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- 2014 production trends
- Preparing for the future in India

Unconventional farming practices in Thailand

European fish feed and farming

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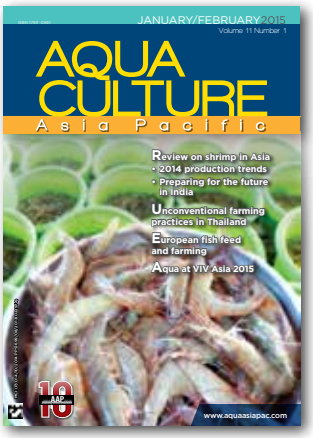

Harvest of large size shrimp in Chanthaburi province (page 8)

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Zuridah Merican

Sustainable and responsible aquaculture in 2015

February 19 heralds the year of the goat in the Chinese calendar but the world economy is starting to look fragile again. What will the new year bring to the aquaculture industry in Asia?

The shrimp industry will have to learn to live with EMS as we enter the 6th year since EMS was first detected. There is news of EMS tolerant broodstock but the commercial results of this are yet to be seen. The practice of biofloc technology to mitigate EMS works best with HDPE lining of ponds which, in turn, increases capital expenditure. In order to improve the return on investments (ROI), farms are moving in the direction of higher densities with deeper ponds and larger output per hectare. Nurseries are also encouraged resulting in 3 phase farming and increasing the number of cycles per year. In all major livestock species, the focus on early stage care has significantly improved survival rates and so should work with shrimp as well. This extra phase brings new opportunities in technology and feed requirements. However, caution dictates that we should not be addicted to high shrimp prices. Output will continue to increase due to both intensification as well as new farming areas and countries. On the other hand, demand has stagnated due to the high prices and the fragile economies of the major markets like the US, EU, Japan and China.

While the US tilapia market continues to grow slowly, the production has taken a different route. In our review of 2014, we mentioned that China will be looking at 2-3 cycles per year for smaller whole fish. This will result in a differentiation of prices with large fillets able to secure premium prices, thereby creating an opportunity for vaccination and animal health companies. There will also be an increasing differentiation between pond raised and cage farmed tilapia with the latter earning premium prices. Major feed companies are already focusing on specialised feeds to meet the nutrient requirements of the species. European feed companies with experience in salmon farming are leading the charge in Asia.

In India where both the pangasius and Indian carp are cash crops in freshwater fish farming, a new era in tilapia farming is expected by participants of the tilapia summit held last December. Although tilapia production in Vietnam is increasing, the pangasius is still the 'cash cow'. In generic marketing of the fish, producers and exporters will continue with image building for the pangasius in 2015. Year by year, Vietnam's producers have enhance their marketing efforts to demonstrate the value of the fish to the world. A new regulation on water content in 2014 is expected to help improve its image this year. Some 40% of the farming area for pangasius is already certified by various certification bodies and the industry target is to increase this. Sadly, there has been little headway with regards to the US antidumping duties imposed on pangasius imports and we hope that this will change soon.

There is no doubt that production of high value marine fish will be on the rise, particularly in Indonesia with the new government emphasizing its vision for a maritime nation. More fish is expected to enter the international live fish market. Almost all Asian producers target the live fish markets in China and Hong Kong. It is difficult to determine what the luxury seafood demand in China will be in 2015, but surely it is time that producers look at more long term and sustainable markets such the frozen and processed ones. According to Michael Fabinyi at James Cook University, Australia, "Very few people know much beyond the next link in the market supply chain. They only know their direct seller or buyer. These dominant perceptions suggest considerable room for increased education and awareness campaigns about seafood sustainability and traceability." Such a focus on short term gains and moving to new species when prices drop is not tenable. They will not have any initiative to seek optimal farming practices which means developing efficient feeds with low impact on the environment, improve on fry and fingerling quality.

Ultimately, the industry must look for long term sustainable and responsible aquaculture practices.

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Linkages for sustainable aquaculture

Taiwan is the cradle of cutting edge aquaculture in Asia. It has not only produced some of the leaders in aquaculture development for the region but the R&D driving the industrialisation of aquaculture in Taiwan and the region. Since the 1960s, Taiwanese researchers were pioneers, particularly in shrimp and marine fish breeding and farming. The National Taiwan Ocean University (NTOU) leads in aquaculture education. In 1974, the Department of Aquaculture for higher education and advanced research on aquaculture was established in NTOU. Since then, it is the only university in Taiwan to offer aquaculture degrees at all levels, from the bachelors to PhD. So far, NTOU has produced 97 MSc and 13 PhD graduates from 26 countries.

Taiwan is no longer considered the leader in shrimp and marine fish production by the majority of aquaculture stakeholders in Asia, as it is no longer able to compete with the lower cost producers in China and Vietnam. However, it is continuing with its research in aquaculture biotechnology and continues to produce highly skilled manpower, as it is determined to grow together with the rest of the region. It will use biotechnology to bring Asian aquaculture to the next level - sustainable aquaculture.

This is the premise for the formation of the collaborative platform for sustainable aquaculture, to link, coordinate and co-develop among industry, government, academy and research. The initiative is funded by the Ministry of Science and Technology (MOST) and was organised by Dr Yew-Hu Chien, Department of Aquaculture, NTOU. This cooperative network and platform facilitate the bilateral and multi-lateral cooperation in aquaculture education and technology with ASEAN countries.

Throughout the workshop held in Keelung, Taiwan from November 4-10, 2014, 30 participants from 10 countries, discussed several aspects of sustainable aquaculture: social, economic and education agenda, research in genetic stock improvements, culture systems and technology, industry participation, gender equality, biotechnology in diseases and health management. Country reports provided information on status of aquaculture in emerging aquaculture countries such as Cambodia and Myanmar.

> **“The willingness to pass on and share is essential to sustainability.”** IC Liao

Emeritus Professor IC Liao (left) with Visiting Professor to NTOU, Hisao Ogawa, Kitasato University, Japan.

In his opening messages, Academia Sinica Academician Emeritus Professor IC Liao briefly explored how to bring forth sustainable aquaculture. His message was simple, “The willingness to pass on and share is essential to sustainability.”

Liao paid tribute to the many scientists and students working with him and industry in Taiwan for their various achievements. He cited the family company, ‘Lin’s father and Sons’ which started with the artificial breeding of the milkfish in 1982 and then went on to breed ten more species.

“The sustainability of aquaculture in Taiwan is demonstrated when you become older and you hear of another success from Taiwan,” added IC Liao. In 1968, Liao set up the Tungkang Marine Laboratory, now known as the Tungkang Biotechnology Research Center. This center is synonymous with Taiwan’s achievements in aquaculture. Prior to his retirement, he secured funding for the National Aquatic Species Banks in Lukang, Tainan, Tungkang, Taitung and Penghu branches of the Fisheries Research Institute of the Ministry of Agriculture. These species banks will be the foundation for future sustainable management of aquatic resources fish in Taiwan. (See pages 47 to 49 for related report).

Dr Y-H Chien (centre) with workshop participants at the Pingtung Agricultural Biotechnology Park

Holistic approach to sustainable aquaculture with biotechnology

The early technological strengths of the aquaculture industry in Taiwan came from dedicated family based farming units, passing experiences from one generation to another and from institutional development in research and education at vocational high schools to universities. It is also the result of advisory and field training by government extension services and farmers' associations. "All these have laid down a solid foundation in aquaculture technology in Taiwan, which then spreads to many parts of Asia," said Dr Y-H Chien, Department of Aquaculture, NTOU in his presentation on "a holistic approach to sustainable development of aquaculture in Taiwan" at the Sustainable Aquaculture Workshop held from November 4-10 2014 in Keelung, Taiwan.

Over the years, aquaculture in Taiwan has seen major changes. In 2012, total aquaculture production was 347,933 tonnes, valued at NTD 36.7 billion (USD 1.1 billion). "Fish farmers are highly motivated. Faced with limitations with water resources, environmental deterioration and high production costs, the industry in Taiwan has been adjusting. The external threat is the keen competition from global markets. We have witnessed the collapse of the black tiger and kuruma shrimp industry and that of abalone farming. We lost the lead in eel and tilapia farming, with competition from China.

"Today, the grouper is a major high value finfish but ornamental fish, though smaller in volume has a higher export value. Many of our feed companies are now producing more aqua feed in their feedmills located in other countries. In 1987, we were a leading producer of the black tiger shrimp, eel, groupers and tilapia. In 1991, we produced 90,000 tonnes of the milkfish compared to only 71,598 tonnes in 2012," said Chien.

The 3R strategy

"We attribute the sustainability of aquaculture in Taiwan to the high demand for seafood, highly skilled workforce and integration of stakeholders. Further development needs a holistic approach. We are using our knowledge in aquaculture to find ways to increase productivity, improve the aqua business environment and give more attention to the ecosystem. We adopt the 3R strategy - Reduce, Recycle and Resources and aim to use less resources and energy. From the demand side, more attention is on what the consumer demands, including certification, environmentally friendly technology and animal welfare."

Chien reported on the latest initiatives to look further into R&D in biotechnology in aquaculture, both of which requires support from the government and research institutes. One example is the development of drum filters to clean up water, a project subsidised by the government. The Taiwan Tilapia Alliance has done much work to upgrade tilapia into a niche product for the sashimi market. Many products from various parts of fish have been processed as high-value products. For example, tilapia tail fins can be processed into imitation shark fins, and scales into collagen based biomaterials which are used for the production of flexible blue jeans.

PPP in aquaculture

Nowhere is public–private partnership (PPP) in aquaculture more evident than in Taiwan. Taiwan has a large pool of PhD graduates in animal health and aquaculture, whose talent the government wants the industry to tap for the advancement in aquaculture and fisheries biotechnology.

Dr Y-H Chien (left) with from second left, Dr Hong Yi Gong, assistant professor DOA, NTOU, Dr Yu-Ho Lin, Htun Win, Department of Fisheries, Myanmar and MSc student at NTOU, Khine Htet Htet Win from Myanmar

Future fisheries and aquaculture biotechnology industry development is being encouraged at the 233 ha Pingtung Agricultural Biotechnology Park, which is under the supervision of the Ministry of Agriculture (MOA) and set up as a bonded area for export. The goals are to strengthen R&D, and help park tenants increase international sales whilst nurturing talent in biotechnology. Private sector investment is matched with R&D by universities resulting in development in products such as the grouper vaccine at Merit Ocean Biotech and PCR diagnostics at Qgene Biotechnology. Japanese company Hanno Top biotechnology is developing green water saving technology such as the recirculation systems for aquaponics while Taiwan Ladies Biotech company is developing cosmetics from giant grouper by-products. In ornamentals, the goal is to raise production to USD 35 billion and integrate research institutes with other resources and build a healthy environment for farming and importation. The centre has an aquarium area for buyers to view the products of Taiwan such as the fluorescent zebra fish.

An outstanding output from a PPP is the R&D at NTOU and Jy Lin Company. Within 30 years, Dr Yu-Ho Lin has made the company Taiwan's largest producer and exporter of ornamental fish. Together with 35 associated farms, Jy Lin has developed a sustainable business with standard protocols for each farm to maintain quality control. It has developed the first green-fluorescent angel fish and the latest product is transgenic fluorescent pink angel fish.

Fluorescent transgenic angel fish at Jy Lin Company.

