients and maximum inclusions.

Meat and bone meal for tilapia

A published trial has evaluated the substitution of fishmeal by MBM in diets for the Nile tilapia (*Oreochromis niloticus*). Diets contained either fishmeal or MBM substituted on a protein and amino acid basis, and with or without soybean oil. A commercial diet was used for comparison. Composition of diets is shown in Table 2. Feed was provided twice daily according to a predetermined scale.

There were no differences among treatments ($P>0.05$). Diets containing mbm gave numerically higher gains, lowest feed conversion and the highest protein efficiency ration (PER). When treatments without and with soy oil are combined the improvement in growth rate for the MBM treatments was 15%.

Addition of soy oil tended to give better performance, and the effect appeared to be greater with the fishmeal diets. MBM when used in this way appears to be an acceptable substitute for fishmeal in feed for tilapia feed and in many situations would be economic to use.

Flesh quality

In tilapia, flesh quality refers to texture and taste, and particularly the absence of "off" tastes. This is an important criteria as tilapia is marketed internationally. Little research has been conducted to find how flesh quality should be maximized. However, it is suggested that the following factors are important.

- Use of high quality, pelleted or extruded feed.
- No use of trash fish, or other similar types of by-product feeding
- Maintaining good water quality

Table 3: Performance of tilapia fed diets with either fishmeal or MBM

	Commercial	Fishmeal		Meat and Bone Meal	
Added soy oil		-	+	-	+
Initial Weight, g	13.1	13	13	13.2	12.9
Final Weight, g	78.6	70.4	79.1	82.3	84.6
Daily Gain, g	0.78	0.68	0.79	0.82	0.85
Feed Conversion	2.17	2.35	2.19	2.08	1.97
Protein Efficiency Ratio (PER)	1.13	1.12	1.21	1.24	1.3

Source: Wu et al., 1999

- Use of both natural (Vitamins C and E) and added antioxidants in feed
- Feeding to the known nutritional requirements
- Post-harvest handling

What is lacking in tilapia nutrition knowledge?

Despite what may seem to be a large amount of published research, text books, and numerous international and regional conferences on tilapia culture and nutrition, the knowledge of the nutrition of this fish species is very weak. Where there is knowledge on protein and amino acid requirements for example, it is usually for the very early growth stages and not for the later growth stages, where most feed is consumed. A review of amino acid requirements from a number of studies shows enormous conflict in the data.

Commercial feeds have largely been developed from the small of amount of researched knowledge, plus a lot of "trial and error". As a result, it is suggested that most feeds are not optimized for efficiency.

Areas where nutrition knowledge is weak, and where good quality research is needed, are:

- Requirements for energy, and amino acids throughout the commercial growth periods.
- Requirements for digestible amino acids throughout the commercial growth periods
- Nutritional values for ingredients, particularly for digestible amino acid levels
- Vitamin requirements throughout the commercial growth periods
- Mineral requirements throughout the commercial growth periods
- Responses to additives, including supplemental amino acids, enzymes, growth promoters, organic acids, etc
- Effects of nutrition on carcass composition and flesh quality

Next issue: Part 2 of this article will cover feed management and show likely requirements for all stages of tilapia

Selected references and suggested reading

Orachunwong, C, Thammasart and C. Lohawatanakul, 2001.Recent developments in tilapia feeds in Subasinghe, S & Singh, T (eds) Tilapia:Production, Marketing and Technological Developments, Infofish, Malaysia, pp13-122.

Quiming, Lai & Yi, Yang, 2005. Tilapia in China: Domestic markets to sustain growth. Aqua Culture Asia Pacific, Vol 1 (2) (March/April), 2005. pp28-31.

Wu, Y V., K W Tudor, P B Brown and R R Rosati. 1999. Substitution of plant proteins or meat and bone meal for fish meal in diets of Nile Tilapia. North American Journal of Aquaculture, 61:58.

