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Strategies to sustain growth in India

H_2S toxicity – the silent killer

Shrimp nursery technology

Tilapia in China and India

Show preview at APA 2016

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Opportunities for aquaculture

Zuridah Merican

While the world is drowning in oil, it cannot get enough salmon. I read with great interest this article that appeared in Bloomberg "For shipping tycoon, John Fredriksen, his USD 1.6 billion holding in Marine Harvest is now seven times as valuable as his similar-sized stake in offshore driller Seadrill Ltd." Could this be a wake-up call for aquaculture? Investors worldwide have the same *modus operandi* – it is a question of risks versus rewards and aquaculture is categorised as a high risk - high reward industry. However, risk is relative and changes with time. In the past decade, it was difficult to secure land in Malaysia for anything except for the oil palm industry, which was riding the commodity boom. Similarly, in 2008 as palm oil prices soared, shrimp ponds were converted to oil palm estates in Thailand. When there are fewer opportunities, that is, when the low hanging fruit disappears, investors increase their appetite and look for higher risk projects.

Let us look at the signs. In early February, Calysta announced the completion of its USD30 million Series C financing, accelerating the introduction of FeedKind™ protein on a commercial scale. This product is a single cell protein which can replace fish meal. Indonesian smart fish feeder start-up secured the pre-series A funding fund led by Aqua Spark, a Netherlands-based aquaculture investment fund. Pontos Aqua Holdings LLC is another private equity fund focusing on aquaculture.

In the shrimp aquaculture industry, the failure rate has been high and both banks and investors have been reluctant to finance such projects. Marine fish farming has also hit the same brick wall in obtaining financing. The salmon industry, however, is the role model where science has led to sustainability.

This is the current situation for risk mitigation behind the success of Asia's aquaculture. Broodstock development and seed supply seem to be well established in shrimp and tilapia but less so in most marine and freshwater fish. The success factor for shrimp and tilapia could be simple, that is, they are single or related species. With a relatively short maturation time, broodstock for these species can be obtained within 12 months. Marine fish face a much longer maturation time, which could reach 5 years for a male grouper. It would help if the industry focuses on a single species, be it grouper or sea bass.

The feed industry is far ahead compared to the other support sectors, and while nutrient requirements for the various species could be fine-tuned, feed is not the bottleneck for the industry currently.

Farming technology does not offer one-size-fits-all solution. It is highly dependent on the environment, species and business model. Marine fish cage and freshwater lake cage farming has a role model in salmon cage technology. Shrimp farming has developed with the increased stocking intensity from large semi-intensive ponds in Ecuador to 3 m deep, much smaller ponds with central effluent drainage systems in South East Asia and China.

Disease is one area that has overtaken the industry and continues to plague it today. The shrimp industry has to live with viral, bacterial and microsporidian infections with no workable therapy in sight. Farmers are learning to live with these diseases and accept lower survival rates. Fish have a brighter outlook with developed immune systems, which allow for vaccination. The animal health companies have not shown much support here but apart from for tilapia and pangasius, the aquaculture industry has not given them any species with economies of scale to work on.

We have to talk about the weather, which affects production planning and disease. Controlled environments have been developed for fruit and vegetables to farm all year round leading to price stability. Such controlled environments when implemented in aquaculture will allow for perennial farming and disease mitigation. As farming intensity increases to maximise output from a limited area, controlled environments would be the logical next phase.

With higher liquidity in the investment market chasing for returns, the risk appetite may have increased. Meanwhile the mitigation measures in aquaculture have also reduced the risks faced by the industry. Is the timing right for new opportunities in aquaculture? *Carpe diem!*

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Aqua India 2016: Stakeholders' participation in shrimp aquaculture

In 2014, shrimp production reached a milestone but in 2015, the industry encountered new problems.

The second wave for the shrimp farming industry in India with the vannamei shrimp saw shrimp production increasing from only 142,000 tonnes in 2010 to more than 400,000 tonnes in 2014. The production drop in 2015 is the result of a multitude of challenges: from poor post larvae quality and husbandry to diseases. During these challenging times, the 12 year-old Society of Aquaculture Professionals (SAP) continued to play an important role to guide the industry towards efficient and sustainable production.

In January, SAP organised Aqua India 2016, its biennial conference in Visakhapatnam, on the east coast, and one of the centres of shrimp farming in Andhra Pradesh. The city has a long history in black tiger shrimp farming and is credited with the establishment of one of the earliest breeding centres, TASPARC (The Andhra Pradesh Shrimp Seed Production, Supply and Research Centre) as well as some of the earliest commercial hatcheries. This year, some of the distinguished participants included Madam Leena Nair, chairperson of the Marine Products Export Development Authority (MPEDA) and Elias Sait, secretary general of the Seafood Exporters Association of India (SEAI). Their presence signalled a linkage between seafood marketers and farmed shrimp producers.

In his welcome address, SAP president, **S. Muthukaruppan**, said "In 2014, we achieved a milestone in production but in 2015, the industry encountered new problems, such as *Enterocytozoon hepatopenaei* (EHP), and running mortality syndrome (RMS) in addition to white spot syndrome virus (WSSV). The list of diseases is now long, causing economic stress." To the large crowd of more than 350 farmers and aquaculture stakeholders, Muthukaruppan said, "SAP will continue to focus on issues affecting the industry to keep the industry alive and sustainable."

State of the industry

After the phenomenal growth in 2014, the production in 2015 was just 363,450 tonnes. Production is from traditional and industrial farms, the latter fast increasing with expansion of farming areas, establishment of new farms and with processors entering shrimp farming. Culture practices differ vastly from state to state. In Gujarat, it was estimated that four major companies produced 70% of the 31,500 tonnes in 2015, which was 17% more than in 2014. At Aqua India 2016, Gujarat producers, Dr Manoj Sharma, Mayank Aqua and Saji Chacko, Onaway Industries, discussed their prudent culture practices, which distinguish industry in Gujarat from the rest of India. In general, farms in the state stock 20-40 post larvae/m^2 in salinities ranging from 15-45 ppt. The feed conversion ratio is 1.8, whereas the national average is 2.2. In contrast, small semi intensive and extensive farms are the major contributors to production in Andhra Pradesh and Tamil Nadu. In general, the first crop which usually show good survival rates, contributed 70% to the production figures.

S. Muthukaruppan (left) with SAP's ex com, from left, D. Ramraj, S. Santhana Krishnan, Udaya Ram Jothy and R. Srinivasan

At this conference, several local and international experts as well as industry leaders looked at the state of the industry along the supply chain in 2015. Covering strategies for the future, **Ravi Kumar Yellanki**, Vaisakhi Bio-Marine, said that there is no one solution that fits all. Each state has its own potential and strategies need to fit into the discipline of farmers and intensification level. At hatchery levels, **S. Chandrasekar**, Inve Aquaculture looked at the importance of nursery operations for successful grow-out operations. This concept is gaining momentum in the country with stakeholders going on study tours to Latin America. Some leading farms have begun to set up on-farm nursery operations with investments close to USD 20,000 (see pages 8-10).

Leena Nair and her team from MPEDA's Rajiv Gandhi Centre for Aquaculture (RGCA), Dr S Kandan (right) and YC Thampi Sam Raj (back, middle)

Dr Victor Suresh (right) with from left, V. Balasubramaniam, All India Prawn Farmers Association, G. Ramesh, Wenger, India, and Ravi Kumar Yellanki.

From left, Dr Subba Rao, YC Thampi Sam Raj, RGCA and S. Santhana Krishnan.

George Chamberlain (second left) at the mini-forum on disease management with, from left, Dr Celia R Lavilla-Pitogo, iAqua Malaysia, Dr Shankar V Alavandi, Central Institute of Brackishwater Aquaculture (CIBA), Panchu Duraisamy, BAP, GAA, Dr KK Vijayan, CIBA and V. N. Biju, Central Aquaculture Pathology Laboratory, RGCA. Lavilla-Pitogo presented on shrimp health management in Asia: re-examining biosecurity and risk management to mitigate AHPND and EHP. Alavandi and Vijayan presented on emerging issues in Indian shrimp aquaculture.

The feed sector is highly competitive with a production overcapacity of 1.8 million tonnes per year (tpy) as compared to the current demand of 800,000 tpy. However, moving forward, **Dr Victor Suresh**, United Research, Singapore appealed to farmers, government and policy makers as well as feed millers to work together to lower feed costs to maintain India's cost advantage at USD 1-2/kg shrimp.

During a mini-forum on diseases in Indian shrimp farming, **D. Ramraj**, Padmanabha Labs and HiBreeds shrimp hatchery said that the current production drop is due both to known and unknown diseases. These are the zoea II syndrome in hatcheries, and WSSV, RMS and more recently EHP and white faeces disease. At stake is the USD 2 billion invested into the country's shrimp farming industry as well as the livelihoods of 0.5 million people.

"For too long we have lacked a rapid response and diagnostic capabiliities for any new disease outbreaks as shown by the fact that no new disease discovery has been reported. Thus, identifying an emerging disease, pathogen or otherwise and developing diagnostic tools and biosecurity principles would be critical if the industry is to recover quickly from major diseases."

Messages from industry leaders

Leena Nair acknowledged the contribution of farmed shrimp to the rise in seafood exports to USD 5.5 billion in 2014-2015. Farmed shrimp contributed 51% valued at USD 2.8 billion and vannamei shrimp accounted for 83% of this. India rose to fourth position in the global seafood export market and a leading supplier to the US shrimp market in 2014-2015.

In her presentation on 'Stakeholders Participatory Shrimp Aquaculture in India,' Nair emphasised on the participatory ethics of stakeholders which are guided by the common interest and for the betterment of the industry. "In the 1990s, we experienced the catastrophe in the shrimp farming industry and the government introduced safeguards in black tiger shrimp farming. Similarly, with the vannamei shrimp farming, we had to introduce safeguards too such as the broodstock quarantine centre in Chennai. This has blocked the entry of broodstock infected with OIE listed diseases. Farmed shrimp production expanded and stabilised. To date, this centre handled almost 560,000 imports of broodstock."

However, with rising demand for broodstock and to discourage the use of pond reared broodstock by smaller hatcheries which had difficulties importing broodstock, MPEDA with the Oceanic Institute, Hawaii (OI) started a broodstock multiplication centre (BMC) in Visakhapatnam. The BMC supplied more than 90,000 broodstock as of January 2016. (An article on the BMC in Visakhapatnam will be published in issue May/June 2016).

"How can we sustain the gains and progress that we have made? Have we learnt the art and science enough for us to move towards production sustainability and towards higher production? In this meeting we see that the need for a participatory approach in the industry. We need to extend vigilance on disease as a safeguard against disease outbreaks. MPEDA will be conducting laboratory studies to learn how best to deal with this disease. Surveillance is on the way and although EHP is not OIE listed, MPEDA will ask for an order to screen imports of broodstock for EHP."

On the potential for expansion, Nair said that the authority will look at increasing aquaculture production in the freshwater and marine sectors through cage farming. In shrimp, the strategy is expansion but in a slow and orderly manner.

Dr George Chamberlain, iAqua Malaysia and Global Aquaculture Alliance (GAA), discussed recent challenges in sustainable shrimp farming. He said, "Disease is the primary factor limiting shrimp farming and the battle against EMS and EHP is now shifting from guessing what to do to implementing what works. These are with genetically resistant broodstock and management of ponds to control organic loads."

On market acceptance, Chamberlain said that daily the industry faces issues in the market place. However, this does not mean that the market will accept whatever is being produced. Environmental and social issues will be more pressing in the future. Sustainability is not a fad but it will continue to be there. It is expected for shrimp farming to double in a decade with shrimp farmed in a responsible way. "By working together we can solve challenges related to feed, zone management and market acceptance, thus providing answers that are beyond our reach individually."

Participants, from left, Ramakanth Akula, CEO and Shravan Kumar Mishra, The Waterbase Ltd and G Amareswara Rao, managing director, ABT Corp, India.

Series C financing for sustainable alternative fish meal innovator

Innovator in sustainable industrial products for food and energy security, Calysta, has completed USD 30 million series C funding for sustainable alternative fish meal production with Cargill, the Municipal Employee Retirement System (MERS) of Michigan and Old Westbury Global Real Assets Fund LLC. Also participating were current Calysta investors Walden Riverwood Ventures, Aqua-Spark and Pangaea Ventures. Calysta Nutrition develops and commercialises FeedKind™ protein, a new fish and animal feed ingredient. In January 2016 Calysta announced a conditional grant from the UK for the development of its first market introduction facility in England for FeedKind™ protein.

Calysta intends to use this series C investment to advance new product development, commercial manufacturing and continued advances in its proprietary state-of-the-art gas fermentation platform. In addition to the funding, Calysta and Cargill will collaborate in the North American manufacturing and global marketing. "This collaboration with Cargill, a world leader in fermentation and protein production, is expected to dramatically accelerate market introduction of FeedKind™ protein at commercial scale," said Alan Shaw, PhD, Calysta president and CEO.

Fish feed joint venture in Zambia

In February, Nutreco and African Century Foods (ACF) entered into a 75/25 joint venture in Zambia, for the production, sale and distribution of tilapia feed. The agreement is subject to regulatory approval. The joint venture, Skretting Zambia, will construct and operate the first dedicated fish feed plant in Zambia. Skretting is Nutreco's global brand for aquafeed. The new plant with an initial capacity of 25,000 tonnes of extruded fish feed, will be located at Siavonga, Lake Kariba, close to the major fish farms in Zambia and Zimbabwe. It will supply ACF's Zambian and Zimbabwean tilapia farms as well as to the open market. ACF is Africa's largest fish producer with tilapia farms in Zambia, Zimbabwe and Uganda. Feed plant capacity will be expanded in a second phase with the aim of supplying the wider southeast African region.

Harm de Wildt, managing director for Nutreco´s operations in EMEA said that the joint venture is a new step in the commitment to the African market, adding to recent fish feed investments in Egypt and Nigeria. Henry Pitman, CEO ACF said: "Having consistent supplies of high quality feed are critical to the success of our aquaculture operations in Zambia and Zimbabwe. This new feed mill will allow us to expand our operations from the current 10,000 tonnes per year and help to reduce our cost of production in line with our strategy to become the lowest cost producer of tilapia in the region."

Three new fish meal plants & certification in Indonesia

In 2016, the Ministry of Maritime Affairs and Fisheries (MMAF), Indonesia plans to build three new fish meal plants to increase the local supply for fish feed. These three manufacturing plants will be built in West Kotawaringin, South Halmahera and Kendari. According to Nilanto Perbowo at the Department on Strengthening Competitiveness of Fishery Products, production of quality fish meal is critical if Indonesia wants to restrict imports of fish meal. In addition, the ministry is clear that the fish meal must also be certified. The report in mongabay.co.id added that it will be interesting to see whether this fish meal plant will solve new challenges with the start of the Asean Economic Community (AEC) and Asean Free Trade Area (AFTA) from January 1, 2016. Within Asean, there are five IFFO RS certified plants in Vietnam and one in Thailand. There are two IFFO RS COC plants in Thailand. To be competitive and in preparation for AFTA, MMAF wants to increase the number of certified fish hatcheries to improve seed quality. Currently only 635 of 180,000 breeders are certified with accreditation to the 'Good Practices for Fish Hatchery or CPIB. The target is to increase by another 140 to 775 breeders in 2016

Thai shrimp farm in SSI

US based Seadex, LLC has created the 'Sustainable Shrimp Initiative (SSI) and will represent Thailand's Sureerath Prawn Farm in the US. SSI is a program that promotes farmers with excellence in all phases of shrimp production. It has established a pond-to-plate supply chain that allows customers to know how their shrimp are produced. Shrimp from SSI farms are marketed through a web-based platform established by ShrimpTrader.com. Seadex collaborates with the Monterey Bay Aquarium and is committed to sourcing shrimp rated as green or yellow by Monterey Bay's Seafood Watch Program.

Sureerath Prawn Farm is an organic, recirculating farm with 133 ponds over a 224 ha site in Chanthaburi. The annual production is 1,500 tonnes (120 tonnes per month) of shrimp. It has a hatchery, and a feed mill that will soon be producing a new type of feed in partnership with Australian Ridley Corporation. It is a founding member of the East Asian Organic Shrimp Farmers Association. Sureerath's shrimp is marketed to some of the finest restaurants in Europe and Asia (shrimpnews.com)

Positive signs for shrimp in Vietnam

In the first two months of 2016, Vietnam's shrimp production and prices showed signs of recovery. The weak supply in February and the rising demand for processing and exports pushed raw shrimp prices up sharply compared with the previous month, reported vasep.com.vn. In Ca Mau, prices of black tiger shrimp size 20/kg increased to VND 290,000/kg (USD 12.9/kg), size 30/kg to VND 230,000/kg (USD 10.2/kg) and size 40/kg to VND 160,000/kg (USD 7.13/kg). Prices for vannamei shrimp size 70/kg increased to VND 140,000/kg (USD 6.4/kg) and size 100/kg to VND 115,000/kg (USD 5.12/kg). With recovery signals of local shrimp production in the 2 months, experts said that this will create momentum to push exports of shrimp, particularly to markets that Vietnam has signed free trade agreements (FTA) as well as to AEC.

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Indian shrimp aquaculture: Strategies for sustainable growth

The industry in India needs discipline in husbandry practices and must have right strategies to sustain growth, says Ravi Kumar Yellanki and other industry leaders at Aqua India 2016.

Farming of the vannamei shrimp began in 2009 and from 2010 up to 2014, there was an upward trend in production. The expansion in production came with added infrastructures such as the increase in shrimp feed capacity at 1.8 million tonnes and the establishment of more than 250 hatcheries for an annual production of 50 billion post larvae. More recently, several processing plants and cold storage facilities came on line. All these added infrastructures are targetting for a potential annual production of 700,000 to 800,000 tonnes of shrimp.

However, in 2015, industry expects a 10% decrease in production. **Ravi Kumar Yellanki**, managing director, Vaisakhi Bio-Resources (P) Ltd, India said that to achieve any projected growth, the shrimp hatchery and farming fraternities need to have more discipline and right strategies.

Less in 2015

The growth in shrimp production in India from 2010 to 2014 has been phenomenal, from 142,000 tonnes in 2010 to 401,000 tonnes in 2014. However, industry gave a production estimate at only 363,450 tonnes for 2015, based on feed and post larvae sales and *Artemia* consumption. In 2015, farms in Andhra Pradesh, the largest shrimp producing state, used 500,000 tonnes whereas the rest of India, used 225,000 tonnes.

"The feed conversion ratio was taken as 2.2 and 1.8 for farms in Andhra Pradesh and the rest of India, respectively. These results were then correlated with post larval sales of 30.15 billion (calculated at 53-54% survival rates and 20 g harvest sizes) and consumption of *Artemia* for larvae production. A further correlation with actual export figures will finalise the production figures," said Ravi Kumar.

"With regard to the ratio of vannamei to black tiger shrimp, over the years we farmed less black tiger shrimp, from 80,000 tonnes in 2012 to only 27,450 tonnes in 2015. With vannamei shrimp, Andhra Pradesh's production declined by 21% in 2015 versus that in 2014. The other states showed large increases in production, in particular for West Bengal and Odisha, with the shift to vannamei shrimp farming. Nevertheless, as Andhra Pradesh produced 61% of the total production, the net change is a nationwide decrease of close to 10%."

A cautious beginning but...

In his presentation, Ravi Kumar used an intensification vs discipline matrix to describe the changes at the farming level. "In 2009, when Indian shrimp farmers began farming, it was in a cautious manner with all kinds of biosecurity measures knowing that this shrimp is not the black tiger shrimp which they have been farming. They prepared ponds carefully and used probiotics when needed. In the first two crops, we had wonderful harvests but then farmers became too conversant with this shrimp and in turn became too complacent in their approach.

"Greed took over particularly with prices rising to as high as INR 700/kg (USD 10.45/kg). New ponds came into the scene. With no breaks in cycle, increased intensification and low discipline, we found ourselves doing more farming but producing less shrimp. All these despite the stocking density capped at 60 post larvae (PL)/m^2 by the Coastal Aquaculture Authority (CAA).

Ravi Kumar Yellanki (middle) with Gujarat producers, Dr Manoj Sharma, Mayank Aqua Farms (right) and Saji Chacko, Onaway Industries.

In developing strategies to sustain growth, Ravi Kumar said, "We cannot have one solution which fits all and different strategies are required for different states depending on the level of intensity, knowledge base and discipline of farmers. It also depends on the current level of entrepreneurship in the various states."

SPF broodstock supply

Imports of specific pathogen free (SPF) vannamei broodstock have been increasing since 2013. In 2015, the hatchery industry used 194,000 vannamei broodstock of which almost 164,000 were imported and 30,000 were from the RGCA broodstock multiplication centre (BMC) in Visakhapatnam, to produce 30 billion post larvae.

"Post larvae demand has been increasing and its production has escalated but our broodstock imports have remained relatively low. I am sceptical that our hatcheries have become more efficient in maturation and in nauplii production and so I believe that a large amount of post larvae is produced using spurious broodstock (including pond reared), especially with the rise in the number of hatcheries," added Ravi Kumar.

CAA is responsible for regulating vannamei shrimp farming throughout the country and this includes registration of hatcheries as well as imports of broodstock. In response to concerns in India's shrimp farming, **Dr P. Ravichandran**, member secretary, said that with only 50% of hatcheries importing broodstock, the use of pond reared broodstock could be rampant.

"The registrations of 70 hatcheries are still pending and CAA is in a dilemma as it needs to assist in industry development. Farmers should go back to the previous practices with black tiger post larvae where they carried out quality checks. CAA has implemented tests for the microsporidian *Enterocytozoon hepatopenaei (EHP)* and early mortality syndrome (EMS) to prevent the entry of these diseases. The future lies in the establishment of stringent nursery systems and CAA will start formulating guidelines for this phase," said Ravichandran.

"We need about 300,000 broodstock to meet demand. There is a shortage of SPF broodstock, particularly during the peak season. Looking at this need, the strategy for the hatchery sector is to have 2-3 BMCs to supply our needs of 200,000 broodstock with 100,000 broodstock to be imported. Such a situation would be ideal as we are restricted by space at the quarantine centre in Chennai for imported broodstock. In addition, hatcheries face logistical problems with imports from Florida and Hawaii. With more broodstock from BMCs, we should be able to plug the route of vertical transmission of disease by stopping the use of pond reared broodstock," said Ravi Kumar.

Using selective breeding

On the prevalence of diseases such as EHP and white spot syndrome virus (WSSV), Ravi Kumar attributed the presence of EHP to some broodstock imports in the early years and suggested that future broodstock imports be limited to those from non- shrimp producing countries.

"In 2015, the industry has seen unprecedented WSSV outbreaks contributing to huge losses. There are some strategies, which we can suggest for the industry such as use of WSSV tolerant stocks. Currently, farmers continue farming without any crop breaks. Will crop breaks of a few months in a year be possible to arrest the spread of diseases including WSSV?"

Ravi Kumar cited the example of farmers in Gujarat who practice complete crop holidays for 3 months. In Andhra Pradesh, he suggested a break during October to December, which is the cyclone season on the east coast.

"Genetics can play a future role for some unique scenarios in India's shrimp farming industry. If temperature tolerance is a heritable trait, will it be possible to develop high temperature tolerant strains? We have close to 60% of farms in low saline waters. Is there a possibility of developing strains tolerant for low salinities for example below 10 ppt?"

His message was, "Indian shrimp aquaculture can achieve sustainable growth only with more discipline in husbandry practices throughout the value chain. We could also implement the Indonesian model of small yet intensive farms on the coast. One strategy is to produce *Penaeus monodon*, *P. indicus* and *P. merguiensis* but this depends on availability of selectively bred broodstock for these species. We also need to work on specific tolerant stocks for WSSV for all these species including vannamei".

Post larvae quality and hatchery management

S. Chandrasekar, Area manager-India and South Asia, Inve Aquaculture, said that there is no doubt that several problems at the grow-out phase can be attributed to poor quality post larvae, stress during stocking and transfer of post larvae, and poor management protocols in the hatchery. "In India, we have slow growth, sometimes from the beginning of culture. At the hatchery, zoeal syndrome is the major problem causing mortalities in the early larval developmental stages. High vibrio loads in the larval rearing tanks and the usage of poor quality algae are the most important causative factors for zoeal syndrome in Indian hatcheries.