Shrimp infected with WSSV, picture provided by Li-Li Chen

Li-Li Chen (left) and Han-Ching Wang

Overcoming the white spot syndrome virus

The shrimp industry in south Taiwan was destroyed by white spot syndrome virus (WSSV) in 1990 and has never recovered. Its scientists have been working with the private sector within Taiwan and also abroad to find solutions against the disease. At the Sustainable Aquaculture Workshop organised by the National Taiwan Ocean University, Dr Han-Ching Wang, National Cheng Kung University and Dr Li-Li Chen, National Taiwan Ocean University, described their anti WSSV research.

"For a sustainable industry, we should learn how to develop technologies for selectively breeding high quality shrimp," said Wang. "The first step is to screen for genetic markers for disease and stress resistance, and high growth. To know what is really going on during WSSV replication in shrimp haemocyte, we used systems biology. This showed that WSSV caused metabolic rerouting in shrimp similar to a Warburg effect in vertebrates. A genetic selection of shrimp with metabolism not amenable to rerouting would prevent viral replication and confer resistance to WSSV. We know that we cannot knock down the glucose transporter as it is important for glycolysis. We therefore need to find out the upstream factors which regulate the whole abnormal metabolic shift, but are not essential to normal shrimp."

Wang explained that the next step is to expand this information into a breeding program. We will start this project with Professor Chu-Fang Lo, in 2015 at the An-Nan Campus, National Cheng Kung University.

Chen recently received an award on her research treating or preventing WSSV infections. "WSSV is a large enveloped virus with large genomes and is rather complex," said Lin. "The large genome of the virus was revealed in 2000 with three isolates from Taiwan, China and Thailand. We have data supporting information on late genesis but have no idea on the early genesis. My focus is to try to know how the virus enters the host cell."

"We know that enveloped virus will touch the receptor and will enter the cell through endocytosis. It will bind to the receptors by its envelope proteins and enter the cell, like a lock and key. Our role is to find a way to prevent the binding. WSSV attacks the gills and gut. In the case of the shrimp, we cannot have a vaccine to induce adaptive immunity. We cannot use drugs or chemicals for food safety reasons. So, we need to inhibit binding and prevent replication. I injected the recombinant VP53A protein into the shrimp and mortality decrease by 50%. Next, we used double strand RNA of the protein CBP and we can have survival at 45% when challenged with WSSV. However, in the field we cannot inject every shrimp. We then used an oral treatment. Data showed that mortality was reduced by 45%."

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Success story: unconventional farming practices

By Soraphat Panakorn

View of ponds in the farm in Leamsing district, Chantaburi province

Sustainable production continues for more than 10 years even despite current crisis with EMS

As the early mortality syndrome (EMS) crisis continues to affect farms in Thailand, an increasing number of farmers are trying out farm specific solutions and have managed to prevent EMS from occurring in their ponds or farms. As we can gather in the media, some farmers adopt hyper concentrations of dissolved oxygen in the ponds whereas others opt for a nursery protocol and adopt best farming practices.

About 10 years ago, I met a farmer who has a different perspective on shrimp farming practices, in fact very unconventional practices. Insisting his way is the most appropriate one, this farmer continues to farm shrimp in his own way and has been successful time after time. However, in the beginning, he had some teething problems in five ponds but gradually managed to slowly develop the most suitable management technique for his ponds.

Here are some of the benchmarks to his success; although simple, he has consistently achieved these results:

- During WSSV season (winter season from November to February) most farmers around his farm would be losing crops to viral outbreaks. Although he faces similar threats, his losses would be less than 5% and he could still show high profit margins.
- Higher efficiency of labour (i.e., less staff is used to take care of more ponds than in other farms. Only one staff is used to take care of 6-8 ponds with autofeeders.

- Production of large size shrimp at all seasons (20-40 g/shrimp) within 130-140 days.
- Losses to early mortality syndrome (EMS) at only 10% and with farms still profitable.
- No major crop losses in the 10 years.
- In the past 8 years, he has not used any antibiotics.

How has he achieved these results?

Farmer Mr Chatchai Chuanchom (familiarly known as Add) is 45 years old and has been farming in Leamsing District, Chantaburi province for 11 years. He started with five ponds and then expanded to 13 ponds in the following year. Gradually the number of ponds increased to a high of 182 ponds. Today, he uses 160 ponds for grow-out as he found that some ponds are not suitable for farming and converted these into reservoir ponds. The ponds are 80 cm to 150 cm in the deepest area, i.e. in the middle where sludge accumulates after each crop. Over a few crops, sometimes this sludge area grows to a mound and even out of the water surface.

With regards to biosecurity, Khun Add installed some bird scaring lines over the ponds which are now in need of repair. He is of the opinion that these lines do not actually serve a purpose and are merely required for the purpose of farm registration. There is no crab fencing or disinfectant baths at the farm. Here are some of the protocols employed which have contributed to his success.

Pond size and aeration system

The ponds in his farm are generally smaller than most other ponds in Thailand. These are just 1,500-2,000 m^2 per pond. On learning of his success, several farmers visiting his farm laughed at the pond sizes and commented that "these are not ponds but pits". However, with time, his methodology has proven to be successful. The aeration system for a pond size of 2,000 m^2 is around 3 – 4 HP with four arms and 12-14 paddle wheels on each arm. It is run continuously at a low speed at 60-70 rpm.

Chatchai Chuanchom, also familiarly known as Add

"I will decide on whether to increase or decrease stocking density for the next crop by looking at the performance of the previous crop. If my previous crop went well, I will increase by 10,000 PL/pond. If the result was just normal, I will decrease stocking by 10,000PL/pond."

However, the recent acquisitions include large ponds from 4,000m^2. Khun Add will use these as is for 4-5 crops before starting to resize these to smaller and deeper ponds.

Stocking density and post larvae.

During the boom time in shrimp farming in Thailand, the world heard of the success by some Thai farmers who were stocking 100 to 200 and even as many as 300 post larvae (PL)/m^2. This

became an attractive story which farmers worldwide wanted to emulate. But in the case of Khun Add, he insisted on a stocking density of only 20-30 PL/m^2 in addition to adjusting his stocking density according to the season.

"I will decide on whether to increase or decrease stocking density for the next crop by looking at the performance of the previous crop. If my previous crop went well, I will increase by 10,000 PL/pond. If the result was just normal, I will decrease stocking by 10,000PL/pond."

During a good season such as the rainy season from June to November, when the temperature is moderate and salinity is optimal, Khun Add will be stocking 30 PL/m^2. During the winter and colder months from November – February, the stocking density will be reduced to 20 PL/m^2. With regard to when to stock ponds, Khun Add said, "When I see birds flying over the ponds looking for food, the insects. I know that the pond is ready for stocking."

Origin of these protocols

During the first year of operations, the farm which he inherited from his mother showed losses when production was only half of the target because the taura syndrome virus (TSV) affected three out of five ponds. At that time, I had just met him. I asked him to just continue feeding the surviving shrimp. When we harvested, we calculated that the TSV infected ponds gave a higher profit as compared to the other ponds, although clean of diseases.

We then continued to conduct trials to compare between low and high stocking densities for a further two to three crops. We focused on percentage of profit instead of tonnage. Finally we conclude that low stocking density is the most appropriate method for him. The reasons are as follows:

- The shrimp were stronger and could easily go through a stressful season such as winter or extremely hot summers.
- Larger shrimp are produced which fetch higher prices.
- This method is easy to operate.
- In case of failures, the losses are smaller.
- A higher profit margin from the investment.
- It is less stressful for the owner (Khun Add).
- Shrimp ponds can be used for several crops without the need to clean the pond after each harvest.

From then on, Khun Add chose this practice. With regard to the post larvae, he co-operates with one reliable hatchery and demands the best batch. He pays higher prices which allow him to have the power to negotiate when something goes wrong. Since he is not forced to stock according to season and shrimp pond conditions like other farmers (see next topic), he can wait for the best batch and always get better quality post larvae.

Add buys post larvae (PL10-12) and relies on the hatchery to carry out all the necessary assessment tests for post larvae. If a problem arises with the post larvae, he will investigate and discuss with the hatchery owner. If the problem is caused by the hatchery, he usually gets a replacement batch of post larvae.

Pond preparation

In his case, it is a "let nature help" philosophy. Khun Add has adopted unique pond preparation techniques which may seem strange to other farmers used to the standard protocols of pond drying and preparation. After each harvest, he will not let the pond bottom dry out but instead will immediately top up with water from his reservoir ponds which actually contain water coming from other harvested ponds. He will then run half of the installed aeration system in the pond for one month.

Pond showing the sludge left over after harvest without cleanup from 12 crops

The basis for this is to allow all organic matter to be fully digested in aerobic conditions within a week. Contrary to the standard practice of stocking within a week, Add found that if he waited for another two weeks, the water colour would still be unstable and shrimp stocked in these conditions will suffer. Usually, Khun Add will wait until the fourth week before he stocks the ponds.

This is when he is sure conditions in the ponds are optimal, with benthic organisms sufficient to act as feed for the post larvae. Those benthic organisms comprise copepods, red worm or blood worm. The process is coined as "natural resurrection" in the farm.

Finally, Khun Add will clean up the pond after about 7-10 crops when it is evident that the ponds have become too shallow to feed the shrimp. Sludge from previous crops after completing aerobic digestion will provide a good mineral and nutrition base to the pond system and shrimp. At this farm, you can see grass everywhere. This is in contrast with other farms where sludge removal is carried out after almost every crop and when the tractor comes most farmers will also repair or rebuild pond dykes.

Management

As you can see in some of my previous articles (e.g., managing shrimp culture with climate change, July/August 2011, Aqua Culture Asia Pacific), the standard practice is that one HP aeration could roughly provide oxygen to shrimp biomass of about 400kg. For his ponds, Khun Add provides aeration at a much higher level as a safeguard. He operates aeration at 4 HP for a pond which holds a harvest biomass of around 1,200 kg. He even starts running the aerators immediately at pond preparation.

Birds flying over ponds searching for insects as food indicates that the pond is ready for stocking

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Khun's Add mother also helps with farm operations

Large size shrimp before harvest in a feeding tray

Khun Add has achieved average survival rates of 80-90% as shown from some recent results from his ponds in Table 1.

Table 1. Production and FCR from some ponds acquired in 2013.

Pond size (m^2)	Stocking density/ pond (PL10-12)	Days of culture (DOC)	Harvest size (pcs/ kg)	Harvest (tonnes/ pond)	Feed conversion ratio (FCR)
4,000	100,000	57	69	1.15	1.0
8,000	200,000	80	58	2.7	1.2
8,000	200,000	62	67	2.8	1.1
6,000	150,000	64	56	2.5	1.1

During the boom time in shrimp farming in Thailand some 7-8 years ago, we had the "Jatukam ramdeva amulet" phenomenon. By this I mean how many successful shrimp famers worship and hang the "Jatukam ramdeva" coin which sometimes can be a coin with a diameter of up to 10 cm around their necks. This is because they believed that this amulet will bring them luck, wealth and prosperity. Khun Add also hangs something like a big coin around his neck but it is a dissolved oxygen (DO) meter dashboard. He walks around, day and night to measure and monitor the DO level in his ponds. With amusement, he told me, "this is my amulet to help me to always be successful in shrimp farming."

Another attribute arising from his previous carrier in the airforce is discipline. He goes to bed at 6 pm and wakes up to watch over the farm after midnight onwards. Before midnight he assigns one reliable staff to do this. In this way, he assures himself that if something were to happen, he would be the one to solve the problem.