Dr David Creswell, an animal nutritionist specialises in ingredient quality, use of ingredients, and in current nutrition and formulation concepts for poultry and swine, including digestible amino acids, and in application of nsp and phytase enzymes. Based in Australia, he currently runs a consultancy business (Creswell Nutrition) which focuses on providing nutritional support for clients throughout Asia. He has published over 75 research and industry papers. Australia Email: creswell@zip.com.au

Complete control

For the last 18 years, Mr Prayoon Hongrath has been developing Sureerath Farm into one of world class standard for the culture of the black tiger shrimp in Thailand. Two years ago, it was certified in the DOF's CoC (Code of Conduct) program. His target is premium quality large shrimp of 25–30 pcs/kg, produced at a low stocking density of 18 PL/m^2.

At present, the farm named after his wife Sureerath, has 133 culture ponds, each of 4 rai in size (0.65ha). It is the single largest farm in the Chanthaburi area in the East of Thailand and draws water from the Plew river. The annual production volume is 800–1000 tonnes from two crops per year.

For Prayoon, a former teacher, the most important factor contributing to the success of his farm is having a complete control of all stages of the culture. Accordingly, during grow out, he has achieved an average survival rate of shrimp of 80% over the 120–150 days culture period. Production reaches 700 kg to 1 tonne per rai which extrapolates to up to 6 tonnes/ha.

This starts with the production of quality postlarvae. After several episodes where postlarvae purchased from commercial hatcheries were infected with diseases, Prayoon decided to set up his own hatchery three years ago. His secret to quality postlarvae is to reduce the variation in both water and air temperature in the hatchery. According to Prayoon, the air temperature is maintained at 37°C and that of the water at 32°C. He has achieved high survival from nauplius to PL11–12 stages of 90%. In his hatchery, only the temperature in the algal culture room is kept cool.

The second success factor at the hatchery is developing the right feeding program for spawners and larval shrimp. Choice spawners from the Andaman Sea are fed combinations of live feeds such as *Spirulina* and cockles. No artificial feeds are used. Prayoon believes that nutrients fed at zoea stages determine the quality of PL. During the zoea to nauplius stage, his feeding program comprises live feeds such as *Chaetoceros*, *Spirulina* and *Artemia*.

Similarly to most farms in Thailand, the farm practices a total closed system. Water is only added to compensate for evaporation.

At the farm (from left) Sureerath, Prayoon and Kritsada

The hatchery at the Sureerath farm with insulated piping

Prayoon also recycles the water discharged from the ponds back into the system. After harvesting, discharged water is channelled into treatment ponds for seven days and then into two reservoir ponds of 75 and 250 rai, respectively. From these ponds, water is channelled through a central canal to the culture ponds. Water is never discharged directly into the river Plew.

In between harvests, the ponds are sun dried for up to 50 days. Accumulated sediment from the previous crop becomes soil and fertilizer for the next crop. Water is pumped into the pond to a depth of about 1.5-2.0 m. Magnesium oxide and calcium carbonate are added to the ponds and allowed to stand for 10 to 15 days to balance the nutrients in the sediment. In each pond, there are four long arm aerators placed at right angles.

"These aerators are run for 24 hours so that I can maintain the dissolved oxygen levels at 5ppm. When shrimp are 1-2 months old in the pond, only two aerators are used. Naturally, the electricity bill is extremely but I am seeking information on how to tap wind energy and cut down on my energy costs", said Prayoon.

The monitoring protocol of selected water quality parameters and that of disease involves the monitoring of oxygen, pH, alkalinity, nitrite and nitrate twice a week and a weekly monitoring of alkalinity. Disease monitoring is carried out concurrently with feed sampling. There are also biosecurity protocols to prevent the spread of disease carriers. Strict hygiene is implemented. At the same time, environmental aspects of the farm are being well taken care. The farm is carrying out an extensive replanting of mangroves. To date, approximately 3,000 mangroves have been planted.