"Most importantly, as we start with SPF broodstocks we also need to pay attention to the nutrition process during maturation for nauplii production. In India, hatcheries use fresh polychaetes from wild sources, which aside from compromising on biosecurity has a variable nutritional value depending on the

S. Chandrasekar (right) receiving his souvenir from Dr KK Vijayan, CIBA at Aqua India 2016 held in Visakhapatnam.

season. Overfeeding of fresh feeds is rampant at more than 30% of body weight on a wet weight basis. This increases the risk of high pathogen loads in the water.

"Today, our hatcheries use 5 kg of *Artemia*/million post larvae, which is the highest volume as compared to the average of 1.5 kg/million post larvae elsewhere. In fact, no *Artemia* is being used in some Mexican hatcheries."

On future strategies to improve quality of post larvae and achieve success at the hatchery level, Chandrasekar suggested, "What we do during one phase affects the next phase in the shrimp's development. On broodstock feeds, we should be looking at formulated feeds such as semi moist pellets with precise nutritional value. We should consider balancing the use of live feeds with formulated feeds but keep biosecurity in mind. The fluctuations in the natural availability of *Artemia* cysts and the inconsistency in quality will affect our dependence on this live feed. Availability of well formulated micro encapsulated larval feeds will help shrimp hatcheries to prepare for reduced use of live feeds but without compromising on larval quality."

Nursery systems

Chandrasekar discussed recent developments in nursery systems in Thailand and Mexico. "Nurseries can help farms overcome disease problems during the early grow-out stages such as running mortality syndrome (RMS). Quality post larvae fed with speciality diets give rise to healthy juveniles. There are several options which hatcheries in India can adapt to local conditions and rules. CAA needs to approve nurseries in farming sites.

"In Thailand, nurseries are located on farm. Size at harvest range from 0.5 g to 2 g which can be achieved in 30-40 days in the nursery. In Mexico, raceway nurseries rear post larvae to as long as 50 days. If transfer and transportation is an issue, there are already insulated containers developed for long distance transfers.

Chandrasekar concluded that production of good quality juveniles depends on specially formulated nursery or raceway diets. Unfortunately, import tariffs for such feeds are high (34%). A viable nursery stage in Indian shrimp farming will require quality feeds and hence stakeholders will need to ask the government to reduce import tariffs on larval feeds.

Developing preventive feeding strategies to mitigate penaeid shrimp sensitivity to EMS

By Stephane Ralite, Mathieu Castex and Dorothée Gotz

Research indicated that the prevention of EMS most likely requires a multi-factorial approach including live probiotic bacteria and yeast fractions.

Early Mortality Syndrome (EMS) or Acute Hepatopancreatic Necrosis Diseases (AHPND) is one of the latest pathologies in shrimp causing large economic losses in Asia and Latin America. Even though the causative agent has been identified, the mechanisms of infection are not fully understood yet. AHPND is likely to be due to the production of some toxins by bacteria. Different strains of *Vibrio parahaemolyticus* have been isolated from the field, which have shown the ability to induce EMS when ingested by the shrimp. Due to the high toxicity of the toxins and the rapid development rates of *V. parahaemolyticus*, preventive approaches appear to be the most effective way to control this pathology.

In the past, the use of selected beneficial bacteria as dietary probiotics or bioremediation agents has been shown to be effective against *vibriosis* in shrimp. In this article, we describe research carried out by Lallemand Animal Nutrition on effective probiotic bacteria strains and yeast fractions for the prevention of *V. parahaemolyticus* infections.

Looking for the best probiotic candidates

Hundreds of live beneficial microbes and yeast fractions from the Lallemand collections (including one of the largest private marine microorganisms collection named Lallemand Aquapharm, Oban, Scotland) were screened in vitro using a dual procedure for their ability to impact growth and maintenance of *V. parahaemolyticus* in solution. The most promising candidates were further assessed in vivo.

Two different approaches were taken to screen the candidates. In the case of probiotics (live bacteria), candidates were screened for their antimicrobial properties against *V. parahaemolyticus* (antagonism assay). Some 331 different bacteria strains were selected based on their identification and their origin of isolation. They were screened in vitro using Lallemand Aquapharm unique screening platform, AquaSearch®.

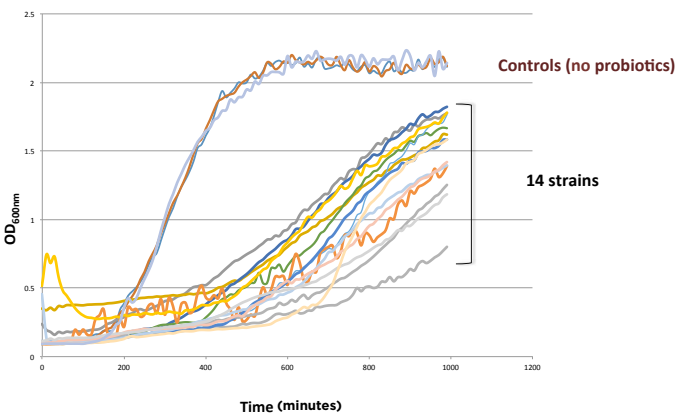

Figure 1. Growth of different *V. parahaemolyticus* strains (measured by Optical Density (OD) at 600 nm) with or without candidate probiotic's metabolites issued from Lallemand Aquapharm bank.

Fourteen strains of interest were selected from this first round (Figure 1). The strain *Pediococcus acidilactici* MA 18/5M (Bactocell®), which was already proven to reduce vibrios concentration in shrimp gut and registered as probiotic for use in shrimp for years, was used as a positive control (Figure 2). Classical microbiology co-culture experiments were then used to validate the specific antimicrobial activity of the probiotic strains against *V. parahaemolyticus*. From these in vitro testing, only four strains were retained as potential candidates for animal testing.

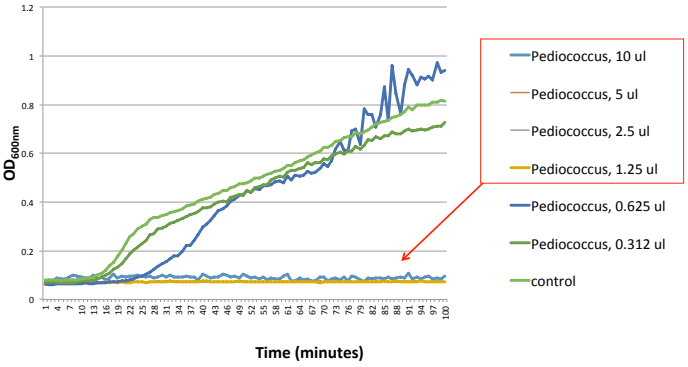

Figure 2. Growth of *V. parahaemolyticus* with or without *Pediococcus acidilactici* MA 18/5M (Bactocell®) metabolites.

Pathogen binding screening

In a separate screening approach (internal method), yeast fractions generated from several different strains of yeast were tested and selected for their ability to adhere to *V. parahaemolyticus* cells in vitro. Here, a proprietary *Saccharomyces cerevisiae* yeast fraction was used as a positive control. The most promising fractions were selected for in vivo testing.

In vivo challenge in shrimp

The best fractions were tested on white shrimp *Litopenaeus vannamei* juveniles in an immersion challenge with 100 mL of a culture of a virulent strain of *V. parahaemolyticus* which is able to induce AHPND at 1.1x 10^9 CFU/mL (grown in TSB + 2% NaCl (TSB+) at 28 °C for 18 h). The testing was done by Dr Loc Tran at the Minh Phu Aqua Mekong Shrimp Vet Lab in Vietnam.

Two trials were performed with *L. vannamei* juveniles, weighing 0.55° 0.07 g and 2.07° 0.05 g, respectively. Shrimp were fed for 21 days either with diets supplemented with the tested fractions prior to the immersion challenge or with diets which are not supplemented. Mortalities were monitored over 10 days and the cumulative survival for each diet was statistically compared to the control within each trial using a non parametric procedure and the Kaplan and Meier survival curves (Kaplan and Meier, 1958).

Probiotics

Two of the potential probiotics selected and *P. acidilactici* MA18/5M (Bactocell®) were evaluated in triplicate. Bactocell® showed protective effect against *V. parahaemolyticus* as the

survival went from 40% in the infected control to nearly 70% with Bactocell®.

One of the candidates confirmed its potential to prevent mortality induced by *V. parahaemolyticus*. Survival rate was slightly over 70%. However, there was no statistical difference between Bactocell® and these new candidates (Figure 3). Kaplan and Meier survival curves were constructed for each diet and the curves were compared using the log-rank test to determine differences between curves and whether the trends in survival were different between treatments. The significance level was set at *P = 0.05*. These results confirm that Bactocell® can be considered as a valuable tool to combat vibriosis, as previously reported (Castex et al, 2009, 2010; Panigrahi et al, 2011). The second candidate only resulted in a slight numerical improvement compared to the control infected group, thus supporting the need to use in vivo studies to validate any in vitro screening process.

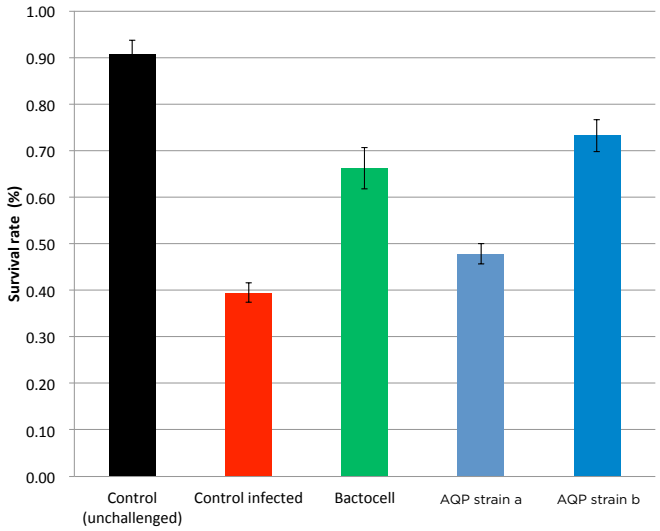

Figure 3. Survival of *L. vannamei* fed three different probiotics and exposed to an immersion challenge with a virulent *V. parahaemolyticus* strains.

Yeast fractions

Based on the in vitro assays, a product has been formulated with the most promising yeast fractions. An in vivo challenge was performed under the same conditions as the first challenge test reported above, using in this case a dose response design.

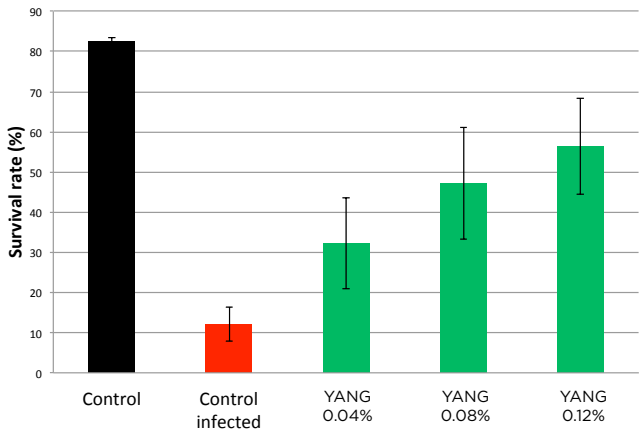

Figure 4. Survival of *L. vannamei* fed a new formulated yeast fraction product and exposed to an immersion challenge with a virulent *V. parahaemolyticus* strains.

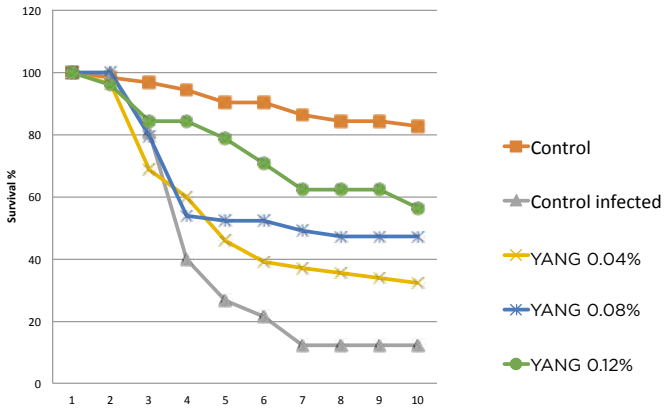

Figure 5. Survival rate of *L. vannamei* juveniles during the course of the challenge experiment with the new formulated yeast fraction product.

Feed was prepared by grounding commercial shrimp feed in Dr Loc Tran's laboratory. The grounded feed was then was mixed with yeast fractions at three different doses for the treatment groups (0.4 g/kg, 0.8 g/kg and 1.2 g/kg of feed) and extruded with a cold process to allow for good feed stability.

The formulated yeast fractions product showed a significant linear dose response effect on shrimp survival following the vibrio challenge with a final survival rate increase from 12.1 % in the control to nearly 60 % at a higher dose tested (Figures 4 and 5.) (Log Rank (Mantel-Cox), *p<0.01*).

Conclusion

These studies indicate that specific microbial based solutions are efficient tools in developing preventive strategies to mitigate the sensitivity of penaeid shrimp juveniles to vibriosis, and more specifically to AHPND. Prevention of EMS is most likely based on a multi-factorial program. We have demonstrated that two different types of specific microbial solutions (live probiotic bacteria and yeast fractions) can bring positive results to such programs.

Finally, the beneficial effect of *Pediococcus. acidilactici* MA18/5M (Bactocell®) against vibriosis has been once again confirmed, and a new yeast fraction formula has shown a good capacity to protect *L. vannamei* during an AHPND infection.


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H_2S toxicity – the silent killer

By Soraphat Panakorn

Losses from hydrogen sulphide toxicity in shrimp farms override mortality from other causes and it is time farmers realise this.

During the 25-year history of shrimp farming, shrimp farmers had contributed to a global production of more than 40 million tonnes. Out of this, I estimated that they had lost about 4 million tonnes to some dangerous diseases such as the white spot syndrome (WSSV) over a period of about 20 years. The early mortality syndrome virus (EMS) has taken only 5 years to destroy 2.5 million tonnes and possibly, Vibrios is the root cause of some 2 million tonnes of losses.

The case of H_2S toxicity is different; it is always present in the pond, possibly killing shrimp slowly each night. Farmers may have experienced losses of about 10% per crop and generally have accepted this as the norm when they do not know the real cause of the mortality or how to handle it. As of now, an estimated 4 million tonnes of shrimp could have been lost from H_2S toxicity.

What is hydrogen sulphide?

H_2S is a toxic gas, detectable by rotten egg smell. It is generated when sulphate reducing bacteria (SRB) digest organic matter (OM) under anaerobic conditions (no oxygen) in the water or under wet conditions. In shrimp farms, the bottom layer of the ponds, mud, sludge and big flocculation granules produce H_2S.

How does H_2S harm shrimp?

The first action of H_2S is to block shrimp from taking up oxygen. This weakens shrimp, makes them sluggish and increases their vulnerability even under a short exposure. Shrimp succumb to mass mortality under strong exposure within a short time. It can also cause tissue corrosiveness, irritating soft tissues such as gills, gut and stomach walls, and hepatopancreatic tissues. H_2S also makes shrimp uncomfortable, lowering their resistance to infection.

A safety level for H_2S in black tiger shrimp is 0.033 ppm (Chen, 1985) and fish is 0.002 ppm (Boyd, 1982). In the case of the vannamei shrimp (48 hours LC50) post larvae can tolerate up to 0.0087 ppm H_2S and for juvenile white shrimp up to 0.0185 ppm. (Federal Register/Vol. 75 No. 38/Friday, February 26, 2010/ propose rule page 8889)

Table 1. Safety levels for H_2S in shrimp and fish

Species	Safety level (ppm)
Black tiger shrimp	0.033
Fish	0.002
Vannamei shrimp post larvae	0.0087
Vannamei shrimp juvenile	0.0185

Methodology of detection

The methodology for the detection of H_2S gas is quite complicated and more difficult than for either ammonia or nitrite. This is the reason why most shrimp farmers determine only the concentrations of the latter two gases and not H_2S. This is despite the fact that the safety level of H_2S is much lower than ammonia and nitrite. In other words, I would say that at the same concentration, H_2S is 100 times more dangerous than ammonia and 1,000 times more than nitrite!

Loose shell syndrome in black tiger shrimp. This usually occurs with long exposure to H_2S leading to stress and lower feed consumption

Table 2. Relative toxicity of H_2S to common gases

Gas	Level (ppm)	X power
H_2S	0.02	1,000
NH_3	2	100
NO_2	20	1

H_2S toxicity to aquatic animal

Toxicity of H_2S is dependent on three key parameters; pH, temperature and dissolved oxygen as indicated in Table 3.

Table 3. Relationship between pH, temperature and dissolved oxygen (Boyd, 1990)

pH	Temperature degree Celsius								
	16	18	20	22	24	26	28	30	32
5.0	99.3	99.2	99.2	99.1	99.1	99	98.9	98.9	98.9
5.5	9.77	`97.6	97.4	97.3	97.1	96.9	96.7	95.6	96.3
6.0	93.2	98.2	92.3	92	91.2	90.8	90.3	89.7	89.1
6.5	81.2	80.2	79.2	78.1	77	96.8	74.6	73.4	72.1
7.0	57.7	56.2	54.6	53.0	51.4	75.8	48.2	46.6	45.0
7.5	30.1	28.9	27.5	26.3	25	19.7	22.7	21.6	20.6
8.0	12	11.4	10.7	10.1	9.6	9	8.5	8	7.6
8.5	4.1	3.9	3.7	3.4	3.2	3	2.9	2.7	2.5
9.0	1.3	1.3	1.2	1.1	1	1	0.9	0.9	0.8

Since H_2S is generated under anaerobic conditions, it will interfere with the oxygen transfer processes in the animal body. A high DO over 3 ppm in the fish/shrimp pond could help to block H_2S production.

A combination of low pH, oxygen and temperature makes H_2S more dangerous. Therefore, monitoring of these three parameters is key to mitigating H_2S toxicity.

H_2S problems in ponds

The following conditions will favour the generation of H_2S. In ponds with clear water before stocking, due to light penetration, benthic algae or lap lap will grow over the bottom. After a certain time, phytoplankton will bloom and this blocks light from penetrating the pond bottom, leading to a crash of benthic algae. Ponds with sandy or loose soil, and very deep ponds with insufficient oxygen create anaerobic conditions which lead to the production of H_2S.

Black gills in vannamei shrimp. This occurs with long exposure to H_2S when shrimp search for food on pond bottom.

Other cases are ponds containing high concentrations of suspended organic matter. Once these solids settle at the pond bottom, conditions will favour H_2S production. High-density polyethylene (HDPE) lined ponds devoid of oxygen underneath the liners promote the generation of H_2S when organic matter seeps under the liners. Ponds which experienced plankton crash and contain high levels of feed wastes, as well as acid sulphate ponds with low pH, and high loads of organic matter will support the release of H_2S. Table 4 provides detectable symptoms of shrimp affected by H_2S toxicity.

> **"H_2S gas in the shrimp ponds can be equated to a silent killer. It is invisible especially when farmers do not have the right knowledge."**

Table 4 Symptoms and causes of shrimp affected by H_2S toxicity

Symptoms	Causes
Loose shell syndrome	Long exposure to H_2S leading to stress and lower feed consumption
Black gills	Exposure to H_2S when shrimp search for food at pond bottom.
Abnormal colour of shrimp gill and body	Stress after long exposure to H_2S.
Mortality following moulting	When shrimp moult, they need more oxygen and stay close to sludge area. If H_2S is high the moulting shrimp will die.
First morning meal, shrimp consume lesser feed	In the morning , water pH and DO will be lowest with higher concentration of H_2S affecting feed consumption.
White faeces disease (WFD)	H_2S toxicity irritates soft tissue in shrimp gut causing the release of fat and mucous to relieve the problem. Note: WFD is also caused by many factors, not only H_2S toxicity.
Detected rotten egg smell.	Gases (H_2S) bubbling in the middle of pond. Discharge water colour is too black with rotten egg smell.
Sudden phytoplankton bloom	H_2S facilitate the release of phosphate freely into the water resulting in a phytoplankton bloom within 2-3 days.
High ammonia and nitrite	Nitrifying bacteria destroyed by H_2S

H_2S is usually the main cause when shrimp die or behave abnormally after heavy rains, a plankton crash, a partial harvest, pumping out sludge or syphoning activity, climate swing, during 30-40 days of culture (DOC) and after DOC 60.

Applying lime to maintain optimal conditions

Summary on H_2S impact in shrimp farming industry

We can equate H_2S gas in the shrimp ponds as a silent killer. It is invisible especially when farmers do not have the right knowledge. In fact, it increases production costs by 10% by reducing average daily growth (ADG) and survival rate, and increases feed conversion ratio and susceptibility to disease. Often, farmers encounter H_2S problems but still do not know how to manage it.

To prevent H_2S toxicity, the farmer should follow these guidelines:

- Keep DO at the critical point (30 cm high from pond bottom and 3 m from sludge edge at 3-4 am) always over 3 ppm, from beginning to harvest of each crop
- Feed on demand and follow my guidelines (Panakorn, S., 2011. Aqua Culture Asia Volume 7, pp8-13). Monitor organic matter well
- Avoid farming in loose or sandy soil or in acid sulphate areas
- Always check bacterial count by TCBS agar plate in water sample collected just 2-5 cm from sludge area. Normal *Vibrio* will show up as green or yellow colonies, SRB will show as a black colony. If farmers see this, it means the H_2S generation has started. The farmer will need to take immediate action
- Keep pH between 7.8 to 8.3 during the entire crop. The daily pH gap must be less than 0.4
- Farmers should be carefull and take prompt action during heavy rains and plankton crash

Some special cases

Heavy rains

During heavy rains, water parameters will change to promote H_2S production. Rains will cause low temperatures, DO and pH, as well as lowering mineral composition and alkalinity in the water. Sounds and waves created by wind also stress shrimp and force them to crowd at the bottom and sludge areas of the ponds. These factors lead to mortality. The farmers should do the following:

- Stop feeding during rainy conditions
- Check water pH and apply lime if necessary to maintain optimal conditions
- Keep aerators running all the time
- Remove fresh water from the pond as much as possible. Avoid floodwaters from entering shrimp pond
- Have mineral and salt solubles ready to mix with feed following the rains
- Apply H_2S edible bacteria to control H_2S

During a plankton crash

Once there is a plankton crash, pH will immediately drop. Organic matter concentrations will increase suddenly resulting in a sudden uptake of oxygen. Toxic gases will be released and bacteria will bloom. The farmer must take the following steps:

- Cut down feed amounts by 50-60%.
- Apply fine lime to maintain pH and flocculate the dead plankton
- Run aerators to settle organic matter to centre of pond
- Exchange of water by siphoning out centre sludge
- Apply effective digestion organic matter to complete suspend particle
- Apply H_2S edible bacteria to control H_2S

Treatment

When symptoms of H_2S are detected as in Table 4, the farmer must:

- Cut down feed immediately by 30-40% at least for 3 days until general conditions return to normal.
- Increase dissolved oxygen immediately (but be aware of sludge disturbance during installation of a new aerator).
- Carry out water exchange to make sure water remains clear and apply microorganisms etc.
- Apply lime immediately to increase pH by about 0.5 or higher than 7.8.
- Apply microorganism that can eat up H_2S for example *Paracoccus pantothrophus*

The message

My objective for this article is to provide a better understanding on H_2S toxicity in shrimp farms, in a simple and easy manner. It is important that farmers are able to detect problems at the pond side and quickly implement preventive measures. Let us not allow H_2S toxicity be the primary cause and bring in a secondary infection or opportunistic disease to block a successful crop.

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Options for a recovery in shrimp production in Malaysia

By Zuridah Merican

Understanding EMS and EHP, controlled nursery and SPR broodstock are some options for industry to recover shrimp production.

Aside from being beset by early mortality syndrome (EMS) and the occasional white spot syndrome virus (WSSV) since 2011, large and small farms in Peninsular and East Malaysia faced a new dilemma throughout 2015 with the occurrence of the microsporidian *Enterocytozoon hepatopenaei* (EHP) which causes slow growth and sometimes also the white faeces disease (WFD). This challenging state of affairs subsequently brought farmers and other shrimp industry stakeholders together at a seminar organised by the Department of Fisheries Malaysia (DOF) in November 2015. Both groups were seeking for solutions and some light at the end of the tunnel.