During hard times, that is, during his first seven years as a shrimp farmer, he never left the farm after darkness. He said, "In my business the critical time is at night." However, today he is beginning to accept some invitations to enjoy himself since his well trained and trusted staff can now handle the farm well.

Feeding on demand

Another diversion from standard protocols is feeding on demand; and he could be the first person, globally, to adopt this practice. The details are in my previous article on "Effective feeding in shrimp culture" (Aqua Culture Asia Pacific, March/ April 2011). I discussed this with him ten years ago after I investigated, researched and developed this technique. He was the first shrimp farmer to test this out. We did a few trials and modified this technique. I am grateful that with his help I could refine as well as prove the concept.

This special autofeeder with a small feed container and a disc distributer is an innovation to narrow the broadcasting area as the ponds are small

During the autofeeder boom in Thailand, Khun Add also started to use autofeeders which he found helped to improve the feed conversion ratio (FCR) from 1.3 to 1.1. Today 100 ponds are equipped with auto feeder. This also reduced the labour required from 4-5 ponds/person to the current 6-8 ponds/person. He has also made some innovations to suit his farming style by adjusting the autofeeder to distribute feed via a disc instead of a tube to narrow the broadcasting area since his ponds are very small.

Staff welfare and loyalty

Most of his farm staff are Cambodians. The whole family will stay in the farm. Khun Add pays them well besides providing good housing and welfare. Many of his staff earn an average salary of more than USD700/month. Most have been with him for more than five years. This is how he has earned staff loyalty and instilled honesty, devotion and diligence amongst staff. With this assurance, Add is able to relax more than some other farmers.

A special client

As the farm has been showing profits, Khun Add has become well known as a good and trusted farmer. With such a reputation, he is able to select quality inputs for his farm. For example, in shrimp feed, he decides his own feed formulation with a feed formulator. He does not mind paying the extra costs of getting custom made feeds. Feed has been a key success factor for Khun Add. He also has negotiating power with a processing plant since each year, even during poor farming seasons, only his farm has been able to supply large size shrimp.

He still manages the farm himself as the farming practice implemented is easy to operate and everything is still under control. Whereas with other farmers with 160 ponds and stocking at high density (from 70-120 PL/m^2), it is unlikely that they will be

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A recent harvest from newer ponds

able to operate as well as Khun Add. He is also willing to share his techniques with several local farmers. They visit his farms and he spends some time to guide them along. He is also open to visits by foreign farmers as he sees this as sharing information. I have written more than five articles on his farming techniques in the Thai language. To this day, I am happy to report that many farmers who have followed this farming practice have achieved success even under the current threat of EMS throughout Thailand.

In summary, I have demonstrated the unconventional farming practices at this farm. The management involves low stocking density, super aeration, small pond sizes, using nature to help prepare the pond, using science in pond operations, employing well trained staff and using the best inputs. A success rate of about 95% during a WSSV season and 90% under threats of EMS have been achieved. Despite these challenges, the farm continues to have consistent, successful crops of large size shrimp at low FCR. One reason why I support this technique is that farmers could reduce the use of shrimp brood stock, further contributing towards a sustainable industry.

Finally, this is Khun Add's message to his shrimp farmer friends; "We feed the animal by depending on nature for more than 95% of our operations. We must understand nature and implement the management techniques that are consistent with nature. If you control your greed, and do not overexploit the natural resources, success will always be yours."

During the rainy season, the farm also cultures the freshwater prawn

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How far are we from a real solution to EMS/AHPND?

By Pedro Encarnacao and Jutta Zwielehner

A holistic approach to try to reduce effects of *V. parahaemolyticus* both in the pond and inside the animal's digestive system is suggested

The decrease in shrimp production in countries (mainly Thailand, Malaysia and China) affected by the early mortality syndrome/ acute hepatopancreatic necrosis (EMS/AHPND) is causing an enormous disruption in the shrimp trade business. The damage has been estimated at more than USD 1 billion, annually. This has led to a short supply of shrimp and an all-time high shrimp prices.

Since 2011, recognising the need to combat this newly emerging disease, many institutions and agencies (national, regional, international; public and private sectors) have exerted efforts to understand and find solutions to this shrimp disease.

There are many products coming in the market claiming to be the solution for controlling EMS. Many of these claims are related to the fact that some of these products/substances can inhibit *Vibrio parahaemolitycus*. However, we need to understand that there are many strains of *V. parahaemolyticus*, some virulent for EMS/AHPND, others not. Even among those vibrios that can cause EMS/AHPND there is a wide range of virulence levels, with some "mild" strains that can cause mortalities when they reach concentration levels of 10^6 - 10^7 CFU/ml, while other more virulent strains can cause mortalities at lower levels 10^4-10^5 CFU/ml. This clearly shows that the pathogenicity of the EMS/ AHPND agent varies greatly and it is a complex process affected by many variables, including host, *Vibrio* strain, developmental stages, physiological conditions, environmental stress, and infection method.

Thus, effective solutions to be brought to the market have to integrate all these variables and test their effectiveness both in controlled laboratory conditions and also under the challenging field conditions.

Knowing the enemy is of prime importance to everyone trying to combat AHPND/EMS. *Vibrio spp.* are found in the water where the environments favour for their proliferation. They are difficult to eradicate because they do adapt well to different environmental conditions and they can adopt a dormant state when the conditions become adverse. Thus, in the fight against this virulent vibrio it is important to understand what conditions can contribute to their virulence and what substances can interfere with their growth or their ability to become virulent, this

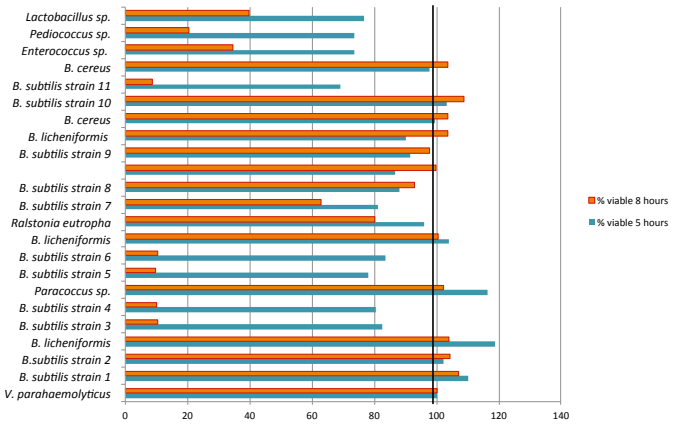
on the pond environment but also in the digestive system where vibrio creates the impact on shrimp.

Throughout these years with EMS outbreaks, we have seen farmers dedicating more attention to pond management techniques to reduce the vibrio presence in their ponds. Disinfection, use of probiotics, and more alarming, the return to wide use of antibiotics have presented no relief to the EMS problem. Often these are just generic solutions, targeting to eliminate all bacteria present in the pond and not those that target specifically the strain of vibrio involved and its capability to survive or become virulent.

We generalise that probiotics are a good solution to improve pond environment and reduce the vibrio in the water. Nevertheless we have to understand that each probiotic bacteria is different and even in the same species, different strains will give different results in the fight against vibrios.

In a laboratory experiment, we demonstrated that pathogen inhibition is a strain-specific property. Even in different strains of the same species for example in *Bacillus subtilis* there is considerable variation (only five out of eleven *B. subtilis* strains were able to inhibit the growth of virulent *V. parahaemolyticus* by 90%). This shows the importance on the selection of an effective probiotics to control the *Vibrio* and that not all probiotics have similar effects.

Figure 1: The survival of EMS virulent Vibrio parahaemolyticus when tested against culture medium of many different probiotics(source: Biomin Research Center).



The conditions and dosage of probiotics also seem to have an impact on the efficacy of the treatment. This was confirmed in a Thai shrimp farm using the nursery system and application of probiotics. After an EMS outbreak (confirmed via histopathology) in the nursery pond, an increase in the application of probiotic dosage using AquaStar® Pond and AquaStar® Hatchery stopped mortality and disease progression. All surviving shrimp recovered from EMS and showed healthy hepatopancreas.

It is clear that probiotics can be a useful tool in the fight against EMS/AHPND, but careful selection of strains against vibrio and the introduction of the right amount of beneficial bacteria are important factors for the success of probiotic application.

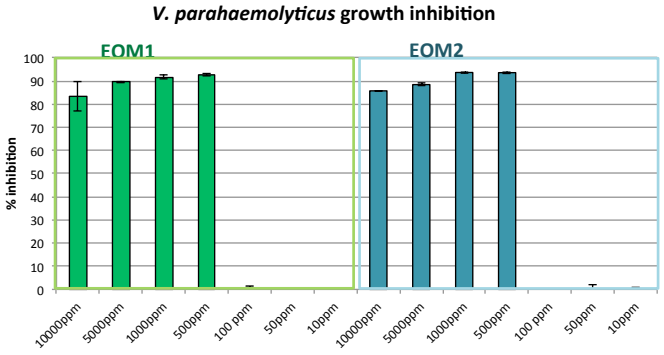
Essential oils and organic acids in feeds

The presence of pathogenic *Vibrio* in the environment will ultimately be felt in the animal digestive system, in particular the hepatopancreas. As such, strategies to reduce the effects of *V. parahaemolyticus* in the shrimp digestive system are also relevant in the protection of the animal.

Essential oil mixtures (EOM) and organic acid mixtures (AM) have been investigated for their inhibitory potential towards *V. parahaemolyticus*. These compounds may be added to the feed to enhance the immunity of the digestive system of the animal. When investigating the application of two blends of AM, results show that both the investigated acid mixtures inhibit *V. parahaemolyticus* (EMS strain) growth by 80-95%, but only at a high concentration of 5,000 ppm. The minimal effective dose would be between 1,000 and 5,000 ppm.

Essential oils mixtures (EOM) have also been demonstrated to have inhibitory potential (Figure 2) Both preparations inhibit *V. parahaemolyticus* growth by 80-85%. The minimal effective dose is between 100 -500 ppm.

Figure 2: Growth inhibition of virulent *V. parahaemolyticus* after exposure to essential oil mixtures EOM 1 and EOM2.



Inhibiting the growth of *Vibrio* prevents the pathogens from reaching a critical mass where they switch on their virulence factors after an intense bacterial chatter (quorum sensing).

However, more elegant tools are at hand that specifically cut the bacteria's phone lines: quorum quenching compounds.

Quorum quenching compounds

A wide range of phytogenic substances used in the inhibition of quorum sensing bacteria has been described. The silencing effect is termed quorum quenching. Natural compounds inhibiting quorum sensing include several species of marine algae, e.g. *Delisea pulchra*. Spices, herbs and essential oils have also been found to possess quorum quenching abilities. Figures 3 and 4 illustrate the ability of two different phytogenic products which can reduce the bacterial chatter in *vitro* without inhibiting growth.