In the pipeline is the production of organic shrimp. Currently, there is an ongoing trial with the Department of Fisheries in three ponds. The stocking density is 18 PL/m^2 although the limit under the national certification for organic shrimp is 25 PL/m^2. Prayoon has already received enquiries on his premium quality shrimp from the UK based Marks and Spencers group. Soon, he will also market the shrimp, organic and non organic, through the internet and his own markets.

In future, Prayoon wants to complete the production from farm to table. The next step will be the production of feed according to his formulation and with this, he will complete the cycle of control. For Prayoon, the ability to trace the specific ingredients being fed to his shrimp is important. (More on the farm at www.sureerathprawns.com)

Listing of Malaysia's Borneo Aqua

Borneo Aqua Harvest Bhd, the marine aquaculture company with hatchery and production operations in Sabah, Malaysia will be tentatively listed on the Mesdaq Market in September 2005.

Coral trout fry

At the closing of its initial issue of 1.5 million shares to the Malaysia public in August, the company said in Bernama news, that the shares were oversubscribed by 29.65 times. It had also assigned one million shares to directors and employees and 22.5 million shares for investors, all of which have been fully subscribed.

Borneo Aqua Harvest is an investment holding company for Plentiful Harvest Sdn Bhd and Marine Terrace Sdn Bhd, which are involved in the breeding, hatching and rearing of high commercial value marine fishes in the Asia-Pacific region. The company said that its subsidiary, Plentiful Harvest has been confirmed by the Fisheries Department as the first Malaysian company to have successfully mass produced fry of the Malabar red snapper, marble grouper and coral trout commercially.

The company will use some of the proceeds from this listing for the acquisition of broodstock and equipment to expand its R&D in several other species with high commercial value. It will also construct 400 new cages for fish rearing and an indoor hatchery on Pulau Palak, Sandakan Sabah. It has budgeted one percent of the group's consolidated revenue for ongoing R&D.

For the financial year which ended in March 2005, group revenue totalled RM 6.03 million (USD 1.67 million), an increased of 265% from the same period in 2004. It posted a pre tax profit of RM 3.34 million (USD 0.9 million) in 2005. *(Related article: Issue July/August 2005, East Malaysian company stirs interest, p10)*

Adult marble grouper

World's biggest tilapia hatchery in Hainan

Genomar has opened its first section of the world's biggest tilapia hatchery in Hainan Province, China. The hatchery is situated in the new farm of 40 hectares in Hainan. Ponds of various sizes and a vast array of concrete tanks will comprise brood stock, nurseries and testing facilities. Additional infrastructure such as deep wells, fresh and saltwater reservoirs and huge filters provide a steady supply of quality water for the whole operation.

The company said that the first two of the four units in the new hatchery was operational in July 2005. The hatchery design is state-of-the-art with over dimensioned filters for extra safety and a modular approach that enables partial disassembly for regular cleaning and maintenance.

The hatching capacity of the each of the four units is 25 million eggs/month. Thus the maximum output of the hatchery is around 80-100 million fry/month or 1 billion fry/year. However, as the market demand for fingerlings in China is seasonal, the hatchery will run at maximum capacity only during peak seasons.

After the full completion of the hatchery and associated infrastructure, the facility will be able to produce around 400-500 million sex reversed fingerlings/year. This will supply a significant portion of the demand for high quality tilapia fingerlings in China. GenoMar is in an excellent position to become the dominant player in China.

GenoMar ASA, based in Norway was founded in 1996 by Prof. Øystein Lie and is among the world's leading life science enterprises specialising in broodstock enhancement of aquatic and marine species. It has companies in China, Singapore and the Philippines.

"Innovative CD on "Fish vaccination and health management in Asia"

Intervet Norbio Singapore and Intervet International have developed a totally innovative educational and training CD on fish vaccination and health management, with a focus on Asia. The content is divided into various sections, including chapters about Intervet, aquaculture, health management and fish vaccination. Media used include presentation slides, video clips, animations, PDF downloads and website links.