In his introduction on the status of the farmed shrimp industry in Malaysia, **Dr Mazuki Hashim**, DOF, said that 2014 statistics from the Department showed a production of 57,161 tonnes of vannamei shrimp and 4,205 tonnes of monodon shrimp. In comparison, it was 48,991 tonnes and 4,483 tonnes, respectively in 2013. Was there a recovery in the shrimp industry in Malaysia?

From left, Kua Beng Chu, George Chamberlain and Mazuki Hashim

According to Mazuki, yes, as the production in 2014 was 22.9% higher than that in 2013. In 2013, production dipped by 42.7% compared to the production in 2010 which was 110,000 tonnes. He added that presently there are 40 active shrimp hatcheries in the country with 90% producing vannamei post larvae and the rest monodon post larvae.

From right, Chong Churn Zarn, Mazuki Hashim, Syed Omar Syed Jaafar, president, Malaysia Shrimp Industry Association and Hiew Yee Wei, Star Feedmills Sdn Bhd.

Monitoring of outbreaks is the responsibility of **Dr Kua Beng Chu** and her team at the National Fish Health Research Centre, DOF. Kua has updated industry frequently on the occurrences of EMS throughout the country. According to Kua, the general signs have been 40-50% mortality at less than 40 days of culture but in 2014, the team reported on a second wave with almost 100% mortality. In this seminar, Kua explained the gut score to control EMS at the farm. This works on the principle of detection on the status of the shrimp gut and linking this to acute hepatopancreatic necrosis disease or AHPND pathology. The aim of the gut score is to help farmers decide when to proceed with further diagnosis with PCR. It also helps the farmers to take immediate action in terms of farm management.

Understanding EMS/AHPND and EHP

During the last four years, industry may have lost some confidence in shrimp farming with frequent crop failures resulting in some farms being sold or leased out while others ceased operations, temporarily or permanently. However, **Dr Robins McIntosh**, Charoen Pokphand Foods Ltd (CP), Thailand said that there is still hope for the industry as long as farmers understand how to manage diseases. Some success were seen in Thailand in June 2015, where 36 tonnes/ha of 36 g shrimp after 110 days and with 82% survival have been achieved. Another example quoted was the harvest of 22 tonnes/ha of 54 g shrimp after 105 days. The latter was achieved with CP's shrimp specially selected for growth, called the Turbo shrimp.

McIntosh focussed on the two current disease outbreaks affecting Malaysian farms. He said that it is important to know the enemy and install the appropriate biosecurity measures. Farms have learnt to manage WSSV by installing appropriate deterrents such as crab fences. However, in the case of AHPND, the pathogen requires a threshold number of bacteria (quorum sensing) and that the bacteria grow and produce toxin on shrimp feed, shells of shrimp as well as on moulted shell and on shrimp sludge. The consequence is that shrimp will die from the high bacterial load. In addition, it needs to ingest toxin from the environment. McIntosh reiterated that AHPND is not a viral disease nor is it vibriosis. Due to competitive exclusion, a high diversity of bacteria in the pond environment lowers the impact of AHPND.

"There is no silver bullet to cure these two diseases but there is science in disease management," said McIntosh. Similar to most microsporidians, EHP can also survive outside the hosts. That is the reason why the 4C's are important in shrimp farming; clean broodstock, clean post larvae, clean water and clean farm. The post larvae should also have clean tubules."

Robins McIntosh

The symptom of EHP infection is slow growth of shrimp. Average daily growth (ADG) will be less than 0.15 g with coefficient of variation at 25-30%. EHP infected shrimp reared in ponds with dirty bottoms can also be infected with WFD but not all EHP infected shrimp will show symptoms of WFD. The transmission of EHP is horizontal in ponds as spores are resident in ponds. The vertical transmission is through pond reared broodstock or via polychaetes fed to broodstock. It is not easy to detect EHP cells and detection requires a real time PCR where the detection level is 10^3 and via histology, it requires a trained technologist who knows what and where to look.

McIntosh gave some examples where the incidences of AHPND have been lowered such as in Hainan, China, Thailand and Vietnam where farms use ground water with low zooplankton populations. As a result of frequent outbreaks, farms in Rayong Province opted for smaller 2,000 m^2 ponds and a 50:50 ratio of reservoir: culture ponds. The shrimp toilet where there is constant collection of uneaten feed and pond waste which are then pumped out to a settling pond, is the latest development aimed at keeping the pond environment clean.

Controlled nursery systems

The uptake of such systems has been slow in Malaysia, although most farms see the benefits of stocking robust juvenile shrimp instead of PL10 directly into ponds. **Louis Wong Yew Meng**, QVC Bio System, highlighted the journey to success of this company which developed the N2P nursery system in 2014. With the advent of EHP, the company modified its 1.2 ha ponds into 6 smaller ponds for easy handling in line with the 'SSS' system being promoted by Star Feedmills, a CP company in Malaysia.

Chong Churn Zarn, Star Feedmills detailed some success with this system in a farm in Tanjong Karang, Selangor in Peninsular Malaysia. Several trials were carried out in the nursery to determine the ideal conditions for nursery production and subsequently to monitor the performance of shrimp during the grow-out cycle. In some trials which started in July 2015, shrimp were reared for 33-47 days in the nursery and the grow-out cycle was only 60 days for harvest of size 44/kg shrimp and 36 days for size 69/kg shrimp. In the 4C concept, Chong said that incoming water is retained in a reservoir, channelled into 3 treatment ponds in a series and conditioned before entering the culture pond.

A comeback with SPR broodstock

In Malaysia, similar to countries such as Thailand, the expansion in production since 2005 was attributed to the use of specific pathogen free (SPF) broodstock for post larvae production. However, despite this and the implementation of biosecurity measures, the industry is beset by diseases. In a joint presentation with **Dr George Chamberlain**, iAqua Malaysia, **Abu Bakar Ibrahim**, CEO of Blue Archipelago said that the company's 152 ha Kerpan farm located in Kedah, Peninsular Malaysia was particularly hard hit by EMS and WSSV. Despite numerous remedial efforts to recover from EMS, crop losses persisted. In 2015, EHP hit this farm and many other farms in Malaysia and Abu Bakar gave his estimate of only 32,000 tonnes produced in Malaysia in 2015.

Chamberlain presented details on how the shrimp industry in Mexico was affected by EMS in 2013 which brought down production by more than 50% to 60,000 tonnes in 2013. However, the industry had a very quick recovery and production in 2015 reached almost 100,000 tonnes. This recovery was attributed to the use of specific pathogen resistant (SPR) shrimp from Ecuador which became resistant to EMS. This SPR approach was then brought over to Malaysia. In 2015, Blue Archipelago and iAqua started trials in 12 ponds stocked with post larvae from SPR broodstock imported from Central America and 31 control ponds using post larvae from SPF broodstock. The initial results indicated higher survival with the ponds stocked with SPR post larvae at 84%, as compared to less than 40% in control ponds.

Jeffrey Lee, Kembang Subur and Yip Kam Toh, Star Feedmills (left)

Biocatalysis with an algae-clay feed additive paves the way for fish meal replacement in diets for the Nile tilapia

By Maarten Jay van Schoonhoven, Marie Gallissot and Jintasataporn Orapint

Trials in Thailand showed better growth performance of tilapia with 5% fish meal inclusions, paving the way for replacement with sustainable ingredients.

The choice ingredient in aqua feeds has always been fish meal due to it being nutritionally complete, easily digestible and safe. The stagnating supply of fish meal and continuously increasing prices are putting pressure on feed formulators on the use of fish meal as an ingredient.

There is also a growing effort to make aquaculture sustainable by decreasing the use of fish meal in aqua feeds. This has led to a growing trend of using fish meal replacements with animal proteins and plant ingredients. However, there are challenges when using these replacements including an increased risk of mycotoxins from plant ingredients. Another challenge is finding the right combination of ingredients to achieve a nutritionally balanced diet which also allows for adequate bioavailability of nutrients through good digestibility.

The relatively new challenges of mycotoxin risks in aquafeeds and their potentially detrimental consequences on aquatic animal species are often reduced with the use of clays (HSCAS). However, there are more to clay than just reducing mycotoxins; clays can also contribute in many other ways when presented in the right form.

Combination of clays and enzymes

Digestive enzymes need to be in contact with their feed substrate in order for hydrolysis to occur. Clays have been reported to enhance this contact between enzymes and nutrients and improves the rate of digestion of feed (Reichardt, 2008 and Habold et al, 2009). These active and stable clay-enzyme complexes are resistant to proteolysis, and can increase the amount of active digestive enzymes in the digestive tract, thereby improving nutrient digestibility.

Some studies also suggest that the increased activity of enzymes in contact with clay, not only comes from the stable structure that is formed, but also from the presence of cofactors in the clay (Reichardt, 2008; Habold et al, 2009). Cofactors are helper molecules required for enzymes to be active. They can be organic or inorganic, most commonly vitamins in the first case

and metallic ions in the latter. In montmorillonite clay, several metallic ions replace some aluminium and silicon ions in the structure. The presence of these metallic ions may contribute to the activation of some enzymes, through their action as cofactors (Niederhoffer, 2000). For example, copper is known to activate lipase and phospholipase A (Jondreville et al, 2002) and zinc is a required cofactor of carboxypetidase (Williams, 1960).

Algo-clay digestibility enhancer

The matrix support provided by clay and the metallic ion cofactors present in the clay structure can contribute to the process of biocatalysis, which improves the performance of a biochemical reaction through the action of an external compound, a biocatalyst. Clay structures can be modified and associated with other materials in order to increase the biocatalytic properties. This association of materials to improve digestive capacity is the innovative technology that has been developed by the Olmix group (France), in the framework of its research program conducted on algae and clays. Clay in a micronized form allows for a fine dispersion of the product in the digestive tract and providing many sites of reaction of enzymatic digestion with easily accessible metal ion cofactors. Moreover, there is a beneficial synergy between clay and algae that increases biocatalysis, as algae bring in a vast diversity of metallic ions, which are sometimes absent in feed and are required cofactors for the activation of several enzymes. This unique combination of algae and clay makes it a unique tool to boost enzyme activity, through the action of biocatalysis, which helps to improve digestive performance.

After successfully improving zootechnical performance in several aquatic species a trial aimed to replace fish meal was designed. This trial was conducted at the Faculty of Fisheries, at Kasetsart University, Thailand.

Experimental design

A total of 720 mono sex Nile tilapia *Oreochromis niloticus* from the same genetic pool were randomly allocated to 240 L glass tanks containing 160 L of water each. Fish with an average initial body weight of 6 g were stocked at 20 fish/aquarium (40 fish/m2). Water parameters were maintained at 27-28°C, dissolved oxygen >6.0 mg/L and pH >7.5. There was a 10% daily water exchange. Uneaten feed was removed and recorded 20 minutes post feeding. Fish were fed three times a day at 3-5% body weight. The trial started after an acclimatisation period of 2 weeks and lasted for 12 weeks. The fish were reared under normal photoperiod during the 12 weeks (natural light).

All experimental diets had the same protein, fat and energy content, with an isonitrogenous (32%CP) and isocaloric (2,550 Kcal DE/kg) formulation. Trial feeds were prepared by extrusion with a 2 mm die. The experiment is based on diets with 2 levels of fishmeal inclusion (5% and 20%) and 3 levels of the algae-clay feed additive (MFeed+), supplemented at 0.0, 0.1 and 0.2% (Table 1). There were six replicates for each treatment.

Table 2 summarises the significant improvement in growth performance among the different treatments. The challenge diet in control 2 with 5% fish meal inclusion, showed the lowest performance. On the other hand, there was significant improvements in fish fed diets with 20% fishmeal inclusion and diets with algae-clay supplementation.

Figure 1 shows a dose dependent increase in growth rate when the algae-clay mix was supplemented to a diet with 20% fishmeal inclusion. Each dose of supplementation of algae-clay significantly improved growth. Likewise, Figure 2 shows a similar significant increase in growth when the algae-clay mix was supplemented to a diet with only 5% fish meal inclusion. When

Table 1. Composition of treatment diets

	Treatment	Experimental diet
T1	Control 1	Standard diet (StDiet) 20% FM 0% MFeed+
T2	Control 2	Challenge diet (ChDiet) 5% FM 0% MFeed+
T3	Treatment 1	Standard diet 20% FM 0.1% MFeed+
T4	Treatment 2	Challenge diet 5% FM 0.1% MFeed+
T5	Treatment 3	Standard diet 20% FM 0.2% MFeed+
T6	Treatment 4	Challenge diet 5% FM 0.2% MFeed+

Growth performance

Table 2. Growth performance parameters

	Control 1 (20% FM)	Control 2 (5% FM)	T3	T4	T5	T6	Effect[1]
Initial weight (g/fish)	6.58	6.56	6.59	6.58	6.58	6.58	
Final weight (g/fish)	65.98 ^{cd}	61.33 ^{d}	73.72 ^{b}	69.27 ^{bc}	82.33 ^{a}	74.42 ^{a}	D**, S***
SGR (%/d)	2.76 ^{cd}	2.67 ^{d}	2.89 ^{b}	2.82 ^{bc}	3.03 ^{a}	2.91 ^{a}	D**, S***
Daily feed consumption (g/d/fish)	0.83 ^{cd}	0.78 ^{d}	0.91 ^{abc}	0.88 ^{bc}	1.00 ^{a}	0.93 ^{ab}	D†, S***
Feed Conversion Ratio (FCR)	1.17	1.21	1.14	1.18	1.11	1.15	D†, S†

[1] From the analysis of variance, taking into account the effect of the diet (D) and the effect of the supplementation (S). †P < 0.2; *P≤0.05; **P≤0.01; ***P≤0.001.
[a, b] On a same line, different letters indicate a significant difference.

the standard diet with 20% fishmeal inclusion was compared to the challenge diet with only 5% fish meal inclusion, better growth can be seen in the standard diet. However when the algae-clay additive was supplemented to the challenge diet, growth improved to an extent that a MFeed+ supplementation of 0.2% showed a significantly higher growth than the standard diet (Figure 3).

A clear trend of decreasing FCR was observed when MFeed+ was added to both the standard and the treatment diets (Figure 4).

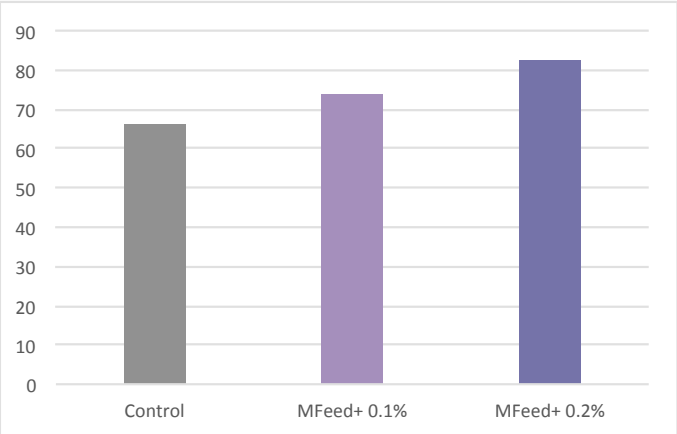

Figure 1. Growth performance (%) of Nile tilapia fed the standard diet containing 20% fish meal and two inclusion levels of MFeed+

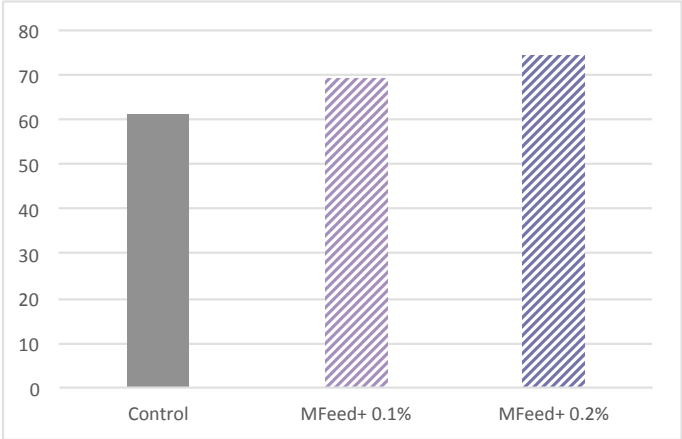

Figure 2. Growth performance (%) of Nile tilapia fed the treatment diet containing 5% fish meal and two inclusion levels of MFeed+

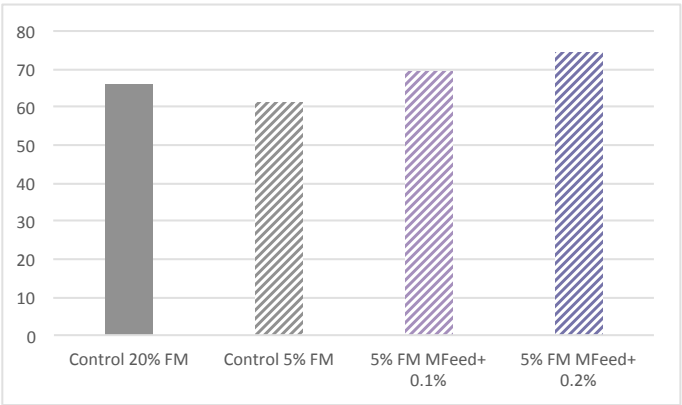

Figure 3. Comparison OF growth performance between the standard diet (20% fish meal) and treatment diets (5% fish meal) supplemented with MFeed+

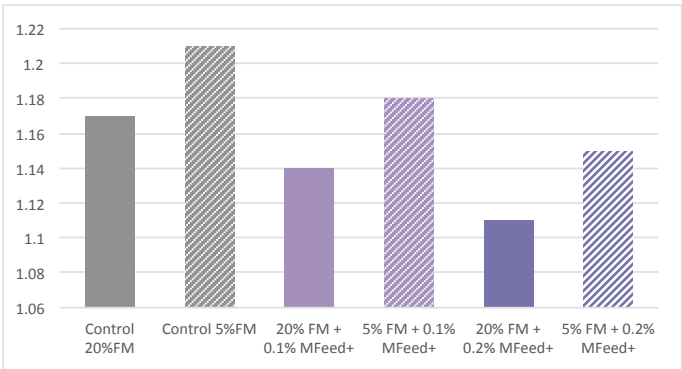

Figure 4. FCR of the control, standard and treatment diets supplemented with MFeed+

Results showed that a decreased level of fish meal in the diet can have a negative effect on the haematological parameters measured in this trial (Table 3). Supplementing the diet with MFeed+ can significantly increase these parameters for both standard diet as well as a diet with a lower fish meal inclusion. This strongly suggests that MFeed+ can improve the fish's efficiency in dealing with challenges such as stress and diseases.

The only significantly lower survival rate was found in fish fed treatment diet with a 5% fish meal inclusion (Figure 5). No significant differences were seen in any of the other groups which suggest that MFeed+ can also improve health parameters in fish to maintain a similar survival as fish fed a diet with a high fish meal inclusion.

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Health parameters

Table 3. Haematological parameters measured

	Control 1 (20% FM)	Control 2 (5% FM)	T3	T4	T5	T6	Effect[1]
Survival rate (%)	95.83[a]	88.33[b]	96.67[a]	95.00[a]	98.33[a]	95.83[a]	D*, S*
White blood cells (x104 cell/mL)	1.38[c]	1.07[d]	1.58[b]	1.21[d]	1.75[a]	1.39[c]	D***, S***
Haematocrit (%)	21.3[c]	18.53[d]	27[b]	19.9[d]	31.57[a]	20.8[c]	D***, S***
Immunoglobulin (IgM, g/L)	0.09[c]	0.033[d]	0.212[b]	0.113[c]	0.32[a]	0.198[b]	D***, S***

[1] From the analysis of variance, taking into account the effect of the diet (D) and the effect of the supplementation (S). †P < 0.2; *P≤0.05; **P≤0.01; ***P≤0.001.
[a, b] On a same line, different letters indicate a significant difference.

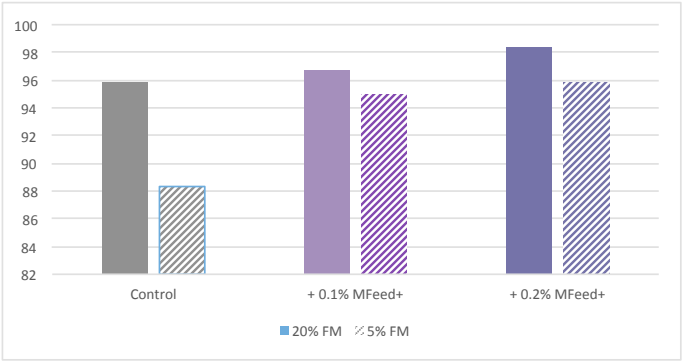


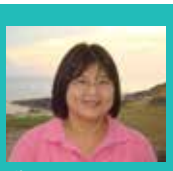
Figure 5. Effects of MFeed+ on survival rate in all treatments

Conclusion

MFeed+ improved in a dose dependent manner the growth performance of tilapia. The 5% fishmeal treatment diet supplemented with 0.2% MFeed+ resulted in a better growth performance than the control standard diet with 20% fishmeal inclusion, thus complimenting the 15% replacement of fishmeal with sustainable ingredients. This trial showed that supplementation with the feed additive gave improvements in growth parameters even when feeds used have a lower fishmeal inclusion. In addition, its supplementation boosted digestibility, thus increasing availability of nutrients and enhancing the overall animal health and well-being.

Maarten Jay van Schoonhoven

Marie Gallissot



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Application of mannan oligosaccharides in fish meal and fish oil free diets

By Keith Filer

The negative impact of soybean meal and soybean oil as replacements require the use of a mannan oligosaccharide prebiotic to maintain tissue structure and gut health for fish performance and disease resistance.

Aquaculture feed production was an estimated 35.5 million tonnes in 2015 and has increased 19% over the past five years. The 2015 production is a 5% decline from 2014, but the increase from 20.5 million tonnes in 2010 to 35.5 million tonnes is a clear indication that long term aquaculture feed production is on an upward trend. In addition to feed production growth is the increased consumption of fish meal and fish oil. Aquaculture feed is estimated to consume 60 to 70% of fish meal production and 80 to 90% of fish oil production. Fish meal production has levelled off between 6 and 7 million tonnes per year with fish oil production at about 1.0 million tonnes per year. Over the previous 20 years, prices have increased over 150%.

With feed costs accounting for 50 to 80% of total production costs and costs of fish meal rising, research is focused on fish meal and fish oil alternatives. Research into alternative raw materials has been very successful in driving down the use of fish meal and fish oil. The fish-in to fish-out ratio has dropped from 3-4:1 to about 1.5:1 for major aquaculture species. Fish meal and fish oil will continue to be important components in many fish diets, but alternatives are reducing the requirements.

Soybean meal and oil as replacements

Soybean meal has been used as a fish meal replacement in a variety of species. The largest source of protein and the second largest source of oil for animal production are derived from soybeans,

Gut villi comparison of control diet (left) and diet containing mannan oligosaccharide prebiotic (right).

whose global production has created interest as alternatives for the aquaculture feed industry. A variety of products from soybeans have been developed and utilised. Soybeans have crude protein levels from 38% to 49%, with concentrated products reaching 72% protein. Soybean oil has been used most successfully in the grow-out phase of aquaculture production.

Most studies indicate that soybean oil can replace fish oil without changes in growth performance. However, a major impact on fatty acid profiles in the fillet of the fish does occur. Soybean oil is deficient in long-chain polyunsaturated fatty acids (LC-PUFAs) and high in 18 carbon omega-6 fatty acids with a limited concentration of 18 carbon omega-3 fatty acids. Freshwater fish have the ability to synthesise essential fatty acids from the 18 carbon precursors but marine fish are limited in this ability. The result can be an imbalance of omega-3 to omega-6 in the diets of some species when high levels of soybean oil are utilised in diets.

The omega-3 to omega-6 imbalance not only impact the fatty acid profile in the fillet but also change the fatty composition of cell membranes, changing cell function by modifying membrane-bound enzymes and the activities of receptors (Torrecillas, et al., 2015). The addition of soybean oil has also been associated with changes in immune cell populations, modified leukocyte killing capacity, alterations in humoral response and variation in eciosanoids production. Soybean oil also causes intestinal morphology changes and variations in microbiota profiles.