Conclusion

Many promising concepts are currently being developed and evaluated. Nevertheless, it is clear that there is no "silver bullet" and no single solution seems to be 100% effective. To some extent, EMS occurs because the interactions between microbes

Figure 3: Phytogenic 1 Quorum Quenching

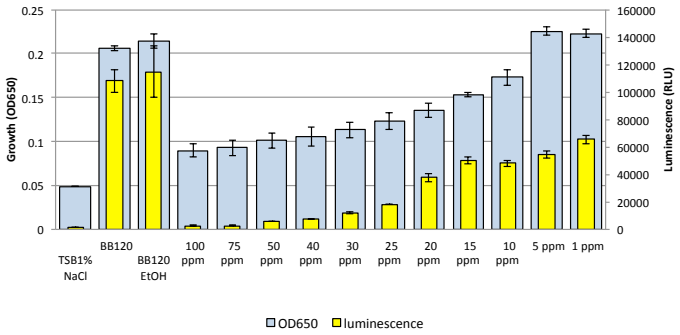
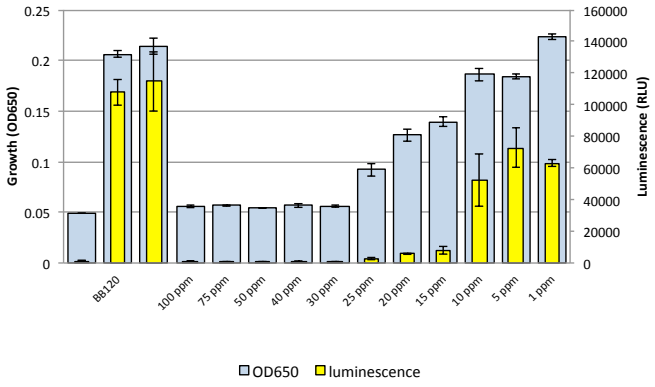


Figure 4: Phytogenic 2 Quorum Quenching



and their effects on shrimp at intensive productions scales have not been well understood or have been treated only from a clinical pathology perspective. Often, the disease, rather than the underlying cause, is looked at.

We now need to develop a more holistic approach and try to fight the problem both in the pond and inside the animal's digestive system. For this, many tools seem to be available but we need to integrate them together in order to fight the EMS menace effectively.

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Marine shrimp in Asia in 2014: Production trends

By Zuridah Merican

An apparent net gain in output with estimates of higher production for most countries in Asia apart from Thailand and Malaysia

The production of farmed vannamei and monodon shrimp by the nine top producing countries in Asia rose 5% in 2014 to 3 million tonnes based on estimates obtained from official sources and in their absence, estimates provided by industry sources (Table 1). Due to the early release of this data, the caveat is that revisions on actual numbers may be necessary but the trends remain valid. In comparison, based on industry estimates, vannamei shrimp production in Latin America could have risen 17% in 2014.

In 2014, production increases in India, Vietnam, Indonesia and the Philippines were attributed to intensification of culture with the shift to vannamei shrimp and increases in farming areas. In Indonesia, it was also the result of the revitalisation of existing ponds and success in controlling diseases after several years spent in combating infectious myonecrosis virus (IMNV). India, Indonesia and the Philippines have not reported any cases of early mortality syndrome (EMS) and producers in these countries are taking advantage of the shortage in supply to ramp up production. The push is also due to high shrimp prices which started in 2013 and continued into 2014.

EMS has affected shrimp farming in China and Vietnam but the impact on production (in terms of production volumes) has been difficult to establish. The severe impact of EMS on shrimp production is clear in Malaysia (since 2010) and Thailand (since 2012) with more than 50% decline in production.

Without doubt, the vannamei shrimp is facilitating this intensification in culture and is quickly replacing the monodon shrimp. Less monodon shrimp was produced, particularly in Indonesia, Vietnam and India. In its database for 2014, the Philippines Statistics Authority (PSA) reports high volumes for monodon or black tiger shrimp production but minimal volumes of vannamei shrimp production (1,429 tonnes in the first three quarters in 2014). Industry doubted the accuracy of these statistics based on post larvae (PL) sales.

Shrimp from an intensive culture system in Vietnam, picture by Carlos Massad (2014)

The monodon shrimp remains the major marine shrimp produced in Bangladesh. The Bangladesh Frozen Foods Exporters Association (BFFEA) expects higher production in 2014 because of its move to encourage semi-intensive and intensive culture and producing 4-8 tonnes/ha from the 160-230kg/ha in extensive systems. Hatcheries depend on wild broodstock and there is a shortage with local hatcheries producing only 6-7 billion of 8 billion post larvae demand (shrimpnews.com). An industry source said post larvae supply from West Bengal, India is reducing as its hatcheries opt to produce vannamei post larvae. Myanmar's traditional shrimp farmers continue to farm the monodon shrimp but production figures are not available. Industry sources indicated that in Malaysia, there are farmers dedicated to farming the monodon shrimp but a major setback is the lack of specific pathogen free (SPF) post larvae and high health broodstock. A similar situation is also occurring in Thailand where there is renewed interest to farm this species.

China

In 2014, production increased as farmers in different areas have successful harvests from various farming models. Industry estimates indicated a generally stable production at 1.21 million tonnes comprising 955,000 tonnes of vannamei shrimp. Industry

Table 1: Production of vannamei and monodon shrimp (tonnes) in 2012 to 2014

	Published and estimates of production in 2012[a]		Published and estimates of production in 2013[b]		Estimates of production in 2014[c]	
Country	*P. vannamei*	*P. monodon*	*P. vannamei*	*P. monodon*	*P. vannamei*	*P. monodon*
China	1,453,241	64,554	850,000	60,000	955,000	60,000
Thailand	540,000	na	250,000	na	220,000	na
Vietnam	177,817	298,607	267,615	292,884	328,000	241,000
Indonesia	251,763	117,888	386,314	178,783	504,000	126,000
Malaysia	48,991	6,577	46,473	4,483	40,000	1,800
India	180,000	60,000	300,000	45,000	300,000	45,000
Philippines	5,558	48,196	20,000	49,466	27,000	48,000
Myanmar		52,693		53,000		53,000
Bangladesh	16,611	57,785		60,000		60,000
Total Asia	2,673,981	706,300	2,120,402	743,616	2,374,000	634,800
Ecuador	281,100		286,000		340,000	
Mexico	100,320		50,000		50,000	
Brazil	74,116		90,000		90,000	
Others	132,508		146,900		190,970	
Total Americas [d]	501,181		572,900		670,970	

a Published production figures (Fishstat Plus, 2014); Thai Shrimp Association; Department of Fisheries, Malaysia; excl 137,468 tonnes of other shrimp in China

b Published and estimates. Thailand (Thai Shrimp Association); Philippines Statistics Authority (PSA); Ministry of Marine Affairs and Fisheries, Indonesia (KPPI, 2013, excl 75,000 tonnes of other shrimp), General Statistics Office, Vietnam (total 560,499 tonnes in 2013); Department of Fisheries, Malaysia

c Estimates from shrimp and feed industry sources, official estimates for Vietnam (MARD) and Indonesia

d Data and estimates for Americas provided by Fernando Garcia, Epicore, USA; Ecuador data for 2013 & 2014 (Roberto A. Santacruz-Reyes, 2014)

reports also indicated higher survival rates in farms in south China in 2014 as compared to that in 2013. More monodon shrimp was produced in 2014 at 65,000 tonnes. In 2015, production is expected to increase by only 4% to a total of 1.26 million tonnes, both for vannamei and monodon shrimp. The production of other penaeid species such as *Penaeus chinensis* is estimated at 190,000 tonnes in 2013 and 2014, and will remain at this level in 2015.

In 2014, China's shrimp farming showed three trends, according to farmers and distributors. First was a better market situation as compared to 2013. Secondly, a higher success rate for the first crop in 2014 and thirdly, the success rate was higher for extensive farms than for intensive farms. In 2014, the general trend was to decrease stocking densities and to harvest as soon as shrimp showed signs of disease. Farmers are attempting to develop low-risk strategies to achieve steady production (shrimpnews.com).

In their outlook on shrimp farming for 2014, Zhong Yumin et al. (2014) said that 'healthy' farming models with low farming density, good quality post larvae, use of probiotic for water quality control and less usage of antibiotics will be more popular. Polyculture and green house farming technology will be more readily accepted and adopted in more areas. Although there are interests in biofloc technology, it still needs further research to be applicable to the various geographical conditions and culture.

Vietnam

The Ministry of Agriculture and Rural Development (MARD) announced that 569,000 tonnes of shrimp were harvested during the first 11 months of 2014 and the official estimate for the whole of 2014 was 660,000 tonnes, an increase of 20.4% over that in 2013. Vannamei shrimp comprised 400,000 tonnes, 45.3% more than in 2013. In contrast to 50% production of vannamei shrimp in 2013, its production in 2014 was 60%. However, industry estimated only 563,000 tonnes of shrimp production in 2014 based on feed sales.

The year's bumper production was achieved despite the occurrence of EMS because of favourable weather and successful control of shrimp diseases. The area for shrimp farming increased to 676,000 ha. The Mekong Delta produced 68% of production and comprised 74% of the farming area. Table 1 shows that production in 2014 was led by Ca Mau province which produces mainly monodon shrimp (86,000 tonnes) in extensive or semi-extensive culture ponds. The large increase in shrimp farming activities has increased the demand for power supplies and infrastructure.

Table 2. Production from five main shrimp farming provinces in South Vietnam in 2014

	Ca Mau	Bac Lieu	Soc Trang	Ben Tre	Kien Giang
Farming area (ha)	267,000	124,471	52,487	52,000	90,389
Production (tonnes)	116,000	95,700	67,312	35,953	51,430

In 2015, production is expected to rise further by approximately 15% from an increase in farming area, according to industry groups. Kien Giang province in the south has made its plans to farm shrimp in an area of 90,000 ha in 2015, striving to achieve an output of 56,000 tonnes up from 51,430 tonnes in 2014 (Vasep.com).

Sectioned off area in a pond acts as a nursery in Thailand, picture by Soraphat Panakorn

A major challenge to the industry in Vietnam is the supply of post larvae. In 2014, 80 billion vannamei post larvae and 36 billion monodon post larvae were produced whereas the demand was 110 billion post larvae. The peak demand is from March to June. Most hatcheries are small-scale (10-30 million/year) with unreliable quality of post larvae; operation cost is low and post larvae are sold at low prices. Large companies produce more than 5 billion post larvae annually with high investments. The Mekong Delta is the main market at 70% followed by the southern central region. Demand is growing in the central region. Industry observers said there was insufficient quantity and inconsistent quality of post larvae in 2014, particularly during the peak season (P. Bandyopadhyay, 10 Jan, 2015, pers comm).

Indonesia

The official estimate on production in 2014 was 630,000 tonnes, up 17% over published figures in 2013. However, industry sources gave lower figures, from 350,000 to 450,000 tonnes. This increase in vannamei shrimp production is a result of a general success in shrimp farming, lucrative shrimp prices, intensification of culture and revitalisation of ponds and new farms in West Java, West Lampung, Jogjakarta, Bali and Sulawesi.

The production of the monodon shrimp is decreasing in most regions as traditional farmers opt for semi intensive farming of vannamei shrimp. This trend is part of the blue economy program of the Ministry of Marine Affairs and Fisheries, which provides the technology and supply of post larvae from the local SPF Vaname Nusantara 1 broodstock. It is also because of higher prices for smaller vannamei shrimp and the lower risk in farming this species. It was estimated that monodon shrimp may comprise only 20% of the total production in 2014.

In general, Indonesian shrimp farmers are managing well and farmers in other countries would like to emulate their success. One of the practices is the constant removal of pond sludge. According to Poh (2014), almost 90% of farms in Indonesia have installed some type of equipment or system to remove pond sludge. This could be a possible reason for the absence of EMS in Indonesia. Another practice is the use of full or semi biofloc culture system. A new trend is that more farms are investing in microbiological capability to check *Vibrio* concentrations as well as microsporidan infections. One setback to this success is some isolated cases of white faeces disease at 60 days of culture with resulting mortality.