This unique CD was first shown at the Intervet's booth at the World Aquaculture 2005 trade show in May and a copy was also presented to all the participants of the workshop on Fish Vaccination in Asia held during the meeting. Copies have also been distributed at the recent AQUA NOR 2005 trade show in Norway. Feedback on the first limited edition has been extremely positive.

"Although approximately 90% of global aquaculture is in Asia, Intervet is the only one of the handful of international aquatic animal health companies to have a real presence in Asia. This is primarily in the form of the state-of-the-art R&D centre in Singapore which opened in January 2000, perhaps at the dawn of not only a new millennium but also of a new concept for fish farmers in South East Asia, that is, fish vaccination", said Dr. William Enright, Marketing Manager, Aquatic Animal Health Division, Intervet International.

"As we now know, for human health concerns, fish farmers need to move away from the use of antibiotics. The concept of vaccination (i.e., prevention) replacing antibiotics (i.e., treatment) has been proven in the successful salmon industry and there is no reason why other major fish species can not adapt to this disease protection technology. Intervet's aim is to help Asian fish farmers do this".

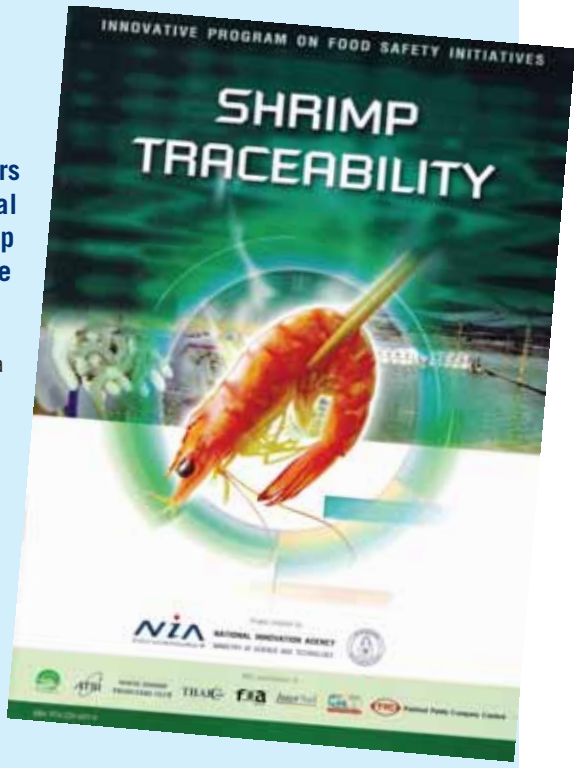
The setting up of the centre in Singapore, already leading with two fish vaccines in Asia (Norvax® Strep Si and Norvax® Vibrio mono), was a major step in this direction. Now the availability of this CD is yet another valuable contribution to farmers and health professionals in the region, being a great way to learn about the concepts and practicalities of fish vaccines and vaccination strategies.

If you are interested in receiving a copy of the CD, please contact info.aqualNS@intervet.com with your full name, organisation, postal address, mail address and phone number.

(related article: Intervet Seminar on fish vaccination at WAS 2005. Aqua Culture Asia Pacific, July/August 2005, pp 12-13).

Shrimp traceability software

Together with members of the White shrimp producers club and Pakfood Public Company, the National Innovation Agency (NIA) has developed a shrimp traceability software. This is part of the innovative program on food safety initiatives.



The project was contracted to a group of software companies. The idea behind this project is to set a national traceability program on national scale. It will set a new standard and improve the level of product safety and quality for manufacturers, farmers and cooperatives throughout the entire process. This will help give Thailand higher credibility in world shrimp markets and maintain its leadership among shrimp exporters. Additionally, this will bring Thai software companies to the forefront and compete in the global traceability software market.