Changes in the gastrointestinal tract was also noted in species when soybean meal is used to replace fish meal. These changes include inflammation in the intestine, morphology changes in the villi, increased presence of inflammatory cells, increased vulnerability to bacterial infections and reduction of nutrient uptake.

Nutritional considerations with soybean meal and oil replacements

Several nutritional strategies to overcome the negative impact of soybean meal and soybean oil have been evaluated. The use of a mannan oligosaccharide prebiotic (such as Bio-Mos®) has been shown to maintain tissue structure and promote the innate immune system. Mannan oligosaccharides have been shown to affect gut health by pathogen adsorption and the modulation of humoral and cellular immune function as well as promote fish performance and disease resistance.

Mannan and other oligosaccharide products are used as prebiotics to beneficially affect the host by stimulating the growth or activity of beneficial microbial populations in the intestinal tract. Pathogenic bacteria are known to have binding receptors that are used to adhere to the intestinal cell wall. The same receptors bind sugars such as mannose. The utilisation of mannose to inhibit pathogen binding has become common practice in poultry production and is an alternative to the utilisation of antibiotics. The utilisation of mannose has also shown to be an immune modulator, activating the innate immune system.

This nutritional approach to improve performance has been demonstrated in a variety of terrestrial animals and more recently, the approach has been investigated in aquaculture species. Improving growth response is important for any nutritional manipulation of a diet and the same is true when utilising a mannan oligosaccharide prebiotic in aquaculture diets. The inclusion of this technology in common carp, rainbow trout, tra catfish, sea bass, sea bream, sturgeon, black tiger and Pacific white shrimp has been shown to improve growth.

Gut health

A mannan oligosaccharide prebiotic has also been shown to have an impact on gut morphology in rainbow trout, salmon, sole and sea bream. Longer villi and a larger surface area have been shown in salmon fed Bio-Mos (Sweetman et al, 2010). Increased microvilli density has been shown in rainbow trout, salmon, sole and red seabream, providing clear indications that gut morphology is impacted with the addition of this prebiotic to diets.

More recent work has focused on the inclusion of a mannan oligosaccharide prebiotic in high plant protein diets and diets where fish oil is replaced with soybean oil. The use of high levels of soybean meal in salmon diets results in histological and functional changes to the intestinal tract. Reports of inflammation, reduced absorption and shortening of villi occur in high plant protein diets. Such observations have also been seen in sea bream and carp. The addition of a prebiotic increased the absorptive surface by producing longer mucosal folds and the microvilli density was increased in the anterior and posterior gut regions (Dimitrogiou, 2011). These results indicate this technology can reduce the morphological impact of high plant protein diets.

Replacing fish oil with soybean oil can have similar inflammatory and histological changes in marine fish. The use of soybean oil in European sea bass creates inflammatory responses, shortens intestinal folds and lowers mucous cell density compared to fish that are fed fish oil. A recent study in European sea bass assessed the effects of Bio-Mos supplementation in soybean oil and fish oil-based diets. The study focused on gut health in relationship to gut morphology and functionality (Torrecillas et al, 2015). The dietary inclusion of this additive significantly increased specific

growth rate (SGR) while complete replacement of fish oil with soybean oil showed a tendency to reduce SGR. The SGR of fish fed soybean oil and Bio-Mos was similar to that of fish fed fish oil. The addition of this additive to diets created more tightly packed mucous cells increasing mucous cell area and compensating for the down regulation of genes related to the function of the mucous barrier.

Feed assimilation and digestibility

A number of factors influence the growth capacity of fish including nutrient digestion and feed conversion efficiency. Digestion of raw materials in feed includes the enzymatic conversion of macromolecules into smaller molecules that can be absorbed. The increased growth with the inclusion of Bio-Mos in diets has been related to improved assimilation or digestion of nutrients in the feed or to changes in the levels of proteins that regulate satiation (Toreccillas et al, 2014).

Disease resistance

Disease problems can have a major impact on commercial aquaculture production. The inclusion of a prebiotic in diets has been shown to improve response to a number of different pathogenic bacteria and parasites. Reduced mortality in rainbow trout when challenged with *Vibrio anguillarum* (Rodrigues-Estrada et al, 2008) and in Nile tilapia challenged with *Streptococcus agalactiae* (Samrongpan et al, 2008) was observed with the addition of Bio-Mos in feeds. Reduced incidences of parasites have been observed in yellowtail and salmon with the inclusion of this additive in diets.

Adsorption of pathogens by mannan sugars is one mechanism to prevent colonisation and increased mucus secretion is also an effective defense mechanism. The mucus layer is a defense barrier between the intestinal surface and the intestinal luminal content. The inclusion of Bio-Mos in diets has been shown to increase skin mucous secretion in salmon (Sweetman et al, 2010) and rainbow trout (Rodriques-Estrada, 2008). Increased goblet cell density occurred in European sea bass when fed this technology.

Conclusion

Mannan oligosaccharide prebiotics can provide benefits when utilised in the diets of commercially important aquaculture species. The inclusion of this additive improves growth, enhances disease resistance and stimulates the immune system. Newer research has demonstrated that Bio-Mos can reduce the impact of replacing fish meal and fish oil in aquaculture diets. The reduction of these materials is important for the continued expansion of aquaculture, and simple nutritional tools that allow replacement to occur are important.

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2016 Global Feed Survey

Trends reveal a 14% increase in global feed tonnage over last five years and a questionable decline in aqua feed production last year

In January, Alltech released the results of its 2016 Global Feed Survey, an annual survey carried out by its sales team. Aidan Connolly, chief innovation officer of Alltech, responsible for this initiative, discussed the survey results during a webinar. "Alltech estimates that international feed tonnage stands now at 995.5 million tonnes, a 2% increase over that reported in the 2015 survey and a 14% increase since Alltech first published Global Feed Survey results in 2011. However it still has not reached the one billion tonnes mark," said Connolly.

The Global Feed Survey assesses the compound feed production from more than 131 countries. It is based on information collected by Alltech's 600 sales representatives, visiting more than 32,341 feed mills annually, as well as from feed industry associations. The 2016 survey was conducted in December 2015.

"With five years of work behind it, this is the most robust and reliable dataset on the sector available today. Compound feed production is defined in different ways in each country but we have ensured that it is factory produced feed and not farm made feeds and does not include forages."

On why Alltech carries out this survey, Connolly explained, "The Global Feed Survey outlines Alltech's estimate of the world's feed tonnage and trends and is intended to serve as open information resource for policy and decision makers and industry insiders alike.

"Having met with groups such as the United Nations Food & Agriculture Organisation (FAO) in Rome and the International Feed Industry Federation (IFIF), Alltech appreciates not only how difficult it is to collect and collate this data, but also how valuable the data is in our journey to feed a planet with more than 9 billion people by 2050," added Connolly.

The analysis of five-year trends showed growth predominantly from the pig, poultry and aqua feed sectors and intensification of production in the African, Middle Eastern, Latin American and European regions. The compound growth was just over 2% a year based on 5-year data. The 2016 survey showed poultry feed has the market share and is growing faster than any other species, with 46% of total global feed manufactured. This year's survey also confirmed that corn and soybean meal are the standard feed ingredients globally.

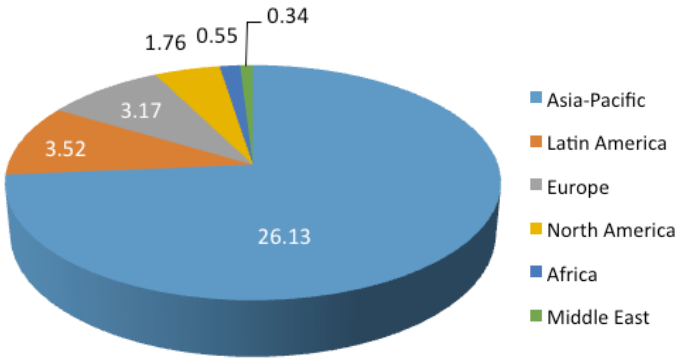
Top ten in Asia

The top 10 feed producers in the world remained the same: China, the United States, Brazil, India, Mexico, Spain, Russia, Germany, Japan and France. As a region, Europe saw the most growth, up 10.3 million tonnes over last year. Although down 2% from production in 2014, China still holds the title of leading feed producer in Alltech's annual Global Feed Survey with 179.93 million tonnes manufactured throughout the country's 8,550 feed mills. However, this is the third year that China has reported a consolidation of its feed tonnage production into a smaller number of feed mills.

According to Connolly, the consolidation of feed production into fewer mills is driven by many factors. "The Chinese, in particular, see a benefit of having fewer feed mills—lower cost, more efficient and easier to control from the perspective of food and feed safety."

Aqua feed production

"Aqua feeds with 35.47 million tonnes, is down 5% this year versus 2014; although outside of China this figure seems to relate to more accurate data collection and not a specific decline, especially given that aqua has been growing with an overall 19% in the past five years. The highest tonnage was from feed mills in the Asia Pacific, supplying 74% of the world's market. Latin America was a distant second with just 3.5 million tonnes (10%). "



Aqua feed production in million tonnes by region

Aqua feed production in Asia

Country	million tonnes
China	17.300
Vietnam	2.780
Indonesia	1.230
India	1.160
Thailand	0.920
Bangladesh	0.730
Taiwan	0.450
Philippines	0.395
Myanmar	0.390
Japan	0.300
Korea	0.200
Malaysia	0.130
Australia	0.120
Sri Lanka	0.010
Nepal	0.010

Connolly added, "This decline in aqua feed consumption is not consistent when we see more and more people eating seafood. China leads with 17.30 million tonnes which is much less than the 20 million tonnes recorded for 2014. We think that the declines may reflect more efficient fish farms, more accurate data collection or just an overall decline in consumption with a drop in Chinese banquets."

Resources:
A summary of the 2016 Alltech Global Feed Survey findings, including a recording of the webinar with Aidan Connolly, a booklet of the results and an interactive map, is available at: http://stories.alltech.com/global-feed-survey-2016.html.

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Efficacy of dietary organic acids as an alternative to antibiotics in tilapia farming

By Wing-Keong Ng, Chik-Boon Koh, Nicholas Romano and Siti-Zahrah Abdullah

The increasing intensification of tilapia farming has caused this hardy fish to be susceptible to various bacterial infections with significant economic losses.

The scalability and sustainability of global tilapia farming is limited by our ability to control and manage the spread of infectious diseases. Of particular concern to tilapia aquaculture are bacterial diseases caused by the *Streptococcal* groups, such as *Streptococcus agalactiae* which can cause widespread mortalities, particularly in warm water cage culture and intensive culture systems. Antibiotics such as oxytetracyline (OTC) are commonly used as treatment and/or prophylactic against these bacterial diseases. It is well documented that the overuse and misuse of antibiotics can lead to adverse consequences such as the development of antibiotic resistant bacteria that may be harmful to the host animal, the environment and consumers.

Due to these concerns, the European Union has banned the use of dietary antibiotics in animal feeds as a prophylactic in 2006 and many other countries are passing similar legislations. As the global trend in antibiotic use becomes more restricted and unpopular in the aquaculture industry, driven mainly by consumers' demand for seafood safety and traceability, it will become increasingly crucial to identify suitable antimicrobials and growth promoting alternatives.

Organic acids and their salts

The development of effective non-antibiotic compounds as an alternative to the prophylactic use of antibiotics to control infectious diseases and enhance growth performance is paramount for the continued expansion of the global aquaculture industry. Short-chain organic acids (C1-C7) and their salts or mixtures, commonly known as acidifiers, are promising alternatives for antibiotic growth promoters (AGP). Organic acids, such as benzoic, formic, lactic and propionic acids have traditionally been used as storage preservatives in food and feed ingredients for preventing product deterioration caused by fungi and microbes.

Some organic acids have been shown to have strong antibacterial effects against important food-borne pathogens such as *Escherichia coli* and *Salmonella spp.* and are currently employed in terrestrial livestock feeds to control bacterial

pathogens. Poultry and swine fed organic acid-supplemented diets have consistently been reported to show improved feed intake, growth, feed utilisation efficiency and health. Although the use of dietary organic acids and their salts have been extensively studied in various terrestrial animals, the research on aquatic animals has only intensified in the last 10 years.

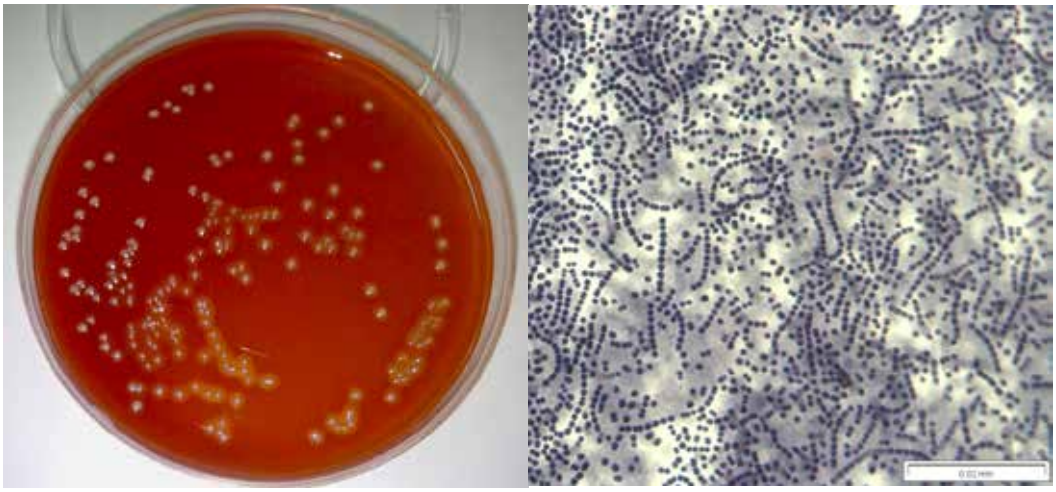
Research and commercial interest in the use of organic acids in aquafeeds is expected to significantly increase in the coming years due to changing global regulatory controls on the use of antibiotics. We recently conducted a study to compare the effects of a prototype dietary organic acids blend (OAB) and OTC supplementations on the growth performance, feeding efficiency, nutrient digestibility, mineral availability, gastrointestinal pH, total viable bacterial counts within the gut and faeces of red hybrid tilapia, *Oreochromis sp*., as well as their resistance to a *S. agalactiae* challenge.

Tilapia feeding trial

Four isonitrogenous and isolipidic practical diets were formulated to meet all the nutrient requirements for the tilapia. Chromic oxide was added to the experimental diets as an indigestible marker to measure nutrient and mineral digestibility. The experimental diets were designated as 0.5% OTC (oxytetracycline dihydrate), 0.5% OAB, 1.0% OAB and a control diet (no added antibiotics or organic acids). The proprietary OAB (Universiti Sains Malaysia) consisted of five organic acids (formic acid, lactic acid, malic acid, tartaric acid and citric acid; 75% w/w) adsorbed onto a silicon dioxide-based inert carrier (25% w/w). The 0.5% OTC or 0.5% OAB diets were incorporated with 5 g/kg OTC or OAB, respectively, while the 1.0% OAB diet had 10 g/kg of OAB. The 0.5% OTC diet was used as a positive control to investigate the prophylactic use of OTC both as an antibiotic growth promoter (AGP) as well as an antimicrobial for tilapia when administered on a long term basis.

A total of 20 red hybrid tilapia *Oreochromis sp.* fingerlings (initial mean weight, 9.45 ± 0.01 g) were randomly distributed into each of twelve 500 L round-shaped fiberglass tanks filled with filtered and de-chlorinated public utility water. Each rearing tank was connected to a flow-through water system. Tilapia were hand-fed to apparent satiation twice daily. Each experimental diet was fed to triplicate groups of fish. Each week all fish were batch-weighed to monitor growth performance. The feeding trial was conducted for 20 weeks.

After 6 weeks into the feeding trial, faeces of tilapia were carefully siphoned and collected with a fine mesh net. Only intact strands of fecal materials (less than 6 hours in water) were collected. The daily collected faecal samples from each tank were pooled, oven dried and finely ground prior to analysing their chemical composition and chromic oxide concentration. At the end of the 20 week feeding trial, all fish were individually weighed and measured for total length. A total of 12 fish per treatment were then randomly removed from each tank, killed, dissected and measured for their hematocrit percentage, organ-body indices and pH of the stomach and gut contents. Total cultivable bacterial counts in the gut were also measured and the results were expressed as CFU/g.



Colonies of Streptococcus agalactiae cultivated on blood agar exhibiting ß-hemolysis (left). Gram stain of S. agalactiae showing gram positive (purple) cocci that occurs singly, in pairs, and/ or short chains (right).

Disease challenge test

A total of 72 fish (18 fish per treatment) were used for the bacterial challenge tests. Tilapia from each dietary treatment were re-stocked into eight tanks and duplicate groups of fish were fed their respective experimental diet twice per day to apparent satiation for 1 week to acclimate the fish prior to bacterial challenge. Pathogenic *S. agalactiae* (strain no. TBK9B), isolated from the brain of an infected tilapia, was used. A volume of 100 mL of this pathogenic strain (1.4 x 10^9 CFU/mL) was used to challenge the experimental fish by bath immersion after the water volume of the tanks had been reduced to 50 L to yield an initial concentration of approximately 2.79 x 10^6 CFU/mL.

An hour after the bacterial challenge, the water volume in all aquariums was increased to 125 L, and over half of the aquarium water was changed once daily. Throughout this period, fish were fed their respective experimental diets to apparent satiation once a day and the challenge tests were conducted for 22 days. Inoculums from the brain, eyes and kidney were aseptically removed from all dead fish and streaked onto blood agar plates and incubated at 30 °C to confirm the presence of *S. agalactiae*.

Efficacy of dietary organic acids

Growth and survival

Tilapia fed the 0.5% OTC diet had significantly higher *(P < 0.05)* final weight and weight gain than those fed the control diet, but not significantly different from tilapia fed the OAB diets *(P > 0.05)*. No significant differences were detected for feed conversion ratio (FCR), protein utilisation efficiency, hematocrits or organ-body indices. Tilapia survival was high (95-100%) and was significantly higher (P = 0.003) for fish fed the 0.5% OTC or 1.0% OAB diet compared to the control diet. Therefore it can be concluded that given the right blend of dietary organic acids at the optimum level, organic acids can be almost as effective as OTC in promoting growth and survival of tilapia without the harmful side effects of antibiotic use.

Diet pH

Supplementation of the experimental diets with 0.5% or 1.0% OAB lowered the diet pH from 5.88 to 5.64 and 5.40, respectively. OTC supplementation did not affect diet pH. While the pH of the stomach contents was not significantly affected by the diets, the pH of the gut contents of tilapia fed either the 0.5% or 1.0% OAB diet was significantly lower compared to those fed the 0.5% OTC or the control diet. Increasing dietary OAB inclusion from 0.5 to 1.0% further lowered the pH of the gut contents.

Tilapia fed the 1.0% OAB diet had significantly enhanced phosphorus, dry matter and ash digestibility compared to fish fed the control diet. Similar improvements in nutrient digestibilities were also observed in the OTC supplemented diet. Both antibiotics and organic acids can improve nutrient digestibilities by reducing microbial competition with the host animal for nutrients and/or reducing the production of growth-depressing microbial metabolites. Unlike antibiotics, the mechanism of action for improved nutrient utilisation with the use of organic acids extends beyond reduction or modification of the gut microbiota.

In the present study, a significant decrease in the pH of the gut digesta of fish fed the OAB diets compared to the control or OTC diet was observed. Potential benefits of acidification may include enhancement of pepsin activation and other digestive enzyme activities as well as improving the solubility of minerals in the digesta. Organic acids may also act as chelating agents binding up cations along the gut resulting in improved mineral absorption.

Bacterial count in faeces

Dietary supplementation of OAB significantly decreased the total viable bacterial count in the faeces of tilapia compared to the control. The highest total CFU/g of faeces was detected from fish fed the control diet which was significantly higher than the bacterial count in faeces collected from fish fed either the 0.5% or 1.0% OAB diets. The viable bacterial count in the faeces of tilapia fed the 0.5% OTC diet was not significantly different than all other treatments. After 20 weeks, fish fed either 0.5% or 1.0% OAB diet had a significantly lower total viable bacteria in the gut compared with the fish fed either the 0.5% OTC or control diet. Fish fed the 1.0% OAB diet had the lowest bacterial population (1.03 x 10^4 CFU/g), which was 68.5% lower than that of fish fed the control diet (3.27 x 10^4 CFU/g).

> **“By using an optimised blend of organic acids and supplementing at an optimal dietary level, the present study showed that organic acids have great potential in replacing the use of antibiotics.”**

After the 22-day *S. agalactiae* challenge, tilapia fed the 0.5% or 1.0% OAB diet had significantly less adherent gut bacterial population than those fed the control diet. Meanwhile, tilapia

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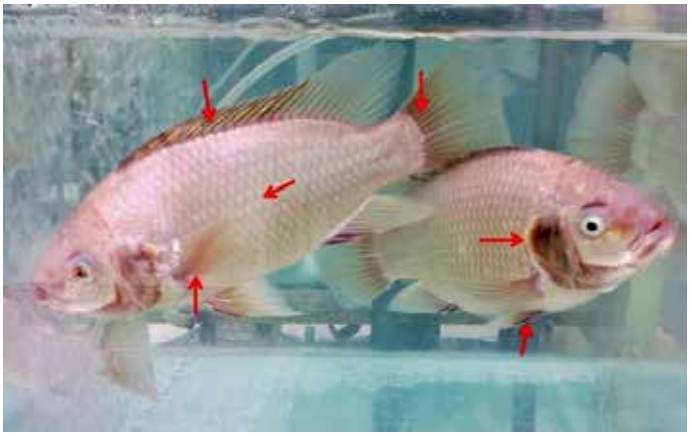


Red hybrid tilapia fed diet supplemented with 0.5% oxytetracycline after 20 weeks. Arrows indicate the distinct yellowish/ brownish pigmentation on the scales, fin rays and operculum.

Vertebral column of red hybrid tilapia fed diets supplemented without (A) and with (B) oxytetracycline (OTC) after 20 weeks. Note the darker yellowish colouration of the vertebral column in fish fed OTC supplemented diet.

fed the 1.0% OAB diet had significantly lower gut bacterial populations than those fed the 0.5% OTC diet. This result is highly significant as it highlights the promise of organic acids as a means to prevent colonisation of the fish gut by pathogenic bacteria that may be detrimental to fish health.

Protection from Streptococcal infections

During the 22-day disease challenge period, infected tilapia were observed to develop overt clinical signs of *S. agalactiae* infection such as erratic swimming, unilateral or bilateral exophthalmia, corneal opacity, lethargy, loss of appetite, and hemorrhages particularly around the eyes, operculum, base of the fins and the edge of the tail fin. Inoculums taken from the brain, eyes and kidney tissues of dead fish were cultured positive for ß-hemolytic *Streptococcus* thereby confirming the cause of death. No streptococcal bacteria were isolated from the tissues of healthy surviving fish at the end of the disease challenge trial. The total number of surviving tilapia fed the control diet was significantly lower than those fed the 0.5% OAB or 0.5% OTC diet, which had the same number of surviving fish after 22 days of exposure to *S. agalactiae* e. For tilapia fed the 1.0% OAB diet, no significant differences were detected when compared among all the dietary treatments. At the right dosage, dietary organic acids are shown to be just as effective as OTC in protecting tilapia from Streptococcal bacterial infections.