A current issue which is being debated by industry leaders is whether shrimp farmers are ready to adopt super-intensive culture in small (1000 m^2) and deep (2 m) ponds at densities as high as 1,000 PL/m^2. This system has been successfully carried out over 6 cycles in south Sulawesi by Dr Hassanuddin Atjo. Harvests reached 150 tonnes/ha. In comparison, the optimal system in Lampung has a stocking density of 120 PL/m^2, survival of 80% and yields of 19.2 tonnes/ha. Industry called for caution

with such high risk culture systems and questioned its long term sustainability (Trobos Aqua, 2014).

India

The rise in production continued into 2014 with an estimate of 317,800 tonnes of the vannamei shrimp and 50,000 tonnes of the monodon shrimp, according to Ravi Kumar Yellanki (2014). In 2013, the production was only 292,810 tonnes. In 2014, India overtook Thailand as the leading source of shrimp into the US market.

The shift to farm vannamei shrimp by monodon shrimp farmers and the entry of new players have been rapid according to Ravi Kumar. He estimated that in 2014, monodon shrimp production will be 50,000 tonnes. Vannamei shrimp dominate production in the three top producing states of Andhra Pradesh, Tamil Nadu and Gujarat. In West Bengal, where traditional farming of monodon shrimp dominates, there are reports that more farmers are shifting to vannamei shrimp.

Dr Manoj M Sharma, Mayank Aquaculture in Gujarat expects a production of 350,000 tonnes of the vannamei shrimp and only 35,000 tonnes of the monodon shrimp in 2015. Some 4,000 tonnes will be from Gujarat state. However, in September 2014, Marimuthu Sudhakaran from Royale Impex, a farming and processing group said in Undercurrentnews.com that if all goes well, a total production of 500,000 tonnes can be expected in 2015. This is based on an increase in farming areas to 180,000 ha comprising 150,000 ha for the vannamei shrimp and 30,000 ha for the monodon shirmp. In comparison, he said that in 2013, shrimp farming area was only 150,000 ha; 80,000 ha for the vannamei and 70,000 ha for the monodon shrimp.

Vannamei shrimp farming is well regulated in India, in comparison with other producing countries. Farms and hatcheries have to be registered by the Coastal Aquaculture Authority (CAA). Imports of broodstock undergo quarantine at government facilities and stocking density is regulated at 60 PL/m^2. Previously, India was known as a supplier of large shrimp (size 20/kg or less) but most of the recent production is of smaller size 50/kg. Mayank Aquaculture is unique as it produces vannamei the monodon way with sizes of 20/kg at stocking density of 15-20 PL/m^2 (Sharma, 2014). The issue in India is not only producing shrimp according to market demand but also the small harvest window. The peak season for harvesting is in May to July which requires more processing facilities. “From 10 to 15 processing plants are being built in Andhra Pradesh alone,” said Marimuthu. The shortage of processing facilities and other challenges facing the industry were discussed at a Society of Aquaculture Professionals (SAP) meeting in 2014 (see page 25).

Philippines

The rapid change in the industry continued in 2014 with increasing volumes of vannamei shrimp being produced, and with an industry estimated production of 27,000 tonnes, based on post larvae sales. “This takes into account losses from WSSV outbreaks calculated at 1 in 4 ponds. Some 15-20,000 tonnes will come from intensive farms while the rest from extensive/ traditional farms in polyculture with milkfish or tilapia,” suggested an industry source.

The Philippines Statistics Authority reported production of 31,877 tonnes of the monodon shrimp, up to September 2014. An estimate of the production in 2014 was calculated using data for the last quarter in 2013. "The total production for 2014 could reach 48,000 tonnes only," said Chris Mitchum Ganancial, Bayer Healthcare, Philippines. Most of the production was from extensive traditional farms in Zamboanga in Mindanao, and Pampanga, Bulacan and Bataan in Central Luzon. Intensive farms contributed 2,000 to 2,500 tonnes. Monodon shrimp production is expected to decline as more extensive and traditional farmers are changing species.

Since 2013, most of the black tiger shrimp farms in Negros have now converted to vannamei farming at stocking density of 80-120 PL/m^2 during the first half of the year and 60-80 PL/m^2 approaching the later months. Intensive farms in General Santos in Mindanao stock up to 120 PL/m^2 where 60% of the total vannamei production of the country comes from.

Although vannamei shrimp farming was introduced in 2007, most farmers are still tweaking protocols and learning to understand its culture. The Philippines Shrimp Industry (Philshrimp) group updates farmers regularly. The most recent conference focussed on EMS. In 2014, the Bureau of Fisheries and Aquatic Resources (BFAR) announced plans to open a shrimp school for 20- to 30-year-old students at the Asian Fisheries Academy, with focus on vannamei shrimp farming technologies. Westly Rosario, BFAR said that once the project becomes successful, the number of shrimp farmers in the Philippines will outnumber those from China and Taiwan, who have become the primary producers of farmed shrimp in the country (shrimpnews.com).

In the Philippines, there are two major challenges in marine shrimp farming, WSSV and typhoons. According to Ganancial, Mindanao farmers were managing well with the vannamei shrimp until 2012 with typhoons leading to WSSV outbreaks. This was repeated with typhoon Yolanda in late 2013 when intensive farms in Calatagan, Batangas and Zambales were hit with WSSV and hydrogen sulphide upwelling in ponds. In collaboration with the Department of Science and Technology-Advanced Science and Technology Institute (DOST-ASTI) and the Philippine Atmospheric Geophysical and Astronomical Service (PAGASA), Bayer organised a monsoon season campaign to inform shrimp farmers of the possibility of WSSV outbreaks. This project NOAH (Nationwide Operational Assessment of Hazard) will map low pressure trends and rainfall forecast in the next 1 to 4 hours.

"An increase of 10% in vannamei shrimp production in 2015 is a possibility if farmers learn to manage their production cost, particularly lowering feed and power costs. The right timing for production is also critical considering the effect of climatic conditions, together with a breach in biosecurity with disease outbreaks," said Ganancial. (Details in a related article on the Philippines: WSSV outbreak and fish kill, breach in biosecurity, in issue March/April 2015).

Thailand

In terms of volume, the largest impact was felt by Thailand, the latest country to report EMS in late 2012. At their peak, Thailand

produced more than 640,000 tonnes (2011) and in 2013, production dropped 60% to 250,000 tonnes. At the beginning of 2014, industry projected 250,000 tonnes but in July 2014, Dr Chalor Limsuwan (2014) gave an estimate on only 180,000 tonnes. Limsuwan said that relative to 2013, outbreaks of WSSV and EMS were more severe in 2014 because of the long winter season up to February. In March to April, a more severe EMS brought down production in the first quarter of 2014.

In the 11 months of 2014, the Department of Fisheries (DOF) recorded a production of 200,000 tonnes, based on statistics from shrimp movement documents. This brought up the estimate to 220,000 tonnes for 2014. Higher production was achieved in the September/October crop with better culture conditions and higher stocking density.

The lower production in 2014 was also explained by the number of ponds in operation. The practice was for farmers to reduce risks of failures by stocking only a few ponds until a viable solution against EMS was developed or shared among them. In 2014, aside from EMS and diseases such as WSSV and Taura syndrome virus, a bottleneck is the shortage of good quality post larvae. Since September, Chareon Pokphand Foods (CPF), Thailand has introduced fast growing high quality post larvae and farmers using these post larvae as well as CPF's new hygienic farming technology (such as daily removal of sludge) reported fast growth in 60 days of culture.

Nevertheless, industry remains positive for 2015. Dr Suraphol Pratuangtum, president of the Thai Marine Shrimp Farmers Association said that the production in 2014 should be the lowest for the industry. He added that the situation will improve in 2015, as shrimp farmers adopt several strategies to cope with the disease. These range from selecting shrimp with a stronger immune system, better farm management and cleaning systems, and sufficient water reserves. In 2015, DOF's target production is 400,000 tonnes whilst industry is of the opinion that it will be closer to 300,000 tonnes.

Malaysia

Despite efforts of stakeholders to find solutions to overcome EMS, crop losses continued in ponds old and new and at varying degrees. According to industry, culture is only in 40% of ponds and out of these only 10% are free from EMS. Coupled with WSSV, EMS continued to bring down production, estimated at between 35,000 to 40,000 for 2014, similar to the industry estimate for 2013 but lower than the published figure of 46,473 tonnes.

In this fourth year with EMS in Malaysia, some farmers have become more cautious, more diligent on pond preparation and opt for a reduction in stocking density from 100 PL/m^2 to only 70-80 PL/m^2.

Since 2012, less monodon shrimp is being produced. The estimated production in 2014 was only 1,800 tonnes. However, there is interest by farmers facing crop losses with the vannamei shrimp to shift to monodon culture at stocking density from 20 to 40 PL/m^2 and harvesting 20 g shrimp. However, the constraint is the lack of sufficient SPF post larvae. Only two hatcheries supply SPF monodon post larvae.

"Industry is really in dire need of help from experts and the authorities on how to overcome the situation. This is important when the Department of Fisheries has plans to increase marine shrimp production to 478,000 tonnes by 2020. One bottleneck is post larvae quality although quantity is not an issue. In 2013, EMS was not reported in Sabah and we had expected it to contribute more to total production in 2014," said Tuan Syed Omar, president, Malaysia Shrimp Industry Association.

In 2014, Sabah in East Malaysia only produced an estimated 6,000 tonnes of vannamei shrimp. This is in spite of more than 200 new ponds in operation, stocking at 100 PL/m^2 to as high as 250 PL/m^2. EMS was not reported in Sabah until June 2014 but with rising demand from buyers in West Malaysia, farmers in Sabah intensified culture.

"Unfortunately, the 2015 production is expected to remain at the 2014 level or at best with an improvement of 10%. We may also produce more monodon shrimp," added Tuan Syed.

Nevertheless, producers in Malaysia have the advantage of a local market and ex-farm prices for the larger size 70/kg have remained high at MYR 22.50/kg (USD 6.4/kg). However, prices of smaller shrimp size 100/kg have dropped from MYR 19/kg (USD 5.40/kg) in January to MYR 17/kg (USD 4.80/kg) in December 2014. This is the result of an over-supply in local markets with emergency harvests.

Myanmar

Currently, the area used for shrimp farming in Myanmar totalled 91,318 ha (Htun Win, 2014). Some 4,000 tonnes of monodon shrimp valued at USD 38 million were exported in 2013 while the amount of white shrimp was 3,000 tonnes valued at USD15 million. Since 2001, Myanmar has 12 large scale farms using semi-intensive and intensive culture systems. Three zones have been identified for shrimp farming; Kyautan, Chaung Tha and Ngwe Saung and the total estimated production was 31,000 tonnes in 2012 (Taw, 2013).