Thailand has 180 shrimp processing plants and in recent years, the GSP and anti dumoing policies in the EU and US have affected the level of shrimp exports. The main purpose of this initiative is to revive the shrimp industry. This investment means that the industry in Thailand can ultimately improve its competitiveness in world markets. (www.nia.or.th)

Mix for prevention of microbial diseases

NTL Biotech Ltd of Vietnam has introduced Microcin, a base analog obtained from an innovative biotechnology process. It has strong and broad antimicrobial activity against GRAM positive and negative bacteria, fungi and viruses including DNA/RNA strains, according to Dr Ho Nhan, Director.

Photo of Ho Nhan (left) and his team at the WAS trade show in Bali, May 2005 with Alan McKibbin from Australia

"Microcin can be used as direct liquid mix in the feed, oral application and as an injection for the prevention and treatment of microbial diseases in aquaculture and livestock farming. It leaves no traces of contaminants and is not toxic to the host. It is very effective at low cost".

The product has a patent in the US and EU, as a future universal anti-pathogenic organism. It has the chemical structure similar to D-Ribose sugar which acts as a base analog to inhibit the genome replication in microorganisms.

It does not cause microbial resistance, since the compound is so small that it can penetrate into the infected cell membrane quickly and cause the pathogenic microorganism to mutate and to malfunction after taking the false sugar base to replicate the genome. In its liquid phase, it has antimicrobial activity at 1000 MIC/ml (Minimum Inhibitory Concentration).

More information: NTL Biotech Ltd. Email: honhan@ntlbiotech.com; www.ntlbiotech.com

Alternative to Malachite Green

Japan's Kobe Steel has introduced the antibacterial coating, Kenifine to reduce parasitic water mould. It said that this is an alternative to malachite green.

Researchers at the Fuji Trout Fishery have verified that Kenifine is effective in reducing water mould on fertilized eggs and that it has no adverse effects on the eggs. Owing to these benefits, the Shizuoka Prefecture Fisheries Experiment Station and Kobe Steel believe that the coating will draw increasing attention from fisheries across the country.

Fish hatcheries throughout the country have been grappling with outbreaks of parasitic water mould, which inhibit the incubation rate of fertilized eggs. Malachite green, a type of dye, has been highly effective at controlling water mould in fish and has been used as a general countermeasure against water mould since the 1950s.

However, since the mid-1970s, malachite green has been suspected of being a carcinogen. In 1981, the United States prohibited its use in food-related applications. The EU and Norway placed a similar ban in 2002. In July 2003, Japan curtailed the use of malachite green in egg incubation facilities and fish farms. An extension until July 2005 allowed the use of the chemical on eggs raised at seedling production facilities on land and young fish of 1g or less.

Kenifine is an electrolytic plating that contains nickel and trace amounts of other elements. When plated to the substrate, the ions in the coating yield antibacterial properties. Highly resistant to corrosion in fresh water, the alloy coating also has outstanding antifungal and antialgal properties. Kenifine has also passed various safety tests, including acute toxicity tests.

More information: Dr. Takenori Nakayama, Email: ta-nakayama@kobelco.jp; Web: www.kobelco.co.jp

New immunostimulant product for China

Italian company Dox-al Italia Spa has announced that it has obtained the registration of the product Aqualase in China. This is an immunostimulant and growth enhancer produced from yeast cells which contains three times the nucleotide content of standard yeast, according to the company. The product is based on beta-glucans, obtained from a selected strain, rich in glutathione (GSH) and in sulfa adenosyl methionine (SAMe).

Aqualase is recommended for use in feed for fish and crustaceans to reduce mortality and enhance growth. Feed fortified with the Aqualase is used prior to situations known to expose the animal to higher infections and which may reduce their disease resistance. The product is already used extensively in a few other countries, throughout South East Asia.