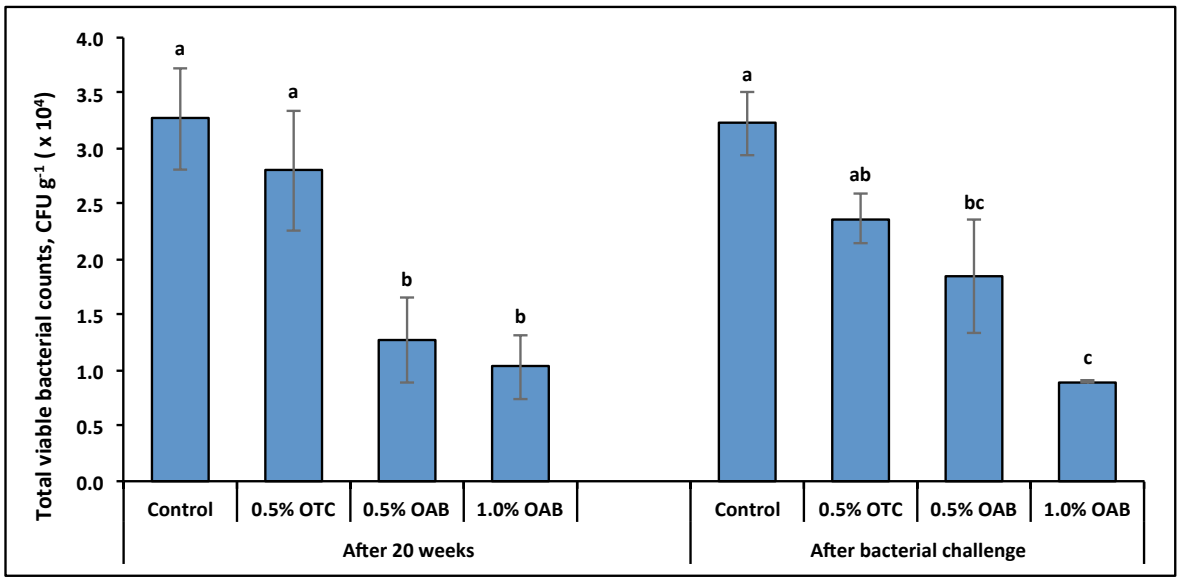
Antibiotic residues

In the present study, antibiotic residue was detected in all the tested tissue/organs of fish fed the 0.5% OTC diet with the lowest concentrations found in the muscle while the highest were detected in the vertebral column. The vertebral column (backbone) of tilapia contained significantly higher OTC concentration (33.17 mg/kg) than all other tissues. The OTC concentration of 0.38 mg/kg detected in the muscle of tilapia in the present study exceeded the maximum residue limit (MRL) set by the World Health Organization, which recommended a MRL of 0.2 mg/kg for fish muscle.

OTC residues were not detected in any of the tissues of fish fed the control or OAB diets. Visual examination showed that tilapia fed the OTC diet had an obvious fluorescent yellow pigmentation of the scales, fin rays and operculum, which increased over time, as well as darkened blotches around the operculum. This was not unexpected as tetracycline products has the ability to chelate calcium ions and be incorporated into tissues that are calcifying as was the case of the developing tilapia in the present study. Such unwanted pigmentation will affect marketability of farmed tilapia, especially when sold live, fresh or chilled.

Concluding remarks

Streptococcal bacterial diseases are a major problem in intensive fish farming systems incurring high economic losses for farmers. In the present study, all treated diets resulted in an improvement



Total viable bacterial count (CFU/g) in gut of red hybrid tilapia after 20 weeks of being fed the experimental diets and after being challenged with S. agalactiae. Different letters indicate statistically significant difference (P<0.05), (from Koh et al., 2016).

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to the resistance of tilapia to *S. agalactiae*, with the 0.5 % OAB and 0.5 % OTC treatments conferring similar protection that was significantly higher than the control treatment. Increasing the dietary OAB to 10 g/kg did not significantly improve survival of fish. Interestingly, fish fed the OAB diets had significantly less faecal and gut bacteria counts than those fed the OTC diet.

The positive benefits of dietary organic acids observed in the present study could be due in part to the fact that a combination of different organic acids was used. Each organic acid has its own spectrum of antibacterial activity and it is generally known that one type of organic acid is not completely effective against all disease causing micro-organisms. Combinations of organic acids are typically believed to be more effective against pathogenic bacteria compared to a single acid, and can have synergistic effects.

We were able to maximise the antimicrobial effect of the OAB used in the present study by combining different organic acids based on our data from various initial in vitro studies on their antimicrobial efficacy against various fish pathogens. In the present study, the beneficial impact of dietary organic acids equaled or surpassed that of OTC, both as an antimicrobial and in its ability to improve nutrient utilisation and growth performance of tilapia. This is particularly promising considering the current trend of increasing emphasis on food safety and traceability in aquaculture production leading to the reduction or banning of antibiotic use. The significant reduction in fecal bacterial counts as well as an improvement in dietary P utilisation for tilapia fed the OAB diets may impart additional benefits by mitigating their excessive discharge to the environment. Organic acids have the potential to become a useful feed additive in tilapia feeds to improve fish health and productivity in an environmentally friendly way.

This article was based on a recent publication by the authors and has been summarised with added illustrations. Koh, Romano, Siti Zahrah and Ng (2016). Effects of a dietary organic acids blend and oxytetracycline on the growth, nutrient utilization and total cultivable gut microbiota of the red hybrid tilapia, *Oreochromis sp.,* and resistance to *Streptococcus agalactiae,* Aquaculture Research, Vol 47, pp 357- 369.


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Shrimp nursery technology: System design and management for cost-effective results Part 1. Design considerations

By Craig Browdy, Peter Van Wyk, Chris Stock, Thomas R. Zeigler and Ramir Lee

Properly designed shrimp nursery systems are high-biosecurity facilities to grow post larvae at high and hyper intensive densities, from 2 mg to as large as 3 g. The aim is to produce healthy, strong and uniform juveniles with significant potential for compensatory growth after their transfer for final grow out. In this two-part article, we will first discuss basic design considerations. Part 2 will discuss water quality, feeds and feed management for these nursery systems.

Hyper intensive nursery systems for juvenile shrimp production have been around for decades, with varying popularity. In recent years they have gained recognition as a valuable tool for the shrimp farming industry to increase efficiency and profits, and in some cases to help exclude (particularly with early mortality syndrome/acute hepatopancreatic necrosis disease (EMS/AHPND) and EHP caused by the microsporidian *Enterocytozoon hepatopenaei* as well as manage other diseases.

System design and management help to facilitate a consistent, low-risk "factory model" defined by foreseeable production inputs and stable, predictable, operating results. Currently, there is limited information available on standard design and management of shrimp nursery systems, and there is much variability among systems in use.

Many shrimp farmers in Latin America are using nurseries as part of their production strategy, particularly larger, integrated companies. The systems are somewhat less widely used in Asia, but are fast gaining popularity and becoming a trend. In general, nurseries typically involve lined tanks/ponds covered by plastic greenhouses or roofs suspended by cables, with an area of 300-7,500 m^2. They can be rectangular (with continuous, rotating water current around a central baffle), square or round (typically with circular flow around a central drain). Stocking densities range from 500 to 10,000 or more post larvae (PL)/m^3, with harvest sizes of 0.3-3 g and harvest biomass of 1-3 kg/m^3.

> **“System design and management has also improved to facilitate a consistent, low-risk “factory model” defined by foreseeable production inputs and stable, predictable, operating results..”**

Views of representative shrimp nurseries, clockwise from top left, Ecuador Mexico, Honduras and China

Advantages of nursery systems

In general, nursery systems permit better and more precise management and manipulation of the young shrimp within practical and advantageous economic boundaries, which may not be economically practical in larger pond systems. Specifically these systems have the following benefits:

Control and biosecurity

By reducing the culture area and volume into a series of intensively-stocked tanks, a higher degree of control is possible over environmental conditions, water quality and feeding, resulting in greater economic efficiency. Managing smaller unit areas/volumes improve the exclusion of pathogens and predators. Similarly, greater accuracy is possible in estimating the juvenile populations and providing important advantages in managing feed during the grow out phase.

A two or three stage production system using a one or two-phase nursery provides the opportunity to increase biosecurity in the quarantined nursery areas. Consequently, this usually produces higher overall survival rates and production per unit area than in single-phase grow out systems.

Efficiency

Well managed nursery systems provide for faster growth (with some density dependency) and production of bigger and stronger juveniles with better survival and a high potential for compensatory growth. Stocking juveniles from nursery systems rather than direct stocking of post larvae, increases the number of grow out production cycles (turnovers) by reducing culture time to market size in the grow out ponds. This in turn, can increase the number of crops per year allowing the final grow out ponds to be used more efficiently and significantly improving the farm’s bottom line.

Improved health and disease management

Larger, older shrimp will have a more developed immune system. As a management strategy for early mortality syndrome/acute hepatopancreatic necrosis syndrome (EMS/AHPND), a nursery phase permits the stocking of large juveniles, with better resistance to the disease. The small confinement provides for significant control of water quality, disease exclusion and proper feeding. In addition, as a management strategy for white spot syndrome virus (WSSV), animals in nurseries can be maintained in water temperatures above 30°C during seasonal periods when temperatures in outdoor ponds are lower, making the animals more susceptible to this disease.

In a properly managed nursery, disease control and diagnostic measures can be implemented allowing the farmer to detect infected animals in the nursery before they are transferred to the final outdoor grow out ponds. This enables the option of terminating the crop at an earlier stage and restarting, thus reducing the financial impact. This is particularly important with the most recent and devastating shrimp diseases, EMS/AHPND, and EHP which can be caught early through available and improving histopathology and molecular diagnostic techniques.

> **“Nursery systems offer the shrimp industry an important opportunity to increase profits..”**

Early stocking

Enclosed intensive nursery systems can further broaden the effective stocking windows for seasonal hatchery outputs. This allows greater efficiency for both the hatchery and the farm. For farms not integrated with hatcheries, intensive nursery head-start strategies may allow the purchase of seedstock in advance of the peak demand periods, at lower cost and with greater probability and certainty of seedstock delivery. Additionally, for shrimp farms in areas of lower salinities, the nursery can be used as an acclimation system.

Shrimp from nurseries are stronger, grow faster and typically have better survival and FCR, and high potential for compensatory growth

Disadvantages

Nursery systems have a few disadvantages. These include greater infrastructure investments (higher construction costs than conventional pond systems) higher operational costs, and increased labour requirements as such systems require trained biologists (often to the level of hatchery operators). Prevention of component/equipment failures is critical. With increasing stocking density and lower water exchange, one important risk is higher organic loading leading to poorer water quality and animal health. Increased stress to animals due to more handling and transferring, can increase susceptibility to diseases. For these reasons, proper management by properly trained personnel of the nursery system is a critical prerequisite for success.

Nursery configurations

The ideal location for a nursery system is in close proximity to or integrated within the grow out farm. Access to high quality water and appropriate infrastructures are critical. The water source

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should preferably come from the farm intake canal or before the pump station, to allow draining and dry-out of the main reservoir channel without affecting nursery operations. Water should drain into the farm discharge channel and away from the intake. To lower costs it is advisable to locate nurseries close to an existing main and emergency back-up power source. If possible, it should be near the farm main administration area close to offices, supplies and personnel. Ideally, construction location should be high enough for good drainage and no more than 5-10 minutes travel time to the farthest pond in the farm.

The size and shape of the nursery system and its tanks are very variable, and it can be a single-phase or a multiple-phase design.

Single phase nursery tanks

Single phase tanks are typically designed to produce 100, 200 or 300 mg juveniles. Tanks are typically from 40 to 200 m^3 and under greenhouse or shade cloth coverings. Four different tank shapes are typically used. Most of these tank systems are built out of concrete, wire mesh, wood, plastic, fiberglass or small reservoirs with formed (compacted) soil with a plastic liner (HDPE or EPDM of non-toxic liner material) or epoxy coating. Stocking densities range between 8 to 50 PL/L to produce harvest-size juveniles of 0.1-0.3 g and a final harvest biomass of 1-5 kg/m^3.

Round and rectangular tanks

Round tanks with centre drain have good water circulation for feed distribution and sludge removal (i.e self-cleaning). Many nurseries use round tanks made of fiberglass, concrete, or the most locally cost-efficient materials. However, there are physical size limits to circular systems, as round tanks larger than about 40 m in diameter lose some of their most desirable characteristics. As the diameter increases, more energy is spent maintaining flow velocities to scour and entrain solid waste, and the tanks tend to be less effective in delivering solid waste to their collection points.

Rectangular tanks are easy to build, are space-efficient under standard greenhouses, and hatchery technicians readily relate to their management. But they are less efficient in the removal of suspended solids and sludge, and in feed distribution. They can also be more expensive to build, operate and manage.

Round tanks are extensively used in these configurations where colder seasonal temperatures are not an issue. Pictures show round tanks used in Ecuador (right) and Brazil

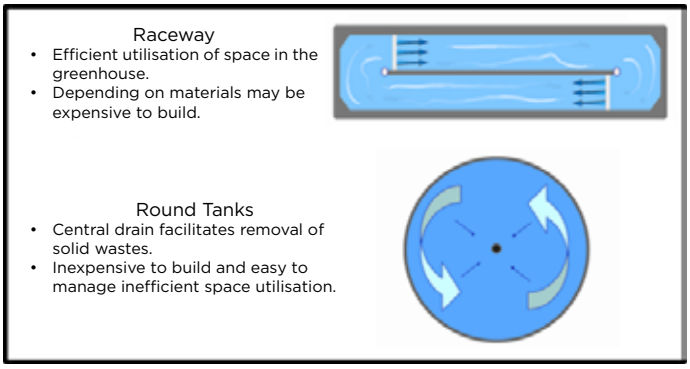
Oval Tanks

Oval raceway tanks have good water circulation for keeping solids in suspension; they fit well under greenhouses, and can be designed to readily remove wastes. However, they can be somewhat more difficult to build and manage than other designs. Regarding production, consistently high amounts of shrimp biomass have been achieved with these systems.

Oval or plug flow "raceways" are typically 33-66 m long by 5-9 m wide, and depths of 0.7- 1.2 m. While they fit nicely into commercial greenhouses and into the conventional freespan width of a closed building, they require more energy in generating the water flow necessary to deliver solid wastes to the designated removal points.

> **"In design, consider the factory model: well-defined inputs resulting in steady state operations with steady production."**

To maintain an organised flow, the oval raceway is usually divided down the middle by a centre wall. In oval (and rectangular) raceways there can be two drains and two points to pick up solid waste.



Rectangular tanks are easy to build, are space-efficient under standard greenhouses and familiarity of use by hatchery technicians.

Stacked raceways

Stacked, shallow (10-20 cm of water) rectangular raceway systems have been designed for super-high densities and space efficiency. These can maximise the biomass per m^2 footprint (up to 10X that of other systems), and are unmatched at efficiency to control temperature, feeding and personnel inputs. They are ideal for extreme environments where space and temperature

A new, 2-phase, shrimp nursery system currently under construction in Vietnam, with the technical support of Zeigler Bros. Inc. Credit: Ramir Lee.

are limitations. These systems are relatively new innovations with initial production results from some promising prototypes suggesting potential for very high production rates. As these systems are commercialised they will have the potential to become much more common, supporting hyper-intensive grow-out operations and inland shrimp farming in cold environments.

Second phase nursery tanks

These are very similar to the single phase systems but built at a larger scale. Stocking is usually of 0.1-0.3 g juveniles transferred from the first phase system. The reason for a second phase nursery at the farm level is related to stocking a greater number of larger juvenile shrimp into production ponds than is possible from just a single-phase system. In markets where seasonal production favours higher prices for early harvests, a two phase system is most advantageous. These systems are typically built in three, differently shaped, covered tanks or ponds (rounded centre drain, oval and rectangle), with an average volume ranging from 300 to 7,500 m^3.

Perspectives

Optimisation of the design and management of nursery systems has been the subject of a great deal of research. Large scale commercial implementation is growing. Nurseries have the potential to enable increasing biosecurity and better disease control which can help to increase stocking flexibility and reduce production costs.

The future holds great promise for expanding application of nursery systems globally. The most successful systems are those designed to take advantage of the lessons learnt from the growing numbers of commercial systems in operation today.

In part 2 we will address water quality, feeds and feeding, arguably the most important aspect of the management of nursery systems.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A genesis in Malaysia's marine fish industry

By Zuridah Merican

Seeing a niche for supply of quality grouper juveniles, made in Malaysia.

Hybrid giant x tiger grouper juveniles of 40g

With a passion for aquaculture, Steven WK Lee left his law profession 12 years ago to join this industry. After a partnership in a business using recirculation aquaculture technology (RAS) in the production of a high value freshwater fish, Lee decided to set up his own nursery with two business partners in Bukit Pelanduk, close to Port Dickson, Peninsula Malaysia. This time, it is in the production of grouper juveniles in an indoor nursery cum grow-out farm for on-growing in tanks and coastal cages as well as for sale in the open market.

Malaysia has an expanding marine fish industry, albeit much smaller in terms of volumes in comparison to that of Indonesia. The total production in 2014 was 45,155 tonnes (DOF, Malaysia). Seabass and groupers are the major species. Today, the industry in Peninsula Malaysia comprise mainly family based farms using floating cages or ponds but at the same time, there are 2-3 large industrial farms, integrated with hatchery and processing activities.

Made in Malaysia

"Generally, grow-out farmers depend on imported fry, mainly from Indonesia for the groupers and Thailand for seabass. Usually, there is a disassociation between farmer and hatchery once fry are sold. The hatchery is no longer responsible for any deformities or poor growth performance. On the other hand, we have given ourselves the mandate to supply farmers with quality juveniles for grow-out. As we also buy back the fish, it is our responsibility to ensure that that juveniles perform well in the farms without any deformities which we know our buyers and retailers will reject.

"A nursery business is very challenging for my team. However, I need to address the challenge to find the most efficient processes. Efficiency in costs is finding the best performance from the feeds available in the market and also staff productivity. I use only a small group of staff comprising 3 management and 10 technical, for a production of an average 50,000 juveniles per month.

"We focus mainly on two grouper hybrids currently in demand by farms in Malaysia. There are also species such as coral trout, barramundi cod and others where we have developed our know-how and experience. However, we do not focus on the Asian seabass *Lates calcarifer* which hatcheries in Thailand can easily produce at a much lower cost," said Lee.

Aqua Genesis has built a strong team to meet the challenge in developing the most effective protocols for an economic operation. Water pumped from a river, is filtered and treated prior to use. With his experience with RAS, Lee is using partial recirculation in this nursery.

A good start with quality juveniles

The main business of Aqua Genesis is in the production of juveniles of the giant x tiger grouper hybrid (*Epinephelus lanceolatus x E. fuscoguttatus*) and another hybrid tiger x batik or cantik grouper (*E. fuscoguttatus* x *E. microdon*). Today, these hybrids are popular species for culture in cages in Malaysia. The nursery imports one inch (2.4 cm) fry from an affiliate hatchery in Bali and grow these to 4-5 inch (>10 cm) juveniles, depending on demand. This takes 1.5 to 2 months. During this time, the maximum survival rate achievable is 80% but Lee is happy if their average survival rate is 70%. This is his benchmark. The pricing for these juveniles will fluctuate with popularity of the species in markets. Currently, prices are good at MYR 5 (USD 1.2) for each juvenile.

"The grow-out farmer then takes about a year for fish to reach market sizes of 1.2 kg fish. In sea cages, farmers face many challenges and one major issue is consistency of feed quality between batches. The main cost for the farmer is feed which have been increasing to MYR 5.6/kg (USD 1.35/kg). However, with ex-farm prices of say MYR 48/kg (USD 12/kg) for the hybrid giant x tiger grouper and feed conversion ratio of 1.7-1.8, profit margins are good. In tanks, the survival rate can be 80%. In floating cages, survival rate depends on species and water quality and can be as low as 30%. Furthermore, the cantik hybrid does not perform well in waters off Kukup in Johore state in the south but survival is high in cage farms in Langkawi in the north.

"In this nursery business, we have been testing out various brands of commercial feeds available in the market. During the

Nursery tanks. The current capacity at Aqua Genensis is an average 50,000 fingerlings per month

70 g cantik grouper juveniles

Steven Lee (right) with Dr Luís Conceição (middle) from Sparos, a R&D laboratory in Portugal.

early stages, we will use microencapsulated and starter feeds which provides the best performance in terms of growth and survival. We have been using a high-end Japanese brand which in our opinion fulfils our bench marking guidelines. In addition, shelf life and packing of the feeds is another criterion for us. Most of these early stage feeds are expensive and are sold on USD terms, both of which we have no control of. At the end of the day, it is our husbandry methodology determining the cost efficiency of the feeds.

"During the late starter stage, we need to prepare the juveniles for grow-out in cages or tanks. As farmers will be feeding juveniles with conventional starter feeds such as those from Cargill and CP, we then slowly wean juveniles onto a combination of these feeds. Our role is to provide farmers with strong juveniles to prepare for a successful grow-out cycle and to ensure that juveniles are healthy and free of any deformities," said Lee.

In 2016, Aqua Genesis will begin operations at a hatchery on the same site. "This presents another series of challenges which my team and I will be ready to address after learning the hurdles in nursery rearing. A concern in any industry depending on imported feeds and farming equipment, will be fluctuations in currency exchanges. As we have observed this year, with the economic slowdown, market prices have remain status quo despite a high demand of fish for the Chinese New Year. In our business, we will then need to look at being more cost efficient but not sacrificing on quality. "

Supporting Asian aquaculture: Part 2

The program for the 21st DSM aquaculture conference held in November 2015 in Bangkok, Thailand comprised a morning session covering aquaculture nutrition. AAP reported on the perspectives on early life nutrition in fish and shrimp, omega 3 long chain fatty acids requirements for fish and an overview of gut health in issue January/February 2016. Here in part 2 of the report, we focus on two presentations during the afternoon session on current issues in aquaculture.

Biosecurity: from the international scenario to the shrimp pond

As disease is a major threat to shrimp farming, veterinarian **Dr Victoria Alday-Sanz** and director of biosecurity at the National Aquaculture Group (NAQUA), Saudi Arabia, presented on the biosecurity tools required for a sustainable industry.

"Biosecurity are measures or activities taken to reduce the economic impact of diseases." At the farm level, Alday-Sanz focussed on the exclusion or pathogen management approaches and syndromic surveillance programs. However, there is a multilayer approach to biosecurity and it is important to understand that success at the farm level is dependent on the right strategy and implementation of biosecurity at each layer.

Capping international spread of diseases

At this level, there are four main biosecurity risks: ballast water, currents, trans-boundary movement of animal and effluents from terrestrial activities. The risk in disease transfer with ballast water movements is growing but fortunately, the shipping industry is currently looking at establishing water quality standards with water treatments.

"Health should not be considered a competitive advantage. We cannot control currents and their movements but countries can collaborate at regional levels, set up a warning system and establish agreements and regulations on trans-boundary movements of animals. With disease outbreaks such as with early mortality syndrome (EMS), governments should show lateral transparency. Sadly, we have national authorities not admitting to the presence of disease. For import restrictions, countries should look beyond OIE reported national health status where information is not updated or complete. In Asia, the Network of Aquaculture Centres in Asia Pacific (NACA) has listed acute hepatopancreatic necrosis disease (AHPND) since 2012 whereas OIE will list this disease only in 2016. Some countries have stopped reporting diseases to the OIE.

Victoria Alday-Sanz

"There should be regular reviews of the biosecurity plans and simulation exercise of the contingency plans."

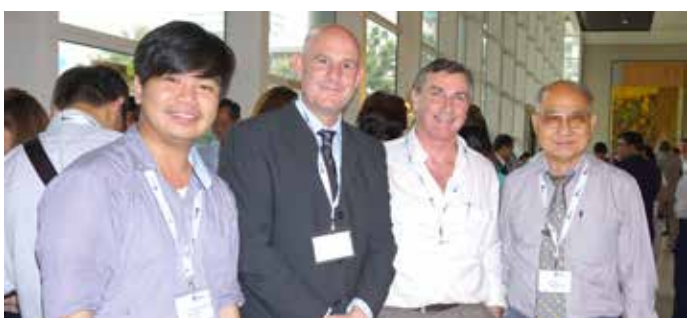
"Countries are allowed to take additional measures such as under the SPS (Sanitary and Phytosanitary Agreement of the World Trade Organisation) to protect national sanitary status. A country has the right to impose commercial barriers for sanitary reasons as long as they are scientifically justifiable."

Stakeholders' interdependence

The national biosecurity layer requires co-operation among government, private sector and academia. The government's duty is on effective legislations and their enforcement particularly on importation, also on zonation and effluent treatments of processing plants. The academia's role is in accruing knowledge for definition of effective biosecurity measures. The private sector's role is to focus on the use of specific pathogen free (SPF) broodstock, water treatment and farm design etc.