Largely dependent on the monodon shrimp farming in traditional (extensive) systems, shrimp farmers in Myanmar (mainly in Rakhine state) saw production decreasing. Vannamei shrimp was introduced in 2006; although many farmers switched to vannamei shrimp farming, there were problems which include infrastructure, financing and disease (WSSV). In 2013, the Myanmar Shrimp Association worked with Dr Nyan Taw, shrimp consultant at Blue Archipelago in Malaysia to introduce semi-biofloc technology using imported SPF post larvae from Thailand. The production ranged from 7.45 to 11.3 tonnes/ha in 6,000 m^2 ponds. Survival was 71 to 94% and FCR ranged from 1.17 to 1.34

The monodon shrimp hatchery sector has expanded rapidly to 20 hatcheries with a total production capacity of 300 million post larvae (monodon and vannamei shrimp and freshwater prawn). However in 2014, it was reported that post larvae production would probably decrease to 20 million because of diseases, down from 30 million in 2013. The number of hatcheries has declined to 15 in 2013 and only 5 of these are operational. The industry is suffering because of erratic power supplies and shortages of ice, cold storage facilities, transportation and laboratories affecting the supply chain. There was a call for investments into the industry (shrimpnews.com).

Acknowledgements

The author is grateful to several industry stakeholders for their help in providing information for this review article.

References are available on request

India's vannamei shrimp farming: Preparing for a better future

The Society of Aquaculture Professionals (SAP) played a vital role in the introduction of *Penaeus vannamei* in India in 2009. "However, recently several issues are threatening the sustainability of this industry. SAP realised that it needs to intervene and bring these issues to the attention of key players in the industry in India as well as the authorities," said president S Muthukaruppan. It organised a special session on November 8, 2014 in Chennai. SAP invited four speakers to give their views on threats along the supply chain: hatchery and broodstock, farming, feeds and feeding, and processing and marketing.

Hatchery operations

Ravi Kumar Yellanki, Vaisakhi Bio-Marine Pvt Ltd listed several issues affecting hatchery operations. Nauplii production efficiency and zoea syndromes are two bottlenecks in this sector. In hatchery operations, faster and modular stocking are keys to overcome zoea syndrome. Antibiotics should be avoided, as it has no role in the recovery of diseased larvae. With regard to broodstock maturation, he brought up the issue of the lack of expertise and 'copycat' broodstock. The latter is seen as a major 'killer' in the industry and may set a dangerous trend, according to Ravi Kumar.

"There is a limited supply of broodstock due to the dependence on one or two sources. Other issues are slow growth, large size variation, and high susceptibility to diseases in vannamei post larvae due to the use of inbred broodstocks. There is an urgent need to establish commercial multiplication centres in India for commercial production of specific pathogen free (SPF) vannamei and black tiger shrimp broodstock locally.

Ravi Kumar Yellanki

> **"Nauplii production efficiency and zoea syndromes are two bottlenecks in hatchery."**

Ravi Kumar also made an appeal to the officials and scientific community to consider domesticating native shrimp species such as *Penaeus indicus* and *Penaeus merguensis*, and to undertake selective breeding to produce SPF broodstock of these species for future use.

Production issues

S. Chandrasekar, Inve Aquaculture, India highlighted issues in production and discussed in particular the early mortality syndrome (EMS) in countries such as Thailand and Vietnam. He said that the manifestation of running mortality syndrome (RMS) in India was due to the use of non-SPF stocks, poor pond conditions and water quality, over feeding, absence of sludge removal, high temperatures, and high saline conditions among others. White faeces syndrome and white muscle syndrome also affect shrimp production.

With regards to RMS, Chandrasekar also compared black tiger shrimp versus vannamei shrimp farming and production trends in the west versus the east coasts of India. Some recommendations for sustainable production and success include improved broodstock and larval nutrition, good disinfecting procedures using quality biocides, adequate pond preparation between crops, application of probiotics and immunostimulants, and sludge management. In addition, he gave details on low density farming in Ecuador and farming using hybrid/semi biofloc systems in Indonesia.

Export markets

Farmed shrimp production contributed 73% to India's shrimp exports. The increase in the production of vannamei shrimp helped the country with higher shrimp exports in the last two years. The US is India's second largest shrimp market at 25.7%. The US is a mature market which is susceptible to fluctuations and the EU markets are still unexplored for head-on shrimp.

"In order to achieve a target of USD 6 billion of seafood exports, a consolidated effort among all stakeholders including hatchery operators, farmers, feed millers, input suppliers and processors is needed," said SAP Founder President, S Santhana Krishnan in his analysis of the shrimp markets.

"India has several advantages over that of other shrimp exporting countries, including anti-dumping duty of 2.49%. It should take greater advantage of the US market since many countries are paying less attention to this market."

Santana said that export markets prefer size 25-30 count with premium prices but supply is seasonal. "However, size 40-50 counts accounted for 50% of shrimp exports from India. Raw material prices change with the season and prices drop during the major harvesting season (April-May) and in June to August, farmers push to harvest size 30 count leading to a short supply of shrimp of 40-50 count. Prices drop and thus understanding and cooperation between all stakeholders are needed in situations of high production."

A common question, according to Santana is whether China's purchase of Indian shrimp can be considered a healthy situation. "In the short term, this market is more suitable for new entrants and small packers. The Chinese market for Indian shrimp is not sustainable as exports to China are commonly routed through Vietnam since direct exports attract a heavy tariff.

"Finally, traceability and quality products are of utmost importance. There should be constant vigilance on antibiotic rejections and an effective residue monitoring program is critical," said Santana. Elias Sait, general secretary, Seafood Exporters Association of India also spoke to the audience on antibiotic abuse and rejections.

S Santhana Krishnan

"In order to achieve a target of USD 6 billion of seafood exports, a consolidated effort among the stakeholders, hatchery operators, farmers, feed millers, input suppliers and processors is needed..."

Ready for the next step

Dr P Ravichandran, member secretary, Coastal Aquaculture Authority (CAA) listed three salient points to move the industry forward and which should be taken up by SAP.

The information on poor reproductive performance and seed production of imported stocks in most of the hatcheries probably reflected the lack of technical knowledge and technical competence of hatchery staff. SAP should consider conducting training to staff in hatcheries which are performing poorly.

Farmers are not following the required best management practices (BMPs) especially with regard to pond preparation resulting in high mortality such as through RMS. This needs to be corrected but government extension services alone (State Fisheries and Central Institutions) cannot change farmers' mindset. As farmers are mainly dependent on advice from feed technicians, consultants and fellow operators, the latter group could play a larger role in the dissemination of information.

The immediate need is to establish broodstock multiplication centres as well as an indigenous breeding program with a nucleus breeding centre. A public–private partnership (PPP) was suggested. The aim is that at least within a time frame of 3-4 years, industry will be able to dispense away with imports of broodstock or postlarvae. (source: Society of Aquaculture Professionals, SAP summary of technical session).

Escape from EMS/AHPND at SGIC

How this is achieved is through management of culture systems, biosecurity, avoiding use of chlorine for pond and reservoir water disinfection and thorough clean-up of hatchery.

Dr Boonsirm Withyachumnarnkul at Centex Shrimp, Mahidol University said that with widespread destruction of crops with early mortality syndrome (EMS) in vannamei shrimp farming, some farms in Thailand have returned to farming the black tiger shrimp in 2013. The Shrimp Genetic. Improvement Center (SGIC), Surat Thani, Thailand has largely escaped being infected with the bacteria causing EMS or acute hepatopancreatic necrosis disease (AHPND) despite having vannamei shrimp farms in the vicinity and the center using the same source of seawater. Withyachumnarnkul attributed this to the difference in management and culture systems.

"At SGIC, culture is in biosecure concrete tanks, canvas ponds, or polyethylene-lined ponds, not more than 800m^2 is size. Water is from large reservoirs and the ratio is 10:1 (reservoir:culture pond). However, this will not prevent the entry of *Vibrio parahaemolyticus*, the bacteria causing AHPND. It could markedly reduce the numbers of the bacteria in the water at the start of stocking but not after the shrimp is stocked into the pond or tank for a few more days or months. The stocking density of monodon shrimp is 25-40 PL/m^2 which is similar to most commercial farms.

"In a few occasions, we detected *V. parahaemolyticus* in shrimp samples without clinical symptoms by PCR but we did not detect the toxic gene. Thus, this suggested that water and shrimp do occasionally contain the bacteria but the bacteria probably have no chance to colonise the shrimp stomach and produce the toxin," said Withyachumnarnkul.

"An important practice is that we avoid the chlorination in reservoirs and rearing water. We believe that it stimulates the re-growth of fast growing pathogenic bacteria and decrease the growth of beneficial bacteria. Several *Vibrio* species, among them *V. parahaemolyticus* is among those fast growing bacteria.

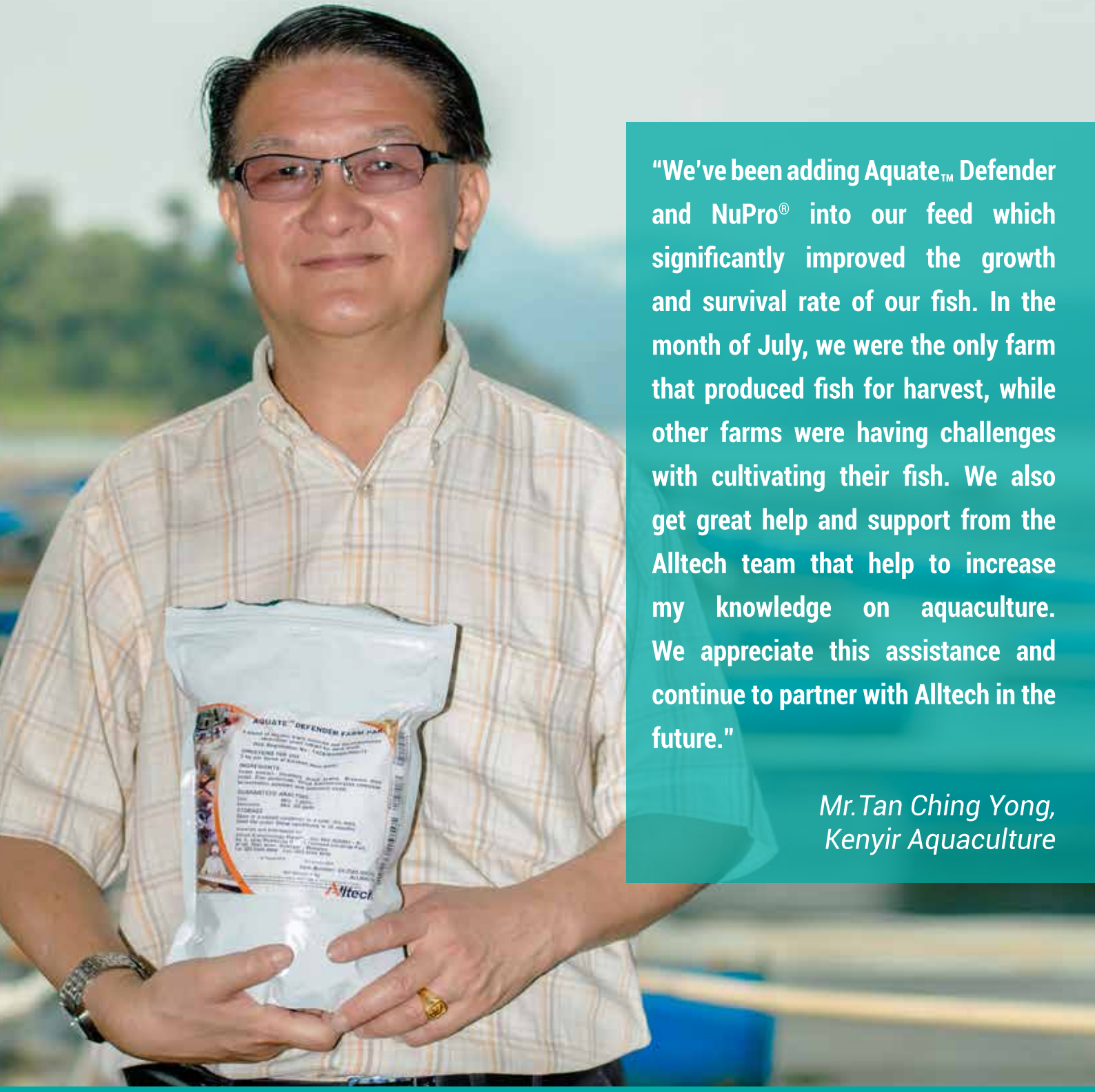
Withyachumnarnkul qualified that chlorination has been used for disinfecting tanks, PVC pipes, floor, equipment, but rarely used as water disinfectant. Another practice is the use of biofloc technology with the belief that several species of bacteria is helps with water remediation and prevent AHPND bacteria to colonise and produce toxins. Fish is stocked in the freshwater and seawater reservoirs as there is evidence that secretions from the fish decrease the number of *Vibrio* sp in the water and suppress AHPND-induced bacteria from colonising and producing the toxin. Stocking tilapia at a ratio of 1:1 in net cages did not affect shrimp growth.