More information, Anna Guerra, Email: anna.guerra@doxal.it; web: www.doxal.it

21-22 September
Aquaculture Technology Conference and Exposition
Fukuoka, Japan
Tel: +81-3-5775-2855
Fax: +81-3-5775-2856
Email: kaji@exhibitiontech.com
Web: www.exhibitiontech.com/aquaculture/

25-30 September
Aquaculture Feed Extrusion, Nutrition and Feed Management
Texas A&M University, USA
Contact: Dr Mian Riaz
Tel: +1 979 845 2774
Fax: 979 458 0019
Email: mnriaz@tamu.edu
Web: www.tamu.edu/extrusion

3-8 October
Shrimp Health Management Training Workshop
Bangkok
Email: shrimp-school@alltech.com
(see page 3)

19-21 October
Second International Sustainable Marine Fish Culture Conference and Workshop
Fort Pierce, Florida
Email: kriley@hboi.edu
Web:www.sustainableaquaculture.org

24-27 October
2005 Global Shrimp Outlook (GSOL)
Ho Chi Minh City, Vietnam
(By-invitation only meeting)
Email: gaa1@attglobal.net
Web:www.gaalliance.org

25-28 October
6th Symposium on Diseases in Asian Aquaculture (DAA VI)
Colombo, Sri Lanka
Contact: Melba Reantaso, FAO
Email: Melba.Reantaso@fao.org
(quote subject:DAA VI)
Web: www.daasix.org/

10-12 November
China Fisheries and Seafood Expo/Aquaculture China
Guangzhou, China
Tel: +1 206 789 5741 ext. 334 / +86 10 58672620
Fax: +1 206 789 0504 / +86 10 58672600
Email: seafoodchina@seafare.com
Web: www.chinaseafoodexpo.com
(see page 39)

8-10 March
Victam Asia 2006 Exhibition and Conference
Bangkok, Thailand
Email: expo@victam.com
Web:www.victam.com
(see pages 35 & 40)

May 9-13
World Aquaculture 2006
Florence, Italy
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Email: worldaqua@aol.com
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(see page 7)

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VICTAM ASIA 2006

Victam Asia 2006 will be held from 8-10 March 2006 at the Queen Sirikit National Convention Center, Bangkok, Thailand. This is one of Asia-Pacific's premier exhibition and conferences for the animal feed production & additives, petfood, aquafeed, rice, grain & flour processing industries. In the last event in 2002, the attendance totalled almost 3,000 trade delegates, mainly from the South East Asian market.

The exhibition has the full support of the Thai Ministry of Aqriculture and Cooperatives, Department of Fisheries and the Thai Feedmill Association, among others. This time, Victam Aquafeed will feature exhibitors on ingredients & production technology, machinery, processing, packaging and finished feed products for finfish, crustacea & ornamentals. As of August 15, there are already several companies in the aquafeed and feed ingredients industry that have registered as exhibitors.

Among the conferences, there will be a one- day technical workshop for the aquafeed industry on 8 March. An international team of industry professionals will make presentations on

- Optimizing formulation and product quality parameters of extruded aquafeeds
- Creating micro-diets
- Fine grinding
- Optimizing the drying process
- Novel and advanced feed ingredients

Pre-registration is required as no "Walk-ins" will be accepted. For more information email: editor@aquafeed.com or download a registration form from www.aquafeed.com.

Other conferences include a conference on livestock feed ingredients and production to be conducted by the Thai Feed Mill Association and the Thai Chamber of Commerce, and supported by the Thai Department of Livestock Development. There will also be a three-day World Grain Conference which will cover rice & grain processing, storage and contamination control. This high-level meeting will feature leaders in the global grain industry and will be a key event for all those in Thailand and the Asia-Pacific region concerned with the trade, storage, handling or processing of grains.

The visit to the exhibition is free of charge and the organizers have requested online registration at www.victam.com. Brochures in several Asian languages are also available from the web site.

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