"In the control on the transfer of pathogens, such as through imports, governments need to enforce legislations and have a competent sanitary authority. Governments need to validate private sector quarantine facilities. Control at origin requires audits of supplier facilities and procedures and knowledge on the official and unofficial sanitary status of the country. Reliable national diagnostic laboratories and reference centres are required.

"Zonation requires active and specific biosecurity measures, national system of notifications and movement of animals. The tight management of zones is critical. In 2013, when EMS affected industry in the north of Mexico, the government closed the country to imports. The non-EMS affected southern farmers had no alternative but to get post larvae from infected north Mexico. A better solution would have been to declare the south as a different zone and allow them to import from non-affected neighbouring countries."



From right, Dr Jirasak Tangtrongpiros, Chulalongkorn University, Thailand, Dan Fegan and Andy Shinn, Fish Vet Group Asia. Jirasak authored a book, in the Thai language, on microsporidians and gregarines in shrimp farming.

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Alday-Sanz also pointed out the introduction of pathogen through frozen products. She listed viral and bacterial pathogens capable of surviving freezing temperatures. The message was to put in place measures to mitigate risks of pathogen transfers into the environment through treatment of processing water and wastes.

Exclusion or pathogen management

"Before we think of biosecurity, farms need good management with good environmental and culture conditions, good nutrition to give good immuno-responses and animals with suitable genetic characteristics (high growth, resistance or tolerance). Once we have lined up all these, then we can think of biosecurity at the farm," said Alday-Sanz.

"Setting up biosecurity measures is an investment and needs to be proportional to the potential economic loss generated from a disease catastrophe. Exclusion versus pathogen management approaches will depend on the economic impact of the diseases, the stage of culture and type of pathogens. Each disease will have its own level of economic impact. For example, the cost impact is high for WSSV but could be considered medium for EHP as it does not cause massive mortalities.

"In addition, there are diseases caused by the farm management. The veterinarian or aquatic animal health expert needs to have a good understanding of the production process to be able to determine the origin of disease and then propose a solution to it."

Table 1 shows transmission of main shrimp pathogens and suggests mitigation measures. In an exclusion strategy, the first thing is to avoid stocking infected post larvae. This means using either specific pathogen free (SPF) post larvae, SPF fresh/live feeds and broodstock, and post larvae transported under strict biosecurity (water treatment and isolation via air and land).

SPF, SPT and SPR shrimp

Alday-Sanz said that it is important to note that, "SPF refers to the sanitary status and this status no longer holds once animals are exposed to potential pathogens. Once the SPF broodstock are kept in open ponds, the SPF status is lost. Once the broodstock is fed with fresh or live feeds, it is no longer SPF unless the fresh/live feeds are SPF as well. SPF also does not replace bad management. The SPF status is defined by the broodstock provider or the buyer and can be classified, for example as being free of all or some of the OIE listed pathogens, or as being free of diseases not mentioned in the OIE list. Thailand has listed only WSSV, TSV, IMNV, YHV and IHHNV.

Table 1. Transmission of main shrimp pathogens

Virus	Vertical Transmission	Economic Impact	Stage Impact	Production Impact	Strategy
WSSV	**Intraovum**	**High (highly prevalent)**	**Grow Out**	**Mortality**	**Exclusion**
TSV	Preovum	High (sporadic)	Grow Out	Mortality	Exclusion
YHV	Preovum	High (sporadic)	Grow Out	Mortality	Exclusion
IHHNV	Intraovum	Medium	Grow Out	Mortality	Exclusion
IMNV	Preovum	High (Localized)	Grow Out	Mortality	Exclusion
BP, MBV, HPV	Mouth Open	Low	All	Slow Growth	Exclusion
Bacteria					
EMS (AHPND)	**Mouth Open**	**High**	**Grow Out**	**Mortality**	**Management**
NHP	Mouth Open	Medium	Grow Out	Slow Growth	Exclusion
Streptococus	Preovum	High	Grow Out	Mortality	Exclusion
Vibriosis		High	All	Mortality/ Slow growth	Management
Parasites					
Fouling		Low	All		Management

Dr Chen Ming-Dang (left) and Suphol Phantumaophas (second right), Charoen Pokphand Foods (CPF), Thailand.

"We heard about animals in Latin America which are tolerant but not resistant to certain pathogens. Whilst Thailand used the exclusion of pathogens through the use of SPF shrimp during the WSSV outbreaks, in Ecuador, they opted to manage production in the presence of WSSV. Over time, the shrimp population acquired tolerance to WSSV and survival increased. These are called SPT and SPR. Tolerance and resistance are genetic characteristics regardless of their sanitary status (SPF or infected). So a broodstock can be SPF+SPR/SPT or infected+SPR/SPT. In Latin America, producers do not believe in SPF as little biosecurity can be implemented in the ponds and the trials done with SPF post larvae had led to failures. However, in Asia, intensive farming requires fast growth and the best performing animals belong to SPF programs."

Further to this, Alday-Sanz explained the development of SPF from WSSV tolerant shrimp (SPT) at the Pescanova farm in Ecuador. This starts with surveillance around the country, collection of more than 30 g broodstock, testing for pathogens and post larvae challenge tests. With zero tolerance for WSSV, infected shrimp were thrown away. Screening was conducted for 3 years but 2 years of disease free screening qualifies shrimp stock as SPF according to OIE and EU legislations.

"Did this bring about improvements? Yes, we tested that larvae from SPF tolerant shrimp reached PL12 faster with higher survival, good condition of hepatopancreas etc. In addition, broodstock maturation rate was good. At the pond level, with WSSV outbreaks, SPF tolerant shrimp showed higher survival at 70% as compared to SPF (US imported) shrimp. However, this SPF tolerant shrimp does not replace good management and both still need to be together. SPF shrimp are now being used in NAQUA to revive production which went down to 600 tonnes when *Penaeus indicus stocks* were infected with WSSV. The use of SPF vannamei stocks revived production to 12,900 tonnes in 2014. This SPF tolerant shrimp are expected to raise production to 29,000 tonnes/year."

Syndromic surveillance

An important source of health information is productivity data such as growth rate, feed conversion efficiency and product quality. Early availability and follow-up of this data allow for the identification of health problems and their built up. "This is done through syndromic surveillance which will alert the farmer in case of deviation from the expected productivity and allow investigations into the causes of the health problems."

Finally Alday-Sanz said, "A biosecurity plan is only as successful as its implementation and depends on the shared responsibility of the staff. Once the biosecurity is in place, it is not over. There should be a regular review of the biosecurity plans and simulation exercise of the contingency plans."

EU retailer and consumer concerns

Jon Ratcliff

> **“Among retailers, there is a preference for farmed seafood because of supply and continuity, control on quality, freshness and taste but consumers have their own perceptions.”**

In this conference, **Jon Ratcliff** from F.A.C.S Ltd, which provides auditing and certification services for companies exporting to European retailers, presented on 'EU food and feed safety standards: retailer and consumer concerns'. The aqua feed industry has a special role in addressing retailer's concerns about farmed seafood for the European Union (EU). Ratcliff discussed its role with regards to sustainability challenges such as the use of fish meal, and fish oil in aqua feeds.

The EU is a major importer of seafood, both in terms of value and volume. Despite the economic downturn in 2007-2008, imports have continued to grow to € 52.7 billion in 2011. In terms of supply, EU imports more than 55% of its seafood demand from Asian countries.

Key drivers and concerns with seafood

Ratcliff said, “The key drivers that influence the EU consumer when purchasing seafood are mainly demographics, socio-economic changes, price, health and diet information. Regarding health benefits, the recent publication of health hazards associated with processed red meats is driving a positive change to increase consumption of seafood.

“This awareness of health particularly on omega-3 foods has led to a surge in demand for fish as well as fish oils. In Japan, where fish is staple food, the ratio of omega 6: omega 3 is 4:1 whereas in Europe is still low (6:1 to 10:1). Consumers are responding by replacing some of their traditional foods with fish. However, fish as a healthy food is threatened with serious negative perceptions with both farmed and wild fish due to consumer sensitivity to environmental and sustainability issues,” added Ratcliff.

“Fish and seafood products are associated with a number of health hazards which include bacterial and chemical contamination. Of the chemical hazards, residues of persistent organic pollutants (POPs), antibiotics and chemotherapeutics, would be most widely publicised by media. The message for industry is that all these issues get into the news quickly and producers have to be concerned with these as hazards to food safety.”

To protect its consumers, the EU has a list of strict regulatory controls on imports of seafood. It has control measures at entry ports of arrival and aside from this, focuses on traceability and labelling. In the Rapid Alert System for Food and Feed (RASFF) for 2014, there was a 4% increase in alerts on contaminants in seafood products. "However, this could be due to the EU authorities conducting more tests," said Ratcliff. (Information on the regulations: http://ec.europa.eu/dgs/health_food-safety/).

Retailers influence

“Exporters do not sell to governments but to retailers and food service companies,” said Ratcliff. “They are the drivers for issues ranging from food safety, fish welfare, traceability and sustainability. Due to the number of food scares, consumers expect retailers, through their purchasing procedures, to enhance government regulations for ensuring food safety. Thus, we find that retailers have standards higher than regulations alone. They conduct their own audit trails along the supply chain. At the end of the day, it is their brand and customers that they are seeking to protect.

“Among retailers, there is a preference for farmed seafood because of supply and continuity, control on quality, freshness and taste but consumers have their own perceptions. Some see farmed fish as unnatural and produced industrially and wild fish as healthier and natural. The industry may counter these perceptions but ultimately what the consumers perceive becomes the reality.”

Role of the aqua feed industry

There are increasing concerns on the sustainability of the aquaculture industry in terms of environmental damage and its reliance on the use of fish meal and fish oil. “Aquaculture has been the cause of several food alerts, a number of which were linked to aqua feeds. Feed is the main source of POPs and heavy metals in farmed fish. There are concerns on high concentrations of fat-soluble pollutants in fish oils, fish meal and fish by products.

“The requirements for the aqua feed industry is to employ appropriate supplier approval procedures combined with monitoring procedures and testing programs for POPs including polychlorinated biphenyls or PCBs and dioxins, pesticides residues, heavy metals, histamines, melamines, salmonella as well as implementation of effective HACCP and GMP standards. The challenge is for the aqua feed industry to not only reduce fish meal and fish oils in formulations but also ensure the use of sustainable sources. NGOs often use the negative image of ‘feeding fish to fish’ to present aquaculture as not sustainable.

Ratcliff said that retailers have responded to consumer concerns by implementing strict supplier sourcing procedures that demonstrate complete transparency and follow industry standards for responsible sourcing such as MSC, IFFO and GAA.

“More recently, the industry has been rocked by media exposure of forced labour and unlawful fishing in certain parts of Asia which resulted in a serious negative image among EU consumers and the threat of an EU ban on imports. The aqua culture industry in Asia has the challenge of how to produce seafood products that are clearly in demand in such a way that they do not present a risk to the environment and society. A coalition of UK retailers and seafood importers, together with organisations such as ISSARA are trying to support the governments and NGOs in the Asean region with a task force to implement track and trace from feed mill to vessel and support for labour initiatives."

Ratcliff's message was, “The aqua feed industry has the ultimate challenge of reducing the reliance on fish meal and fish oil. However, substitutes such as plant meals will require large areas of agricultural land, animal meals face issues with consumer acceptance because of its history in Europe, GMO ingredients still face a political barrier in Europe and krill meal faces ecological resistance. Most likely the future will be with novel ingredients such as single cell protein, insect meals, seaweed or feed additives.”

Certified to win more markets

By Donna Richardson

ASC certification lifts China's tilapia farms to greater heights of responsible farming and enhances their reach to the discerning European markets.

Tilapia in cages in Hainan, Photo credit: CAPPMA

Increased consumer demand in Europe and China for certified tilapia products has been the catalyst for a major transformation of the aquaculture industry in China. With one-fifth of the world's population, China accounts for two-thirds of the world's reported aquaculture production. In 2012, global production of farmed tilapia reached three million tonnes a year, with 40 % produced by China alone.

Figures for this period also show that the European Union (EU) imported approximately 10% of the tilapia exported from China every year, making them the third largest importer of Chinese tilapia in the world, after the United States and Middle East. The demand is driven by European consumers buying the species, however this same customer base shows a strong preference for sustainably produced products.

These two factors have led to an increased interest in Aquaculture Stewardship Council (ASC) certification in China. The first Chinese farms to undergo rigorous assessment against the ASC standard achieved certification in 2015.

The current ASC output of Chinese tilapia is 1,841 tonnes, all derived from Qionghai Zhongpingzi Grobest, Chengmai Xingyuan Development Co Ltd, and Wenchang Zhou Qinfu. These three farms reflect the pioneering initiative and efforts of responsible operators to meet the major challenges facing the industry in China. Each of the farms is in the southern provinces — the region which includes Hainan, Guangdong, Guangxi and Fujian, and accounts for nearly 90 % of China's total tilapia production — and all gained ASC certification late last year.

ASC certification gives retail partners and consumers confidence that farms are operating according to the best standard for environmental and social responsibility. It can also decrease barriers to desirable markets and allow certified farms to reach consumers interested in purchasing only responsibly produced seafood.

The increase in certification bodes well for the industry across China and the success of the three is inspiring more farms to follow their lead. Throughout Asia, the ASC currently has scores of farms in assessment in China, Taiwan and Vietnam. In terms of output in the region, Indonesia leads with a total certified production volume of 40,710 tonnes of ASC certified seafood, followed by Vietnam with 12,000 tonnes and Malaysia with 3,630 tonnes.

The journey to responsible aquaculture

In 2012, when the first ASC certified farmed fish products entered the world's seafood markets, China faced some major challenges in tilapia aquaculture production. Issues including a lack of transparency and traceability in the supply chain, poor environmental and social practices, and weakness in the production system in some Chinese tilapia farms, led to unsustainable practices which diminished consumer confidence in the industry.

The situation inspired the World Wildlife Federation (WWF) China to kick-start a transformative change in China's enormous tilapia aquaculture sector in order to achieve higher efficiency and measurable environmental sustainability goals. Together with the ASC, they formed a partnership with the China Aquatic Products Processing and Marketing Alliance (CAPPMA) to create a joint project called Greening the Supply of Chinese Tilapia.

This two-year long project engaged tilapia aquaculture enterprises in China to improve transparency within the industry, raise awareness among consumers and inform the government of China about responsible fish-farming policies. The project also introduced ASC standards to China. Thus, the program paved the way for farms to achieve certification against a standard that rewards and recognises environmentally and socially responsible production and brings with it the potential to reach new markets.

How certification works

To retain its independence, ASC does not assess fish farms itself; instead relying on third party certifiers to audit farms against the ASC standards and assess whether they are operating responsibly. Certificates are issued by the independently accredited certifying agency.

Assessing a fish farm's operating systems and their environmental and social impacts is complex. But the basic concept is simple – farms must have in place the most effective systems that ensure minimal negative environmental and social impact. Every ASC certified fish farm has demonstrated that it is well managed and minimises any adverse impacts.

As a result ASC certified farms deliver a cleaner seabed, cleaner water and healthier fish. They can also demonstrate that they are preserving the diversity of the species and wild population, adhering to strict feed requirements and ensuring social responsibility.

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Marketing tilapia at the China Fisheries and Seafood Exposition in November 2015.

Traceability

The ASC requires all companies processing certified seafood to have in place traceability systems that ensure that no product mixing or substitution can occur.

In order to achieve chain of custody certification, each company in the supply chain must meet strict requirements and have in place traceability systems that ensure no product mixing or substitutions can occur. Thanks to this requirement, certified seafood is fully traceable throughout the entire supply chain to ensure the future availability of seafood, the health of the ocean and the enduring livelihood of the local communities in which the farms operate.

The ASC program in China

The ASC is a market based program, designed to create incentives and reward responsible farming practices. It also promotes and rewards responsible fish farming though the use of the ASC on-pack logo, which helps consumers to make an informed choice in the supermarket. The logo assures buyers that the fish they purchase has been responsibly sourced, with minimal impacts on society and the environment, and is fully traceable back to a well-managed farm.

Through the use of the logo and assessment against robust standards, the ASC provides companies with a competitive advantage. European retailers and food service providers are keen to buy ASC certified products and increased ASC certification across Chinese tilapia farms will help drive access to western markets. Farms also immediately benefit from ASC certification with greater insights on supply volume, traceability and recognition for achievement of corporate and social responsibility goals.

There is still much to do to move the Chinese tilapia industry towards sustainability. Work continues to increase public access to detailed information on the tilapia supply chain and to promote responsible production and the wide adoption of the ASC standards. However, the dedication to this effort shown by all stakeholders is already creating valuable improvements in the industry.

Together with CAPPMA and WWF China, and other stakeholders, the ASC and its partners are supporting the Chinese tilapia industry implementing these improvements.

Donna Richardson is a contractor for the Aquaculture Stewardship Council working in PR and Public Affairs.
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Tilapia in India

Preparing for a future demand for fry and fingerlings

Aresen Bio-Tech's 20 mm Chitralada tilapia fingerlings

In 2007, India opened up its aquaculture industry for the farming of the tilapia but this was limited to four companies which were allowed to import broodstock and produce fry and fingerlings. One of them is Aresen Bio-Tech and Farms Pvt Ltd in Vijayawada, Andhra Pradesh.

The tilapia farm cum hatchery/nursery is run by Arun Kumar. The hatchery is also a part of feed miller, Growel Feed Pvt Ltd's innovative plan to develop tilapia farming in India.

"There is now a market for the tilapia, although this has been very slow in comparison to what we have seen in Bangladesh. For example, the demand is about 1 tonne/day in Mumbai, which comprises live fish supplies to restaurants and fish for home consumption. This is supplied by West Coast Frozen Foods Pvt Ltd which produces 20-25 tonnes/month," said Arun.

"Here on the east coast, we also grow market size tilapia in our 20 acres (10 ha) of ponds. However, our main purpose is mainly to study aspects such as stocking density. We stock 2.5 fish/m^2 with no aeration and 6 fish/m^2 with aeration. Fish grow to 500 g within 6 months. This is our target size. The average growth rate is 4-6 g/day. However, if we also stock large fingerlings (30-50 g), we can increase stocking density to 40 fish/m2 and grow them for 4 months. Feed used is Growel's extruded formula for general freshwater fish with 24% protein and 3% fat."

The target production is 200 tonnes/year but so far Aresen Bio-Tech has produced 4-5 tonnes/month, all of which are sold in South India, Kerala and Tamil Nadu. The selling prices to local markets is INR 60/kg (USD 0.9/kg). "Our cost of production is INR 48-51/kg (USD 0.7/kg). Survival is more than 80%. However, the selling price depends on the market source. Fish produced in Madurai, an industrial area is sold at INR 180/kg (USD 2.7/kg). In Tamil Nadu, one producer sold saline tilapia farmed at salinities of 33-35 ppt at INR 150-200/kg (USD 2.2-2.9/kg). However, it takes 6 months for the fish to reach 270-300 g. In Kerala, prices are usually INR 180/kg but rises to INR 250-300/kg (USD 3.7-4.5/kg) during Christmas and in May to June during the fishing ban. This means that the customer first needs to be identified."

Tilapia has a huge potential in India. "Tilapia has a better meat texture, is tastier than the pangasius and has less bones than the carp. The younger generation prefers a less bony fish. The omega 3 fatty acid profile is also much better than pangasius," said Arun. "Tilapia was referred to as a weed fish for a long time. Here in Andhra Pradesh our production is being constrained by market acceptance of the fish. Now I can only wait for the time when demand picks up and I can increase my hatchery output."

Arun Kumar

"With the tilapia, we can increase the productivity of the land. The fish from low saline ponds will taste much better and it will be easier finding markets."

Hatchery and nursery

Aresen Bio-Tech, set up in 2009 is now the only private commercial producer. The capacity is 2 million/month of 0.2 g (20-25 mm) fingerlings. However, with the current demand, production is only 0.5 million fry/month. The fry of 20 mm is sold at INR 2 (USD 0.03) each, more expensive than those sold in Thailand. The nursery stage is in hapas located in earthen ponds. Hatchery operations are for 8 months only and will break for the summer months when temperatures rise to 37-38 °C.

"Our broodstock is from the Chitralada strain which was imported in 2011 from the Asian Institute of Technology (AIT), Thailand. The strain has good attributes such as growth, condition factor and can withstand saline conditions. However, at temperatures above 32 °C, *Streptococcus* infections set in. There is also the Nagri strain of the red tilapia which has poor consumer acceptance because of a spot on the skin," said Arun.

"Today, I can say that our Chitralada is the only pure line available as the original stock at AIT has probably been adulterated during the 2009 floods. Today we are following a two-family line

Nine month old Chitralada broodstock weighs 1.1 kg. Characteristics of this strain include good growth and condition factor as well as able to withstand saline water conditions

Nursery hapas in a pond

selection process and are in the second generation. We are in the process of going into genetic selection for further generations. Our plan is to undertake some selective breeding work but this will require us to expand facilities but with such low demand for the fry and fingerlings affecting our bottom line, we will just need to wait."

The other research work carried out at the hatchery is the development of a vaccine isolated from fish infected with *Streptococcus*.

Low saline culture of tilapia and vannamei shrimp

Part of the demand for Aresen Bio-Tech's fry is from shrimp farmers who stock tilapia together with vannamei shrimp. Arun also expects a future demand of tilapia fry for stocking low saline ponds after the first crop of vannamei shrimp has been completed. Usually these ponds are unused from August to January, after harvesting the vannamei shrimp crop which ends in June-July before the monsoon season. Usually the shrimp crops fail when temperatures are low at 22 °C and white spot syndrome virus is a major problem.

"With the tilapia, we can increase the productivity of the land. The fish from low saline ponds will taste much better and it will be easier finding markets. Slowly, the vannamei shrimp mania is easing and farmers are reducing to 1 to 1.5 crops. Tilapia can then fill in this niche and make this a natural crop rotation cycle. However, shrimp farmers resist polyculture with tilapia as they are unable to sell the 200 kg or so of tilapia," said Arun.

Based on demand, the hatchery acclimatises the fry to 3 ppt salinity. In polyculture at the farm, the stocking density for the vannamei shrimp is 20 post larvae/m^2. Here the ponds are not ideal, ie. they do not dry completely. During this time, water from the underground water source becomes saline (3-4 ppt).

"In India, the tilapia is still a small baby but soon we can see it growing. Processing of fillets is done at Ananda Aqua Exports and Mulpuri Aqua Processors Pvt Ltd. for the pangasius but not for tilapia. Currently, West Coast is concentrating on live fish sales and is in the process of developing infrastructure for fillet processing, and so is Growel processors Pvt Ltd," said Arun.

Eleventh International Symposium on Tilapia in Aquaculture

April 26-29, 2016
Surabaya, Indonesia

This ISTA in 2016 will be held together with Asian Pacific Aquaculture (APA 2016) and in collaboration with the Asia-Pacific Chapter of the World Aquaculture Society (APC-WAS). The venue will be the Grand City Convention and Exhibition Centre. It is an event co-sponsored by the American Tilapia Association (ATA) and Aqua/Fish Innovation Lab. This is a highly successful series of symposia bringing together tilapia biologists to review the latest discoveries in tilapia nutrition, physiology, reproductive biology, genetics, ecology, improvements in production systems, and other fields related to tilapia aquaculture.

ISTA 10 was held in Israel in recognition of the 30-year anniversary of the first ISTA that was held in Israel. Earlier meetings were held in Thailand, Philippines and China. This will be the first ISTA to be held in Indonesia, which has recently expanded production to become the second largest tilapia producer in the world. With more than one million tonnes of tilapia farmed per year, Indonesia is now a become a major exporter and consumer of tilapia products.

The ISTA 11 symposium will have a special emphasis on best management practices, quality control, new product forms, international trade, and opening new markets for farmed tilapia products. The symposium will include a trade show, which provides a forum for industry suppliers, seafood marketers and aquaculture media to network with researchers and producers. Recent advances in production, health products, nutrition and feed formulations will be reviewed. Over 50 tilapia papers have already been submitted to the conference organisers with additional papers coming in daily.

Kevin Fitzsimmons, Past President of the World Aquaculture Society and prominent tilapia biologist will offer the keynote address with an overview of the industry and its future path. Major farm operators, marketers and research scientists will lead discussions to share knowledge and inform symposium members on various aspects of the world industry and its future. Dr Sidrotun Naim is the ISTA 11 co-chair and leader of the local organising committee. Submissions for presentations are still be accepted. Full papers will be reviewed for inclusion in the proceedings.