"Lastly, sanitation in the SIGC hatchery is carefully observed. Cleaned and dried equipment, tanks, pipes, and others are washed, chlorinated and dried out between crops of fry production.

His message was, "All or any of those items may help fight against AHPND but most probably bioflocs and fish stocking are the two most important factors."

This article was extracted from a presentation at the Sustainable Aquaculture Workshop, NTOU, Keelung, Taiwan, November, 2014.

"Farming. It's what we do."



"We've been adding Aquate™ Defender and NuPro® into our feed which significantly improved the growth and survival rate of our fish. In the month of July, we were the only farm that produced fish for harvest, while other farms were having challenges with cultivating their fish. We also get great help and support from the Alltech team that help to increase my knowledge on aquaculture. We appreciate this assistance and continue to partner with Alltech in the future."

Mr.Tan Ching Yong,
Kenyir Aquaculture

It's what we do that makes it more profitable.

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2014 DSM Aquaculture Conference

The new team at DSM, Dr Fuci Guo (left) and Dr Eilin Ooi (middle) with Christos Antipastis (second left), Nuanpa Ariyapinyo, Marketing Coordinator, Aquaculture Centre Asia Pacific (second right) and Dr Jacques Gabaudan (right).

Learning from key strategies which helped to advance the salmon industry in Norway, carotenoids in marine shrimp in Australia, phytate P analysis in feeds to diseases and biofloc in shrimp farming in Asia.

The year 2014 marked the 20th edition of the annual DSM Aquaculture Conference for industry and clients in Asia. DSM Aquaculture Conference Asia Pacific began in 1994 when the centre in Bangkok was previously known as Roche Aquaculture Centre. In keeping with recent trends for a holistic approach to aquaculture, presentations covered key trends in feed technology and farm management, threats from diseases and discussions on how to innovate culture forms to mitigate diseases and increase farming efficiency.

In his welcome address to more than 280 participants in Bangkok, Christos Antipastis, regional marketing manager, Asia Pacific, announced the retirement of Dr Jacques Gabaudan who was director at the centre for 14 years. Gabaudan has had a long and outstanding history in aquaculture in DSM and in Asia. He welcomed the new team of Dr Fuci Guo as the regional aquaculture manager and Dr Ei-Lin Ooi as regional technical and research manager (see page 59).

"The presence of these two members demonstrates DSM's strong commitment to the growth of the aquaculture community. We will continue to contribute and further enhance our contribution to the industry. We want to understand the needs of the industry and we wish to work together to achieve a win-win situation. This has led to our success and growth of DSM's aquaculture business."

In feed technology, presentations were focussed on one on the challenges in the European fish feed and farming industry and its solutions, NIR and practical implementation of phytate P analysis, and an assessment of the mechanism of pigmentation in the black tiger shrimp. In fish and shrimp farming, presentations covered the use of biofloc technology, and the threats of EMS/AHPND and emerging shrimp diseases.

Challenges and solutions in European fish feed and farming

This was presented by **Siri Johnsen**, CEO and owner of G.O. Johnsen A.S, Norway, the 108 year-old family company and agent for DSM in Norway. The company was the first to market vitamin C in Norway in the 1930s. Johnsen described the development of optimal farming practices and feed for the salmon and how key developments helped to advance the farming industry to its current level.

"In 1987, Norway produced only 48,000 tonnes of Atlantic salmon and by 2013, this expanded to 1.2 million tonnes. This demonstrates a generation of growth and development in technology and feeding strategies over 30 years. We do things differently in tune with the competence that has been built up and shared by stakeholders in the industry.

"Today, the production chain from roe to table, takes 3 years, comprising 10-14 months in freshwater tanks for fish of 100 g. Vaccinated by injection, each 100 g fish is then transferred to seawater cages for the next 14-24 months to produce marketable 4-5 kg fish. In Norway, 24 companies produce 80% of its salmon output and feed is supplied by five companies, three global and one integrated. Salmon is fed on high energy extruded diets."

Siri Johnsen

> **“Communication and dialogues with NGOs, public, retail consumers are part of getting the permission to grow...”**

A permission to grow

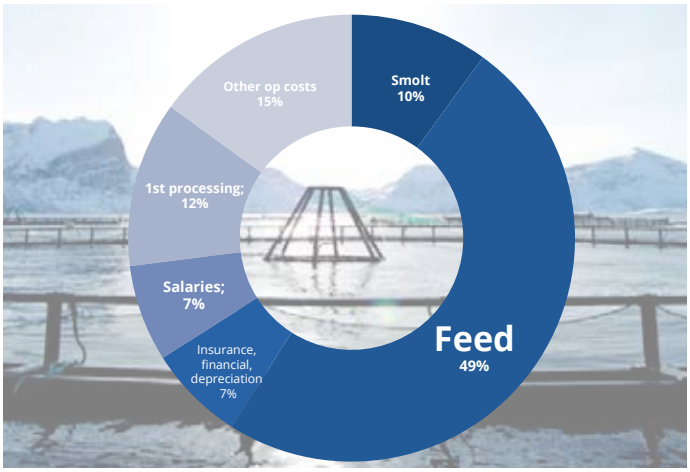
“Throughout the supply chain, the government is a major stakeholder, not only with by-laws and regulations but also in funding research. Together, industry, research institutes and the government jointly work to explore further new farming areas. In feeds, although Norway is not a member of the European Union (EU), it follows EU regulations on feed, raw materials, use of by products and additives”, said Johnsen.

“Non-governmental organisations (NGOs) are major stakeholders and have concerns and interest in the way farming is done. Communication and dialogues with NGOs, the public, retail consumers are part of getting the ‘permission to grow’. In Norway, we have nature given conditions which will allow the industry to grow up to 5 million tonnes by 2050. But to do this in a sustainable way, we need to address some challenges.”

Johnsen clustered these challenges under the discussion on ‘permission to grow’ as she believes that this requires the agreement of stakeholders. There should be respect of the ecosystem as fish farms need good quality water. This can be done by allocating sites. In future, it can be expected that authorities will have more and more regulations on limits on discharge of nitrogen and phosphorus. Another aspect is the protection of wild populations of salmon (with their specific genetics linked to rivers) returning to rivers. These cannot be contaminated with farmed salmon (whose genetics comprise stocks from several rivers). The strategy is to limit the number of escapees from farms.

“The biggest issue is management of parasites and diseases. The peak of antibiotic usage was in 1987 when there was no effective vaccines. In 1994, with the advent of vaccines coupled with good husbandry practices and functional feeds, the volume

Figure 1. Cost components in Norwegian salmon farming (Source: Norwegian Directorate of Fisheries, Profitability Survey 2012)



From left, Aekaphan Ratchatasettakul and Dr. Prakan Chiarahkhongman, Charoen Pokphand Group, Dr. Boonsirm Withyachumnarnkul, Centex Shrimp, Mahidol University, Dr. Nyan Taw, Blue Archipelago Malaysia, Suphol Phantumaophas and Chaweng Thongtuak, Charoen Pokphand Group

of antibiotics dropped to one tonne. Despite the increase in production, industry has maintained this same volume of antibiotics," said Johnsen.

"Infestation with sealice remains a problem. The government regulates a limit of 0.5 female mature lice per fish per week and the farmer has to count lice on each fish each week. Chemical treatment is allowed twice per year. Cooperation among farms is important especially when farms carry out treatments. This is a concern by all farms in a whole area or fjord. Salmon is important to Norway. It is a big industry providing employment in coastal areas. Furthermore as some companies are going global, the expectation is that they extend best practices worldwide."

Biology and cost as keys to success

In Norway, the authorities regulate production with a maximum allowed biomass per site and the farms seek to optimise production based on variation in growth rate linked to changing water temperatures.

"In 2013, we achieved a feed conversion ratio of 1.2 but feeds remain the highest cost component at 49% followed by smolt costs at 10%, fish processing at 12% and insurance and salaries at 7%. The current cost of production is € 3/kg. The ex-farm price is € 5/kg and we expect this to remain as we have data on the number of eggs and the smolt supply (Figure 1).

The new normal in salmon feeds

"Feed is an important input factor but is also a challenge. In 1990, salmon feed contained almost 90% marine raw materials, comprising 65% of marine protein and 24% marine oils. With a lot of science and after years of searching for alternatives for sustainable growth, in 2013, the new normal for feed composition is 36.6% of plant proteins and fish meal was reduced from 30% to 18%. The rest of the ingredients include 19% plant oils, 11% fish oil and 3.7% micro-ingredients of which krill meal is 1%."

Johnsen added, "Plant meals comprise more than 60% soy together with other plant meals (wheat, sunflower, maize, faba beans and peas). Soy is mainly soy protein concentrate (SPC) which is refined and without anti-nutritional factors. It costs more but we are assured of optimal nutrition and growth of fish. If we use normal soy, there will be a problem with gut health.

"Trials were conducted to replace all the fats with rapeseed oil and its effects on the sensory quality of fillet. If only 75% of rapeseed oil is used, the sensory change is not obvious. So this is a question of optimising between plant oils and fish oils."

Alternatives to marine meals

However, this is not the end. Future alternatives are precondition on ensuring fish quality and that the salmon remains as a healthy, tasty product with the essential omega 3 fatty acids. Johnsen said that it is fortunate that out of the 30% marine raw materials in feed in 2013, 25% came from by products from marine fish processing. Krill is a sustainable source but is costly and is usually used in functional feeds and as taste attractant. Other possibilities are mesopelagic fish and algae.

"Although the EU authorities have allowed the use of animal by product meals in aquafeeds, this is still prohibited in Norwegian salmon farming because the consumer does not want these in feed. The standard is communicated along the supply chain and industry follows this. But it could change in the future with the lack of availability of raw materials. Plant materials are being refined to remove anti nutritional factors. The use of GMOs (genetic modified organisms) is not allowed and it is difficult to foresee this being used in Europe because of concerns from consumers. Some future alternatives are microbial and single cell proteins from gas and insect meals. Algae high in DHA and EPA from lower parts of the food chain can be selected and industrialised production can be done" said Johnsen.