The registration will be in conjunction with the APC-WAS and Indonesian Aquaculture Society. The cost will be USD35 paid as an extra workshop fee to the WAS conference registration. The fee will cover the Tilapia gala dinner and a copy of the ISTA 11 Proceedings. The program will be posted at these websites: http://ag.arizona.edu/azaqua/ista/ISTA11/ISTA11.htm and www.was.org

New farms in Thailand and a hatchery in Bangladesh

Thailand's Nam Sai Farms producing high quality monosex tilapia, pangasius catfish and barramundi fry, opened two new branch farms in Thailand. A new hatchery is currently under construction in Bangladesh.

Nam Sai Farms Co. Ltd. established their first tilapia hatchery 120 km northeast of Bangkok in Ban Sang district, Prachinburi province in 1994. The hapa-based monosex tilapia mass production technology, developed by Dr David Little at the Asian Institute of Technology, was instrumental in the rapid development of the company. Soon after, increasing production scale and proximity to farmers became a limiting factor for its expansion. Nam Sai then developed a new branch model based on supply of hatchlings and nursery feed in order to simplify management and ensure fry were over 99% male and of high quality.

The first branch, a joint venture partnership between three brothers, Suchat, Jaran and Sopon Piyasirinon was established in Don Tum district, Nakhon Pathom province in 2005. Quality of fry produced by the branch has been exceptional and they have since increased production to 15 million Nile and red tilapia monosex tilapia per month to cope with high demand. Nam Sai has now announced the opening of two new branches in Thailand to cover the northeast and south of the country.

In October 2015, the company opened a branch, Grobest Nam Sai Co. Ltd in Pangkone district, Sakon Nakhon province with a capacity to produce 15 million monosex Nile tilapia per month. A large part of the production is supplied to Grobest's fingerling farm for grow-out by tilapia cage farmers located in rivers and lakes in northeast of Thailand, including its own vast cage facility located on the Mekong River in Nakhon Panom province. The flavour and meat quality of tilapia produced in this river are said to be special due to characteristics of the river. All production is processed at the company's processing plant for export.

The second branch, Nam Lae Farms opened in November 2015. This is a joint venture company between Nam Sai Farms and Adrian Simpson. The farm is located on a brackish water site in Pak Ror, Singha Nakhon district, Songkhla province. The production of monosex Nile and red tilapia is supplemented with production of barramundi fry and fingerlings in 2016 to supply farmers in southern Thailand and Malaysia.

Nam Sai's first hatchery project outside Thailand is a joint venture with Spectra-Hexa, a Bangladesh-Thai feed mill in 2008. The first hatchery was established in Mymensingh province, 120 km north of Dhaka in 2009. Production is based on Nam Sai's disease-resistant GIFT strain of Nile tilapia which includes the Bin Nin strain. Spectra-Hexa-Nam Sai has now announced the development of a brand new hatchery facility in Jessore district in southwest Bangladesh. Sales are expected to begin in late 2016. More information:www.tilapiathai.com

Apple co-founder Steve Wozniak, former Ford CEO Alan Mulally to speak at *ONE: The Alltech Ideas Conference*

ONE: The Alltech Ideas Conference is an event dedicated to inspiring innovation. The annual international conference, now in its 32nd year, traditionally draws nearly 3,000 attendees from more than 60 countries to network with peers and discuss world-changing ideas. On Tuesday, May 24, 2016, Alltech will welcome Wozniak to its main stage.

"When you think about the power of innovation, you think of Apple. Few companies have had a more profound effect, and so it is a real treat for me personally, as an entrepreneur who also started my business in a garage, to announce that Steve Wozniak, Apple's co-founder, will be joining us for ONE," said Dr Pearse Lyons, founder and president of Alltech.

Currently, Wozniak is the chief scientist at Primary Data. He is also the author of the *New York Times* best-selling autobiography, 'iWoz: From Computer Geek to Culture Icon.' Former president and CEO of Ford Motor Company, Alan Mulally will join author and businessman Seth M. Siegel and title-winning University of Kentucky Men's Basketball Coach John Calipari as the opening keynote speakers on Monday, May 23.

Throughout his career, Mulally has been recognised for his contributions, industry leadership, and service. He is now a director at Carbon3D, Inc., a 3D printing company. Siegel is a forward thinker on the coming global water crisis, and what to do about it.

Closing the conference will be Riverdance in a special live performance on the morning of Wednesday, May 25. This international Irish dance phenomenon has been seen by more than 25 million people in 46 countries. ONE: The Alltech Ideas Conference will be held in Lexington, Kentucky, USA from May 22-25. More information and registration at one.alltech.com

New group in aqua and animal premix

Dr Yang Yong

Since January 2016, Dr Yang Yong and Dr Zhang Song have been leading their technical team to set up a new Group, named LinkOcean Group. The office and factories of this new group are located in Guangzhou, China. The group will have several businesses, ranging from aqua and animal premix, feed additives, probiotics, raw material trading and consulting. A big LinkOcean high-tech industry park is under construction in Zhuhai, China.

Both Yang, Zhang and their team are well known with their knowledge, experiences and integrated services in the aqua feed industry. Yang brings with him 20 years of experience in aqua feed formulation and nutrition as well as business administration whilst Zhang's expertise is mainly in aqua and animal nutrition and technical service systems. Together, they have 15 years experience in general feed milling and feed formulation of aqua feeds.

"We will provide excellent services and best quality products to feed enterprises through our subsidiary, Guangzhou Nutriera Biotechnology Co., Ltd. Nutriera provides integrated solutions including diet formulation, quality control of raw materials, feed processing, marketing services, farming technology, staff and farmer training, fish hatchery and others," said Yang. "We mainly focus mostly on Asian countries where aquaculture is expanding. We provide the best premix products and technical service systems according to different farming species and farming models. We will also bring the best integrated solutions to the aqua feed industry in Asia," said Yang.

Both Yang and Zhang were formerly with Guangdong Hinter Biotechnology Group Co., Ltd, the feed additive arm of one of China's large feed group, Haid. More information: Email: nutriera@163.com; www.nutriera.cn

Supporting aquaculture in India

Peter Coutteau receiving the gold sponsor award for Nutriad at Aqua India 2016 from Dr P. Ravachandran, Member Secretary of the Coastal Aquaculture Authority

Aqua India 2016, a biennial event organised by the Indian Society of Aquaculture Professionals (SAP), was held this year in Vishakhapatnam, Andhra Pradesh from January 29-30. Nutriad showed its commitment to the Indian aquaculture industry through a Gold Sponsorship for the event. The conference focused on the theme of 'Indian Aquaculture: Assuming Responsibilities & Adapting to Changes.'

"Seafood exports from India have increased fivefold in the last 15 years reaching USD 6.5 billion, making India the fourth largest seafood exporter globally, "said Leena Nair, chairman, Marine Products Export Development Authority (MPEDA). Some 67% of the export value came from shrimp of which 77% is farmed. Increased production costs and diseases are likely to slow Indian's shrimp production in 2016. "A more than 10% production decline due to flooding and disease outbreaks was already seen in 2015. A recovery is likely to be marginal due to lower returns from farming," said S. Muthukaruppan, president of SAP.

"White spot virus (WSSV) continues to be the predominant threat to farmed shrimp in India, but new diseases are increasingly important too," according to Dr Shankar Alavandi, principal scientist at CIBA. Surveillance programs have revealed new diseases such as the running mortality syndrome (RMS), white faeces syndrome, and *Enterocytozoon hepatopenaei*, a microsporidian causing slow growth and bad feed conversions. India still has an enormous potential to expand production of vannamei shrimp into new farming areas in the states of West Bengal, Odisha and Gujarat.

During the interactive sessions at Aqua India, participants expressed the need for increasing capacity of quarantine and broodstock multiplication centres, enhanced bio-security measures to avoid spreading new diseases, genetic programs and new technologies to control microbial development in pond systems including probiotics and specific functional feeds.

Upon receiving the gold sponsorship award Dr Peter Coutteau, Nutriad BU manager Aquaculture stated: "Nutriad has been working alongside producers in India for many years. Together with them we develop concepts that address the current and future challenges of the industry."

Nutriad delivers products and services to over 80 countries through a network of sales offices and distributors, supported by 4 application laboratories and 5 manufacturing facilities in 3 continents. More information: www.nutriad.com/nutriad-species/aqua/

New Aquaculture Research Centre

Dr Craig Browdy

Dr. Craig Browdy, director of Research and Development for Zeigler Bros., Inc., announced the startup of the company's new aquaculture research center located at Florida Atlantic University Harbor Branch Oceanographic Institute in Fort Pierce, Florida.

The new research centre, Z-ARC, is a cooperative agreement between Zeigler and the Florida Atlantic University and will be the site of animal research trials aimed at improving and expanding aquaculture technologies for the industry. The existing facilities at Harbor Branch will significantly extend the scientific capability of Z-ARC to evaluate different species, health management, and the impacts of feeds and nutrition.

"This new research capability will contribute to much faster innovation of new and improved products, customised to specific markets around the world, resulting in faster and more profitable growth of the world's aquaculture industry", said Tim Zeigler, vice president of Sales for the company. Peter Van Wyk, a 30 year veteran of the aquaculture industry and manager of the new facility, reports that new important findings have already been made during the startup phase of the facility.

Browdy stressed that, "in addition to developing our own products, we are looking forward to cooperative efforts with other technology companies to identify and test new ingredients, additives, and technologies. By striving for win/win solutions, we can grow our industry, create jobs, and improve options for heart healthy seafood around the world."

Zeigler, currently in its 81st year, is a privately owned manufacturer of aquaculture and specialty animal feeds. Located in Pennsylvania, USA, the company exports to over 40 countries and has 3 licensed manufacturing operations in Mexico and Ecuador. More information: craig.browdy@zeiglerfeed.com; www.zeiglerfeed.com

2016 World Nutrition Forum

BIOMIN has announced details on the 7th edition of the biennial World Nutrition Forum, the premier animal nutrition event hosted by the company. Leading livestock and aquaculture professionals along with researchers, academics and other representatives from the food and feed industries will gather in Vancouver, Canada from October 12 to 15, 2016. 'Driving the Protein Economy' will be the theme of this forum.

The 2016 World Nutrition Forum will offer top industry professionals the opportunity to 'look under the hood' to explore the factors driving the protein economy, its trajectory and future. Species-specific breakout sessions will provide a platform to delve further into topics concerning poultry, swine, ruminants, and aquaculture production. A top-class mycotoxin expert session will address key research findings and the application of the latest technologies in mycotoxin deactivation, along with a second expert session on gut and rumen health and performance.

"Since the very beginning, Biomin has focused on supporting animal nutrition in ways that privilege natural and innovative solutions for the benefit of animals, producers and the environment," said Erich Erber, founder of Biomin and major shareholder of Erber Group. "The World Nutrition Forum was created as a platform for the industry and the scientific community to engage on a host of issues from farm to fork in order to better face the challenges of tomorrow."

First held in Salzburg in 2004, the World Nutrition Forum hosted by Biomin has become the leading opportunity for industry practitioners to share ideas and exchange knowledge. These biennial summits are consistently well rated by attendees. Each iteration draws upon the uniqueness of the location, speakers and participants while maintaining the highest quality standards for both content and organization. More information: www.worldnutritionforum.info

Proven efficacy of clay and seaweed feed additive at VICTAM 2016

Orapint Jintasataporn with trial facilities at Kasetsart University, Thailand.

The Olmix Group, supplier of natural feed additives from France, will update its customers and partners on the latest findings in the efficacy of MFeed+, a unique combination clay and seaweed at Victam Asia 2016. The trade show will be from March 29-31 2016 at the Bangkok International Exhibition Centre (BITEC), Bangkok, Thailand.

"As an exhibitor at Victam Asia 2016, we will take this opportunity to update our customers and partners on the latest MFeed+ trials, which have shown that it is an efficient natural solution in boosting growth performance and health of livestock and aquaculture species," said Chakrit Ridmontri, marketing manager, Olmix Asia.

MFeed+ improves performance of the animal by improving nutrient digestibility through boosting enzyme activity in the small intestine of the animal. This has been confirmed in the trials conducted at various countries in 2015. The first trial, which was conducted by a feed company in the US, demonstrated that every €1 invested in MFeed+ in feeding broilers resulted in a return of €2.

In fish, Olmix commissioned Kasetsart University's Fisheries Department in Thailand to conduct a trial on tilapia and MFeed+. In the trial, the control group was fed diets containing fish meal at 5% and 20%. The experimental group was also fed these diets, but added MFeed+ at inclusion rates of 0.1 and 0.2%, respectively.

Dr Orapint Jintasataporn, lecturer at the university supervised the trial. She said the study clearly showed that MFeed+ improved protein and carbohydrate digestibility of tilapia. That was the reason why growth performance and health of the experimental group was better than that for the control group. As expected, the fish fed a diet containing 20% fish meal and 0.2% MFeed+ showed the best result. More information: Email: marketingasia@olmix.com (Chakrit Ridmontri); www.olmix.com

Interactive PAES W.A.T.E.R. aquaculture website

In February, Pentair Aquatic Eco-Systems (PAES) launched of a new website for PAES W.A.T.E.R. (World Aquaculture Technology Engineering & Research), its state of the art Recirculating Aquaculture Systems (RAS) demonstration facility located in Apopka, Florida. The all new PAESWATER.com is a fully-interactive website designed to provide the user with an experience of the 12,400 square-foot facility as if they were there in person, including an enhanced navigated path tour, featuring 39 'product hotspots.' Each hotspot focused on a specific piece of equipment integral to the functionality of the five separate recirculating aquaculture systems (RAS) in the facility. Viewers have the ability to learn more about each product, view photo galleries, watch explanatory videos and contact the PAES team of technicians if they need more information.

Additional highlights of the website include the ability to access live streaming cameras with views of fish in the multiple systems. The video connectivity component will also be host to future live events and educational demonstrations. With research and education as the focus of this facility, the website will also provide visitors real-time information from the monitoring systems, including dissolved oxygen, ORP, conductivity, pH and temperature statistics. More information: PAESWATER.com

Launch of a new submersible pumps

Pentair also announced a new product. These SHURFLO® submersible pumps are smart, reliable and efficient as well as suitable for many applications. They are built for the harsh marine environment to withstand the toughest conditions. These pumps control and manage water intake by transferring and removing excess water. More information: pentairaes.com/submersible-pumps-12-24vdc.html

Shurflo® submersible pumps, 12 & 24VDC

New feed mill for local production of shrimp feeds

On January 29, 2016, the Chief Minister of Tamil Nadu, Ms Jayalalithaa inaugurated the foundation stone laying ceremony of Sheng Long Bio Tech (India)'s new aqua feed mill project in an area of 14 acres (5.66ha) at Sipcot, Thervoykandigai, 44 km from Chennai. The planned capacity is 50,000 tonnes per year of both shrimp and fish feeds with an expansion potential of another 50,000 tonnes per year. Feed production is scheduled for January 2017. The company has already began construction of a vannamei shrimp hatchery with a 2 billion post larvae per year capacity in Vilambur Village, Cheyyur Taluk, Kanchipuram District, 106 km from Chennai, Tamil Nadu. This will begin production in October 2016.

Sheng Long Bio Tech International Co is one of the leading aqua feed producers in Vietnam with an estimated capacity of 20,000 tonnes per month of shrimp and fish feeds at three feed mills in Binh Duong, Long An and Nha Trang. In 2015, it had 14% share of the shrimp feed market in Vietnam. Its entry into the shrimp feed market in India began in 2014 with the establishment of Sheng Long Bio-Tech India.

"In 2015, our imports of shrimp feeds totalled 15,000 tonnes, " said A. Kumaresan, director-marketing at the Indian subsidiary.

According to Kumaresan, the reason for this domestic production is, "Once our import volume enter beyond 20,000 tonnes/year, we will face logistical problems in arranging shipments, storage, supply etc. We will avoid this by manufacturing feed in India.

"At the moment, Sheng Long's shrimp feeds show good performance in all the farms using them. Farmers are satisfied with quality, growth rate and feed conversion ratio. Even with local production, we will ensure that the quality of shrimp feeds produced in India will be equal to that of imported feeds from Vietnam. Our quality and pricing will be competitive with domestic feeds."

The Indian marketing team with vice president, Sheng Long Vietnam, Maple Hung (centre right), from left, N. Bhaskaran, regional manager, Andhra Pradesh and Tamil Nadu, T. Iyappan, service team leader, A. Kumaresan, director- marketing, Sairam Panda, regional manager , Odisha & West Bengal and B. Kiron, regional manager, Gujarat.

The main markets for Sheng Long's shrimp feeds in India are Odisha, West Bengal, Andhra Pradesh and Tamil Nadu. The sales target for 2016 is 25,000 tonnes and the team will be selling to farms in Gujarat.

Bacterial toxin control product gains market share for shrimp EMS challenge in Mexico

In February, Amlan International announced that 50% of shrimp feed produced in Mexico in 2015 contained Calibrin-Z to fight the damaging effects of early mortality syndrome (EMS) with positive feedback given by current customers. The Calibrin- Z market penetration rate in the introductory year was significant as the product was introduced to the Mexican market just months earlier.

Calibrin-Z is a bacterial toxin control product that protects the hepatopancreas from the damaging effects of EMS in shrimp, which was first reported in Mexico in 2013. This fairly new disease appears during the first seven to 30 days after stocking and is caused by toxins secreted by the bacteria *Vibrio parahaemolyticus (Vp)*. The Vibrio is transmitted orally and colonises the gastrointestinal tract of shrimp, causing tissue destruction and dysfunction of the vital digestive organ the hepatopancreas.

Calibrin-Z works by adsorbing the *Vp* bacterial toxin in the body, thereby increasing the rate of survival in a shrimp crop. Studies have shown improvements in survival, up to 84% in comparison to controls, when shrimp challenged with the *Vp* toxin were fed Calibrin-Z. EMS is characterised by a high mortality rate, often reaching 100% within the first 30 days. The studies were conducted at the University of Arizona. More information: www.amlan.com or CalibrinZforEMS.com

26 – 29 April 2016
Grand City, Surabaya, Indonesia

Asia-Pacific Aquaculture 2016

Asia Pacific Aquaculture 2016 (APA 2016) conference and trade show is organised by the Asia Pacific Chapter of the World Aquaculture Society (APC-WAS) together with the Ministry of Fisheries and Marine Affairs, Indonesia. Co-located conferences and tradeshow will be Forum Innovasi Teknologi Akuakultur (FITA 2016) and Indonesian Aquaculture (IndoAqua 2016). The International Symposium on Tilapia in Aquaculture (ISTA) will be part of the APA 2016 program. APA 2016 will also have several producer programs of interest to industry in Indonesia and the region.

The tradeshow at APA 2016 will have more than 300 booths featuring the latest in aquaculture technology, equipment and services from around the world. Below is a preview of a selection of exhibitors at press time.

PT. Stargold Internusa Jaya is an Indonesian company, specialising in assembling HDPE circular aquaculture cages. The advantages of using Stargold cages include the strength, flexibility and durablity. The PE material used comply with Indonesian Quality Standard (SNI) while an anti UV radiation additive is added to extend life span. It is environmentally friendly with hydro-dynamic design. The designing, planning and assembling of Stargold circular cages are carried out by Indonesian experts. Stargold cages are suitable for use in rivers, streams, lakes, coastal areas and offshore.

At the show, the product range will include circular aquaculture cages with diameters ranging from 3-30 m depending on use. The company has recently introduced new products such as IMTA circular aquaculture cages, work platforms, floating docks and floating guard houses.

Booth No: 37-38
Imam Kadarisman (marketing@stargold.co.id)
www.stargold.co.id

PT Matahari Sakti (MS), established by Puspita Dewi Prijadi in 1988, started with shrimp feed production and moved to producing fish feed and pet food, to meet customer demands. The progress of MS was supported by cutting-edge technology and its human resources leading to quality products. MS markets these aqua feeds to Indonesia and international markets. MS has its core values; Quality, Innovation, Nurture and Smart Solutions.

At its booth, MS will feature the Fengli brand for intensive monodon shrimp farming, Kaiohji, New Tata and Tata-TM brands for intensive vannamei shrimp and Tata-TT for traditional shrimp farming. The fish feed brands, Preo, Prima and Bravion are for the catfish, tilapia, carp, pangasius and milkfish. It also has feeds for the grouper, seabass and pompano (Megami). MS also produces feeds for fish fry (PF-500, PF-800 and PF-1000) manufactured from premium quality ingredients.

New products: In 2016, MS will launch fish fry feed (PF-0, PF-100, and PF-200), and feeds for the eel and koi (Akarui and Ikushu Breeder Plus).

Booth No: 98, 99, 100, 101
Puspita Dewi Prijadi (dewi@mataharisakti.com)
Rudy Purwono (rudy.purwono@mataharisakti.com)
Teddy Njoto (teddy.njoto@mataharisakti.com)
www.mataharisakti.com

Behn Meyer Aquaculture is a leading distribution company in Indonesia, serving the aquaculture industry; feedmills, hatchery and grow-out ponds. It provides quality and worldwide known products comprising shrimp and fish hatchery feeds, probiotic, prebiotic, enzyme, immunstimulant, toxinbinder, antimold, amino acid, vitamin, mineral and disinfectant. Behn Meyer Indonesia is located in Jakarta, Surabaya, Medan, Semarang, Solo and Banyuwangi.

Booth No: 118 & 120
Hesmi Hidayat (hesmi.hidayat@behnmeyer.co.id)
www.behnmeyer.co.id

As a pioneer in the aquaculture industry, **INVE Aquaculture** has always been about enabling growth. The healthy growth of fish and shrimp, the growth of our clients' local businesses and the growth of global aquaculture as a whole. Since December 2015 INVE Aquaculture has become part of Benchmark Holdings, market leader in applied biotechnology with focus on aquaculture. Together we support our customers to take better care throughout their production lifecycle, resulting in sustainable growth and long-term success. We offer advanced technological solutions for:

- Nutrition: the best balance between enriched live feed and formulated larval & nursery diets
- Environment: optimal living conditions thanks to water & soil treatment and algal substitutes
- Health: controlled biosecurity and bioremediation supported by nutraceuticals, probiotics, vaccines and vet services
- Genetics: perfected selection strategies for the most resilient broodstock, fingerlings & juveniles

Booth No: 160-163
Wawan Siswanto (w.siswanto@inveaquaculture.com)
www.inveaquaculture.com

Solmax International is a worldwide leader in the manufacturing of polyethylene (PE) geomembranes and offers containment solutions to protect the environment. Manufactured in Canada and Malaysia, its PE geomembranes are distributed to over 60 countries across all continents and are used by the biggest names in the mining, energy, waste management, water, aquaculture

and agriculture sectors. Solmax's PE geomembranes are prime choices for shrimp farming in reducing disease risk, improving oxygen containment, turnaround time and water quality. Solmax Vision: Covering the World, Protecting the Earth.

Booth No: 90 & 3
Kelvin Hor (khor@solmax.com)
www.solmax.com

Ictyopharma is a European-based contract research organisation specialising in aquatic animal health. Combining technical and regulatory experience with a state-of-the-art R&D facility, Ictyopharma provides services to the pharmaceutical, nutrition and breeding industries including aquatic health product development, vaccine development, audits, training and regulatory affairs. Ictyopharma is a trusted partner to the world's leading pharmaceutical and nutrition companies.

Booth No: 69
Cedric Komar (cedric.komar@ictyopharma.com)
www.ictyopharma.com

Zeigler, currently in its 81st year, is a privately owned manufacturer of aquaculture and specialty animal feeds. Located in Pennsylvania, USA, the company exports to over 40 countries and has 3 licensed manufacturing operations in Mexico and Ecuador.

EZ Artemia is a liquid Artemia replacement diet formulated to provide the same nutritional benefits of Artemia. EZ Artemia provides stable & consistent supply, bio-security, equal or better performance as well as a significant cost savings and a reduction in labour. EZ Mate (Improved) is a versatile broodstock diet which enhances the fecundity and quality of nauplii production. Recently updated, EZ Mate now has enhanced attractability supporting improved nauplii output. EZ Mate becomes a semi-moist diet with the addition of water, allowing users to customize the product with their own ingredients.

*Presentation:*Nursery systems and nutrition by Dr. Craig Browdy

Booth: 131 & 132
Chris Stock (chris.stock@zeiglerfeed.com)
Craig Browdy (craig.browdy@zeiglerfeed.com)
Ramir Lee (ramir.lee@zeiglerfeed.com)
Satya Murthy (satya.murthy@zeiglerfeed.com)
www.zeiglerfeed.com

Founded in 1980 by Irish entrepreneur and scientist Dr Pearse Lyons, **Alltech** improves the health and performance of people, animals and plants through nutrition and scientific innovation, particularly yeast-based technology, nutrigenomics and algae. The company's guiding ACE principle seeks to develop solutions that are safe for the Animal, Consumer and the Environment. Alltech provides solutions for aquaculture which consist of natural, nutritional technologies tailored to address challenges impacting modern aquaculture production and profitability, providing farmers an advantage in a competitive marketplace. Alltech will focus on Aquate, a natural growth permitter at APA 2016.

Booth No: 170 & 171
Jorge Arias (jarias@alltech.com)
Serge Corneillie (scorneillie@alltech.com)
Hery Santoso (hsantoso@alltech.com)
www.alltech.com/aqua

Evonik Nutrition & Care GmbH produces and markets all four essential amino acids used in advanced animal nutrition. The company markets innovative products and a comprehensive range of services in analytics, animal nutrition and handling solutions in more than one hundred countries. With the new introduction of the AQUAVI® Met-Met, the peptide of DL-Methionine, it will minimize cost for its customers and contributing to a healthy and environment-friendly animal nutrition.

Evonik is hosting a technical session during APA on utilisation of amino acids in aquaculture. Join us in Diamond 1 on 28 April 2016 at 1.20pm to 5.20pm.

Booth No: 140-143
Mercyawati Subianto (mercyawati.subianto@evonik.com)
www.evonik.com/animal-nutrition

MiXscience provides a wide range of innovative solutions to aqua feed manufacturers and aquaculture producers for all stages (hatchery, farm, processing and more). Products and services boost development and face your challenges by optimising the feed formula, processing and preservation, optimising the animal's nutrition for its growth and health and optimising the farm rearing methods and environment.

New products: A-LIVE, a natural growth promoter which controls pathogenic bacteria and viruses, delays parasites infections, improves global survival through animal welfare, enhances growth performance by better energy use. The product helps reduce production cost and high yield.

Booth No: 130
Thi Banchereau (thi.banchereau@mixscience.eu)
Frederic Jozwiak (frederic.jozwiak@mixscience.eu)
www.mixscience.eu

At the show, the **Phileo-Lesaffre Animal Care** team and its aqua experts will launch the new Aquasaf range, a ready to use innovative all in one formula to address the specific needs of shrimp and fish farmers or feed manufacturers at each production stage from hatchery till processing. The latest research in fish and shrimp is on how to improve health through nutrition thanks to Safmannan exclusive solution, with many scientifically proven beneficial effects on pathogens binding, gut integrity and immune modulation.

Booth No: 180-183
Justine Cau (j.cau@phileo.lesaffre.com)
www. phileo-lesaffre.com

Aeration Industries International, the worldwide leader in aeration systems and expertise, offers aquaculturists the premier aeration system for all water quality management needs. The AIRE-O2 Aquaculture Aerator is a high quality, minimal maintenance unit with proven superior performance for over 40 years. Whether increasing production or preventing fish kill in floating cages, improving production and vertical mixing in intensive shrimp pond or treating the effluent from processing plant, the comapny has a solution.

Booth No: 108
Marcos Kroupa (marcos.kroupa@aireo2.com)
www.aireo2.com

Fish Vet Group is the largest provider of evidence-based veterinary services, dedicated diagnostic technologies and innovative aquatic health products for aquaculture producers around the world. Staff and laboratories in Thailand service the Asia region.

New products include Virasure® Koi, a newly developed pond sanitizer that combines oxidizing properties with a surfactant in acidic conditions, to break down viral and bacterial proteins resulting in enzyme inhibition and destruction of microbial cell walls. This helps keep ponds and tanks clean and infection pressure down.

Presentation: At the IndoAqua plenary, on Aquatic animal health management: Farm level control of Streptococcus and EHP (26 April).

Booth No: 153
Dr Andy Shinn (andy.shinn@fishvetgroup.com)
Dr Matthijs Metselaar (matthijs.metselaar@fishvetgroup.com);
Don Griffiths (don.griffiths@fishvetgroup.com)
Keith Morris (keith.morris@bmkanimalhealth.com)
Dr Leo Galli (leo.galli@fishvetgroup.com)
www.fishvetgroup.com

SPAROS is a spin-off company of the Centre of Marine Sciences of Algarve (CCMAR)/University of Algarve, devoted to innovation in the development of new products and processes for fish feeding and nutrition. It offers the alliance of a strong scientific background in the area of fish nutrition with a flexible pilot-scale feed technology platform to the aquaculture sector. SPAROS is located in the South of Portugal (Algarve region) but aims to serve the whole European market.

New products: A new line of products specially design to meet the most demanding needs of state-of-the-art hatcheries.

WIN Flatplus - larval feed containing a large fraction of soluble proteins, n-3 HUFA´s and marine phospholipids, ROODFeed and BROODFeedLean - for specific stages of sexual maturation resulting in optimal fecundity and egg quality and WIN Fast, weaning microdiet for fast growing marine fish larvae and nutritionally balanced for maximum growth and improved stress/disease resistance.

Booth No: 178
Luis Conceicao (lconceicao@sparos.pt)
www.sparos.pt

Nam Sai Farms Co. Ltd, Thailand is a supplier of monosex Nile and red tilapia, tilapia broodstock, striped catfish fry and barramundi fry. They also provide technical support and equipment supplies through Baan Pramong Co. Ltd., a Nam Sai joint venture company. This company compliments Nam Sai in the export of fish fry by also providing consultancy and training courses. The company also conducts contract research for other companies and institutions.

Booth No: 16
Warren Andrew Turner (warrennamsai@gmail.com)
Cherd Kaewmanee (dainsfarm@gmail.com).
www.tilapiathai.com

At **BIOMIN** we harness the power of science to support animal health and performance. By applying state-of-the-art and proprietary technology we deliver natural, sustainable and profitable solutions to the livestock industry. For over 30 years we have pioneered innovative solutions for mycotoxin risk management and gut performance. Our in-house R&D program at the BIOMIN Research Center is staffed by 80 scientific researchers and supported by eight Centers for Applied Animal Nutrition and a research network of 150 academic and research institutions globally. Our clients in the aquaculture and livestock sectors are located in more than 100 countries worldwide.

Booth No: 172-175
Anwar Hasan (anwar.hasan@biomin.net)
Justin Tan (justin.tan@biomin.net)
www.biomin.net

AQ1 Systems Pty. Ltd (AQ1) leads in sensor based feeding control and sizing systems for shrimp and fish aquaculture, using acoustic and optical sensing technology. AQ1 has released the SF200 shrimp feeding and control system. Using acoustics, it measures shrimp feeding activity to match feed delivery precisely with appetite. The system also monitors oxygen and temperature to regulate feeding if required. Oxygen can also be used to control aerators to save on power costs. System management can be local as well as over the internet. The SF200 acoustic shrimp feeding control system produces significant productivity gains in growth and feed conversion.

Presention: Increased shrimp performance using passive acoustic feeding control by Peter blyth and Danthai Thongphiew

Booth No: 135
Peter Blyth (pblyth@aq1systems.com)
Dr Danthai Thongphiew (danthait@aq1systems.com)
www.aq1systems.com

Uni-President VN has three feed mills and a shrimp hatchery in Vietnam. We help farmers succeed through collaborative innovation, applying global knowledge to research and produce new ranges of feed to consistently meet the various demands of consumers. We have developed photosynthetic bacterial PSB (brand Uni-Light). It reduces organic matter in water, and minimise H_2S at pond bottom. A special Bacillus probiotic will be launched. Our misson is to provide solutions for successful aquaculture.

Booth No: 167
Hung Cheng Yen (yen@upvn.com.vn)
Ma Chin Tien (chintien@upvn.com.vn)
Shu Su Lin (shulin@upvn.com.vn)
www.uni-president.com.vn

Since 1972, **Keeton Industries** has been a leader in fish farming and sustainable aquaculture and our management team works to ensure we have satisfied customers every time they work with us. The probiotics and microbes we manufacture produce some of the highest survival rates in fish and shrimp aquaculture environments in the world. Keeton Industries has received 7 patents on our biological treatment systems and hold the only patented probiotic in the aquaculture industry. The Keeton Industries team has travelled all over the world to meet with customers face to face in order to understand their needs and obstacles in aquaculture.

Booth No: 70
Mike Moore (mike@keetonaqua.com)
Luke Keeton (luke@keetonaqua.com)
www.keetonaqua.com

Soleval (Akiolis Group) is a French producer of premium, sustainable poultry-based ingredients for aquafeed. It provides poultry meal, hydrolysed feather meal and poultry fats to be used in many species diet such as shrimp, tilapia, salmonids, sea bass or sea bream. For each product of the range, keywords are protein content, digestibility and food safety. In Surabaya Soleval will focus on HyPro™ their special range of feather meal with a particularly high content of digestible proteins. Allowing an optimised diet formulation, HyPro™ also offers better palatability and easier pellet processing thanks to high levels of soluble proteins.

Booth No: 95-97
Mélanie Guedon (melanie.guedon@akiolis.com)
Lionel Flament (lionel.flament@akiolis.com)
Franck Boher (franck.boher@akiolis.com)
www.soleval.akiolis.com

Pentair Aquatic Eco-Systems, Inc. is the largest source of aquatic products and systems worldwide. PAES offers solutions and expertise to improve growing conditions in any environment from recirculating aquaculture systems to improving water conditions in pens. Pentair AES can help you improve results in any part of the growing cycle. As pioneers in the industry who earned their knowledge by running operations of their own, we provide the best possible solutions for aquaculture facilities, from hatcheries to grow-out and everything in between. At APA 2016, Pentair's booth will exhibit the products, services and solutions we offer to assist with all aspects of your aquaculture project.

Booth No: 29
Gaia D'Incecco
PentairAES.com

Trouw Nutrition, is a Nutreco company working closely with all Nutreco companies, R&D centres as well as supporting farmers, integrators and the feed industry around the world for over 80 years. Trouw Nutrition offers a broad range of specialised products, animal and economic models, and services that enable our customers to optimise their business by gaining better insights and making better decisions. Our mission is Feeding the Future.

At the APA 2016 we will introduce our Selko Aqua approach. Selko is a feed additive brand of Trouw Nutrition, now developed for aquaculture. These are Selko Toxo, Selko Fylax and Selko TNI Betain.

Presentations: These are on efficient mycotoxin analysis to aquaculture feeds and stress reliever in aquaculture - osmoregulatory effects of betaine in aquatic diets

Booth No: 110-113
Attila Honfi (attila.honfi@trouwnutrition.co.id)
Ramakanta Nayak (ramakanta.nayak@trouwnutrition.co.id)
Intan Anggraeni (intan.anggraeni@trouwnutrition.co.id)
www.trouwnutrition.co.id

What to look forward to in **Aqua Culture Asia Pacific in 2016**

Our editorial calendar for 2016 reflects the new trends and technologies in aquaculture in Asia Pacific. These are most relevant to the industry and will help you reach your target audience.

Volume 12 2016				
Number	3 – **May/June**	4 – **July/August**	5 – **September/October**	6 – **November/December**
Issue focus *Recent developments and challenges for the next step*	R&D & Genetics in Fish/ Shrimp	Industrialisation & Automation	Biosecurity & Disease Management	Probiotics
Industry Review *Trends and outlook, demand & supply*	Aqua Feed Production	Catfish	Marine fish	Freshwater Fish/Prawn
Feeds & Processing Technology *Technical contributions from feed industry*	Additives/Probiotics	Extrusion & Processing Technology	Feed Safety/Feed Enzymes	Nutrition & Formulation
Production Technology *Technical information and ideas*	Recirculation Aquaculture Systems	Sustainable & Responsible Aquaculture	Biofloc & Biotechnology	Aeration Technology
Aqua business Feature articles	Experiences from industry and opinion article covering role models, benchmarking, health management, SOPs, social investments, CSR, ancillary services etc			
Markets	Developments in markets (live fish, product development, market access, certifications, branding, food safety etc)			
Company/Product news	News from industry including local and regional trade shows			
Deadlines for Technical articles	**March 15**	**May 15**	**July 15**	**September 15**
Deadlines Advert bookings	**March 22**	**May 22**	**July 22**	**September 22**
Show Issue & Distribution at these events as well as local and regional meetings ****Show preview***	**Asia-Pacific Aquaculture Expo** May 26-28 Xiamen, China	**11th Asian Fisheries & Aquaculture Forum** August 3-7, Bangkok, Thailand **Vietfish 2016,** August 3-5 Ho Chi Minh City, Vietnam **The Aquaculture RoundTable Series, (TARS 2016)** August 17-18, Phuket, Thailand	**China Seafood & Fisheries Exposition 2016** November 2-4 China	

Farm tours

Surabaya is located close to shrimp and fish farms as well as research institutions. Post conference, the APA16 organisation committee has lined up several tours to aquaculture farms and research institutes as well as to top tourist destinations, beaches and museums. A summary of two farm tours is given below. More information on other tours to touristic destinations around Surabaya, details and costs of the following farm tours are available online at http://apa2016.mandiratravel.com/tour.php Email contact for farm tours is Info.apa2016@gmail.com

Madura Farm Tour- A day tour to observe shrimp farming activities such as intensive farming with a stocking density of 100-150 post larvae/m^2. The tour route will be across the famous Suranamadu bridge, which is 5.4 km in length, the longest bridge in Indonesia. The tour will also include a visit to a local village and a fish market.

Bali Tour – This 3-day visit to Bali province, east of Surabaya, starts with a flight from Surabaya followed by lunch at Ubud, in the centre of the island. The tour includes a visit to the Institute of Mariculture Research and Development in Gondol to observe work on lobster, abalone and marine fish, such as the grouper, snapper, milkfish and tuna. Next will be a visit to Gerokgak Farm, a large scale shrimp farm with a stocking density of 100-150/m^2. In between these will be visits to some of Bali's famous historical and touristic sites.

2016

Details on the events below are available online at **http://www.aquaasiapac.com/news.php**
To have your event included in this section, email details to **zuridah@aquaasiapac.com**

March 29 – 31
FIAAP Asia, VICTAM Asia, GRAPAS Asia 2016
Bangkok, Thailand
Web: www.victam.com

March 29
Aquafeed Horizons Asia 2016
Bangkok, Thailand
Web: www.feedconferences.com

April 26-28
Seafood Expo Global
Brussels, Belgium
Web: www.seafoodexpo.com/global/

April 26-29
Asia Pacific Aquaculture 2016
Surabaya, Indonesia
Email: worldaqua@aol.com
Web: www.was.org

May 26-28
Asia-Pacific Aquaculture Expo
Xiamen, China
Web: www.apaexpo.com.cn

June 2-4
Middle East Aquaculture Forum (MEAF-16)
Izmir, Turkey
Email: meaf16@meaf.ae
Web: www.meaf.ae/meaf16/

May 22-25
ONE: The Alltech Ideas Conference
Lexington, Ky., USA
Web: one.alltech.com

August 3-5
Vietfish 2016
Ho Chi Minh City, Vietnam
Web: www.en.vietfish.com.vn

August 3-7
11th Asian Fisheries and Aquaculture Forum 2016
Bangkok, Thailand
Web: www.afsconferences.net

August 4-6
Asean Fisheries and Aquaculture Conference and Exposition 2016
Bangkok, Thailand
Web: www.aseanfishexpo2016.com

August 8-9
Aqua Fisheries Cambodia
Email: sabrina.hoang@veas.com.vn
Web: www.veas.com.vn

August 17-18
The Aquaculture RoundTable Series (TARS 2016) - Shrimp Aquaculture & The New Normal
Phuket, Thailand
Email: conference@tarsaquaculture.com
Web: www.tarsaquaculture.com

September 20-23
Aquaculture Europe 2016
Edinburgh, Scotland
Web:www.easonline.org

September 28-30
Aqua Fisheries Myanmar
Yangon, Burma
Email: sabrina.hoang@veas.com.vn
Web: www.veas.com.vn

NEXT ISSUE

May/June 2016

Issue focus: R&D Genetics in Fish/Shrimp

Industry review: Aqua feeds in Asia

Feed/Production Technology: Additives and Probiotics/ Recirculation Aquaculture Systems

Show & distribution: Asia-Pacific Aquaculture Expo 2016, Xiamen, China, May 26-28

Deadlines: Articles –March 15, Adverts – March 22

Email: zuridah@aquaasiapac.com; enquiries@aquaasiapac.com for details

Asia Pacific Aquaculture 2016

Surabaya
Indonesia
April 26-29
2016

APA16

ASIA PACIFIC AQUACULTURE 2016

WORLD AQUACULTURE Society

For more info on the TRADESHOW
mario@marevent.com

For more info on the CONFERENCE
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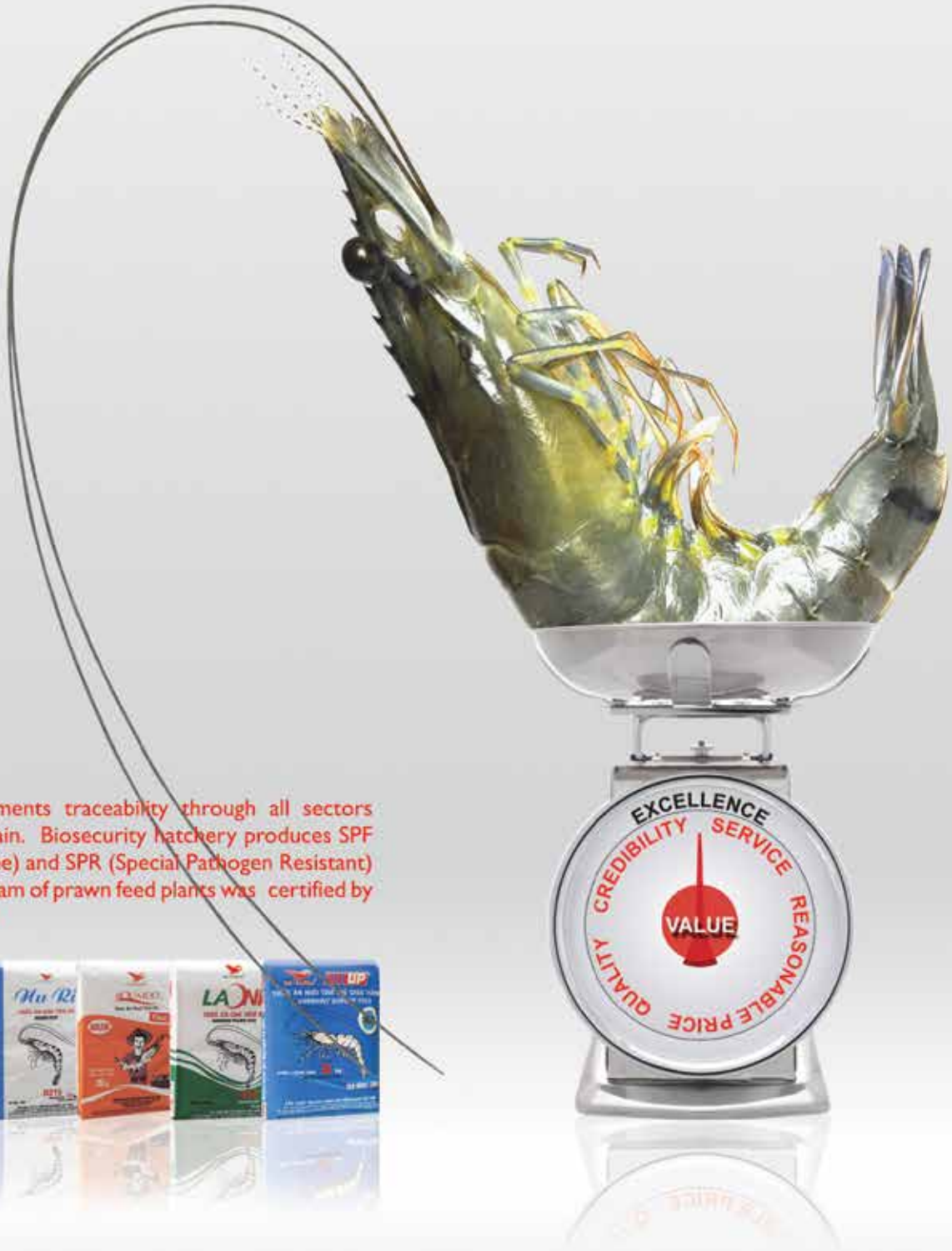

Uni-President implements traceability through all sectors along with supply chain. Biosecurity hatchery produces SPF (Special Pathogen Free) and SPR (Special Pathogen Resistant) larvae. Quality program of prawn feed plants was certified by ISO 22000 & HACCP.

- No.16-18-20, DT743 Road, Song Than II Industrial Zone, Di An Ward, Di An Town, Binh Duong Province, Vietnam
- Tel: +84-650-3737626 - Fax: +84-650-3790819
- Email: aquafeed@upvn.com.vn

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THE
AQUACULTURE ROUNDTABLESERIES® 2016

TARS 2016
The Aquaculture Roundtable Series
August 17-18 2016

A shared vision for aquaculture in Asia

SHRIMP AQUACULTURE & THE NEW NORMAL

August 17-18 2016, JW Marriott Phuket Resort & Spa, Thailand

Asia's premier aquaculture conference returns for the 6th successive year!

Don't Miss This Premier Aquaculture Industry Exchange & Networking Opportunity!

Limited to 200 participants
Early bird rate ends on 17 June 2016

Shrimp Aquaculture & The New Normal

The presence of ongoing and emerging diseases in Asia's shrimp aquaculture industry comes with adverse multiplier effects. From loss in production efficiency and rising production costs, to profitability and emotional stress for farmers. Shrimp farming is viewed as risky business today.

TARS 2016 will facilitate the exchange of insights and experiences to explore how Asia, as a unified group, can reconcile to increase its sphere of control in disease prevention and management. It will bring to focus, new management tools and production techniques, research and development, as well as new business models. The objective is to take the industry to a ***New Normal*** to better manage and control the variables in shrimp farming; build on industrialisation; and develop technical, operational and production efficiency.

INTRODUCING HARD TALK WITH SHRIMP FARMERS!
Hard-hitting questions on farming models, challenges and success with disease mitigation.

16 PLENARY SESSIONS AND 3 BREAKOUT SESSIONS

TARS 2016 *promises a comprehensive agenda of state-of-the-science and industry presentations by leading international experts that will set the tone for highly informative and interactive breakout sessions.*

STATE-OF-THE-INDUSTRY AND CHALLENGES

- State-of-Industry in Asia
- Marketing Asian Shrimp
- Challenges in India's Second Wave
- Post IMNV in Indonesia: Lessons Learnt

WEAK LINKS IN THE SUPPLY CHAIN

- Genetics for productivity: SPF versus SPT
- An Early Start for Stronger Shrimp
- Production Planning and Maximising Efficiency

LIVING WITH DISEASE

- Counting Costs of Disease Outbreaks
- Current Disease Threats and What Next?
- Disease Mitigation: Management and Production Innovations
- Disease Mitigation: Management and Feed Innovations
- Future of Extruded Shrimp Feeds in Asia?
- Living with Disease: Experiences from Thailand

TOWARDS A SUSTAINABLE SHRIMP FARMING BUSINESS

- Public-Private Partnership in Disease Mitigation
- Success with SPR Shrimp in Semi-Intensive Models in South America
- Intensive Farming under Controlled Conditions

ABOUT TARS

The Aquaculture Roundtable Series (TARS) is designed as a series of roundtable sessions to focus on specific sectors of the industry. TARS is a stakeholder driven platform where the industry, academia, government and non-government organizations convene to share new knowledge, deliberate on critical issues, and identify key strategies to ensure the sustainable development of Asia's aquaculture industry.

For more information;
email: **conference@tarsaquaculture.com**
or visit **www.tarsaquaculture.com**

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