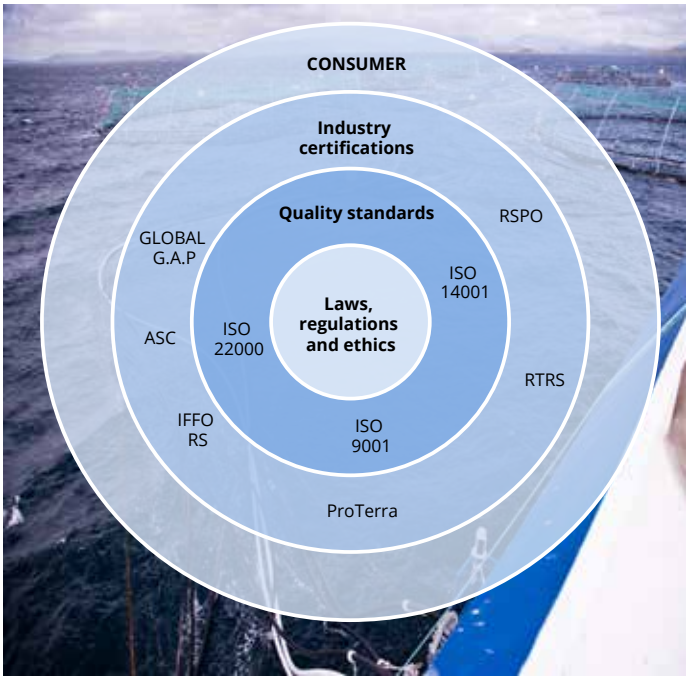
"The use of micro-ingredients was only 1% in 1990 and has increased to 4% in 2013. Micro ingredients such as amino acids and vitamins A and D and minerals enabled the switch from marine to plant raw materials. This also means that research to re-evaluate the addition of nutrients like amino acids and vitamins with new ingredients is required. In Norway, functional feeds containing compounds such as beta-glucans and nucleotides have been integrated into feeding the salmon to boost the immune system and are used at specific periods such as during fish transfers, and periods of temperature changes. The future will be the use of enzymes to reduce discharge of nitrogen and phosphorus into the environment."

Product quality

"However, with whatever sources of raw materials, there is the challenge of having sufficient EPA/DHA in feed and fish. What is the required level of DHA and EPA in salmon feed in order to secure the health and growth of the fish? What is the right level in the salmon fillet in order to ensure that salmon is a good source of omega3 fatty acids?

"EFSA (European Food Safety Authority has recommended an intake of 0.25 g of DHA and EPA per day for cardiovascular health. If the content of DHA and EPA in salmon feed was 5% of

Figure 2 Criteria for sustainable sourcing



total fatty acids, this will give 2.2 g of DHA and EPA in 250 g fish. This would be more than the recommendation. This is how the industry is trying to achieve a scientific platform in the future."

Challenge on quality sourcing

Once the raw materials have been procured, how can the feed producer secure a safe and sustainable supply? Johnsen said that firstly the user need to ensure that the raw materials conform to laws, regulations and ethics before it can be allowed into the supply chain. ISO standards assure that the supplier has consistency in quality. The goal is that all fish meal and oils used is from responsible stocks. IFFO RS (Responsible Supply of Fishmeal and Fish Oil), RSPO (Roundtable on Sustainable Palm Oil) and RTSR (Round Table Responsible Soy) are recognised Figure 2. The outside influence is the consumer and Johnsen explained the issue with blood meal.

"Blood meal is a good protein source for the fish. It contains the scarce histidine. It is allowed, meets quality and industry standard but it is not used. The consumer perception is that it should not enter into the animal food chain. The consumer does not like the image of blood meal being part of the salmon diet. Another example is how palm oil has been removed in diets by key producers, despite it being a good energy source and binder. Pressure was from consumers and social media."

The key takeaway message is that the 'unlimited power of the consumer' is valid throughout the whole industry'.

"The clusters of challenges mentioned are not company specific. In Norway, we see how the different stakeholders cooperate and share competences that they have built up. At present, industry may have found solutions and have reached a certain level but there are still more to be addressed."

Carotenoids and pigmentation in crustaceans

Dr Nicholas Wade, research scientist at the CSIRO Agricultural Productivity Flagship, Brisbane Australia discussed creating the perfectly coloured crustacean. In *Penaeus monodon* this is a moving target. The red colour is a major factor in consumer desirability and acceptability. Higher production costs are offset by increased sale prices. In Australia, feed costs more but the farmers are receiving a premium of AUD 2-3/kg for shrimp with enhanced red colouration in cooked shrimp.

In his presentation on 'Optimising pigmentation in crustaceans, combining diet, environment and genetics', Wade discussed carotenoids and pigmentation followed by carotenoid utilisation.

With regard to carotenoids and pigmentation, he said that feed, photoperiod, environment and genetics work together to impart a desired colour and subsequently, the challenge is how to keep the colour. The research at CSIRO focussed on *P. monodon*.

"The carotenoid astaxanthin is most abundant in shrimp tissues and is the most efficient additive. If beta carotene or any other carotenoid is given, it is converted to astaxanthin for storage. We are clear on the feeding rates of the carotenoid astaxanthin which has been optimised over the last several decades. Today, we know that if we feed more, the faster the colour will develop or we can lower the inclusion in diets and feed for a longer duration to achieve the same level of pigmentation.

"A rapid effect on pigmentation is the environment i.e. background colour. After feeding, to enhance the colouration, it is also possible to expose shrimp to a black background. This can also help reduce variation in shrimp colour. Using the SalmoFan™ scale to assign a score to the colour of cooked shrimp, we can see that exposure to either a black or a white coloured background produces shrimp at opposite ends of the colour scale as in Figure 3.

"Colour is controlled by eyestalk hormones expanding and contracting the chromatophores. Background colour causes a shift in the proportion of astaxanthin esters in the hypodermal tissue of the shrimp. With a black background, there is a higher proportion of free astaxanthin and with a white background, astaxanthin is esterified to mono- and di-esters. Carotenoids are not removed but are being rearranged," said Wade.

Nick Wade

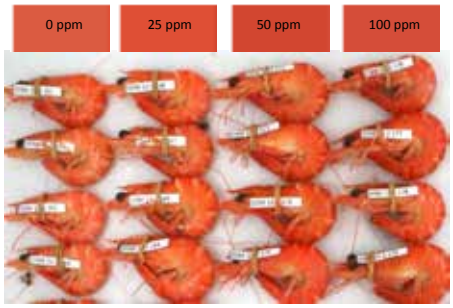
> **"The reverse is that you can also ruin the effects of feeding the shrimp with with increasing levels ofastaxanthin by exposing them to a white background."**

Some participants from Thailand, Bonggan Ganjanagidsopon, Top Feed Mills (left), Dr Juadee Pongmaneerat, Department of Fisheries (second left) Dr Mati Nitibhon, Charoen Pokphand Group (second right) and Dr Sompong Doolgindachbaporn, Khon Kaen University (right).

Do environment and genetics interact?

Wade also discussed the genetic effects on crustacean colour. The critical element in producing optimal shrimp colour is the protein called crustacyanin (CRCN) which binds astaxanthin and adjusts its colour. Two genes have been identified. Cooking the shrimp releases free astaxanthin.

Figure 3. Effects of dietary astaxanthin supplemention



This was investigated in a 6-week trial where shrimp was exposed to either a wblack or white background and fed 50 ppm astaxanthin. A protein gel separated the CRCN protein from all other epithelial proteins.

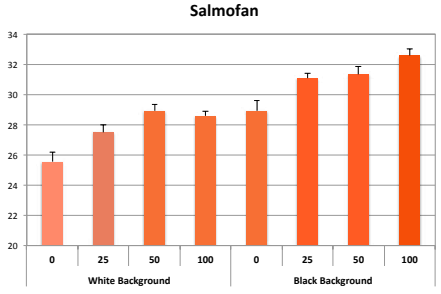
"With a dark background, there is an increased amount and distribution of the CRCN protein. We did not see any change in CRCN gene expression with exposure. In a white background, the animal is rearranging and storing the carotenoid in tissues as mono or di-esters. The CRCN protein is reduced and colour is not distributed in the same way. This suggested that to achieve the dark colouration, not only do we need the carotenoid but need the CRCN protein. Abundance of this protein is critical to achieve the highest grade scores."

Effects of diet and environment

In another trial, shrimp were kept for 6 weeks in a red background, and fed treatment diets with astaxanthin at 1, 25, 50 and 100 mg/kg diet inclusion rates followed by a short term (120 minutes) exposure to a black or white background. In uncooked shrimp, the effect of dose response was clear, according to Wade.

"If you do not feed carotenoids and expose the shrimp to either a black or white background, the shrimp are much paler in colour compared with shrimp fed dietary astaxanthin. Therefore colour increases with increasing amounts of dietary astaxanthin and is higher again with exposure to black backgrounds. The effect is additive.

Figure 4. Colour score chart of cooked shrimp fed different levels of astaxanthin and exposure to black or white background



"The reverse is that you can also ruin the effects of feeding the shrimp with increasing levels of astaxanthin by exposing them to a white background. But you can also impart colour by increasing the inclusion level of the astaxanthin as shown in the graph (Figure 4). Diet and evironment work in combination to improve the shrimp colouration."

Commercial application

CSIRO collaborates with industry in Australia to demonstrate effects in a farming situation. Shrimp were fed feeds containing 80 ppm of astaxanthin for 6 weeks as finishing diets. Shrimp were then harvested live into the large bins, either black or white in colour and held for different lengths of time up to 2 hours.

"We did this three times. As with live animals, the results were different each time. In general, exposure to a white background gave a significantly lower grade score which meant that the farm may benefit from changing the harvest bins to get higher colour scores. This shows that this works in farms although not as well as in the laboratory. There are other factors contributing to the colour change such as pond water, background and algae, which we could not measure. There is also an element of harvest stress."

From Thailand, Dr Supis Thongrod (middle) and Ekanant Yuwabenchapol (left) Thai Union Feed with Donald Prayogo, Inter Pacific Marine Products, Thailand

Is pigmentation retained? Wade showed that any changes in pigmentation before harvest are retained through freezer storage. They assessed colour up to 217 days of storage at less than 30 °C.

Carotenoid utilisation

New information show that carotenoids in tissues may go beyond just pigmentation. There is a better understanding that dietary astaxanthin has positive effects on crustacean growth, colour, and quality, including other possible benefits on stress and disease challenge. There is evidence to show that either growth or survival or both are positively affected by carotenoids in the feed for crustaceans. Tests are also being conducted to assess viral susceptibility and resistance to physiological stresses. In trials, *P. monodon* fed four different carotenoid levels (0, 25, 50 and 100 mg/kg of astaxanthin) over 6 weeks showed no differences in survival for all treatments but growth was lower in the group fed diets with no dietary carotenoid. The critical level is still unknown but without dietary supplementation, it appears that carotenoid levels are depleted over time which affects both growth and colour. High dietary carotenoid levels are well utilised and form specific esters that may have other beneficial effects such as responses to disease and stress.

NIRS to determine phytate P

Arne Korsbak, DSM marketing manager for feed enzymes for Europe, the Middle East and Africa gave a presentation on using the NIR system (Near Infra Red) to determine phytate in feedstuffs and the practical implementation of the phytate calculator and data in a least cost formulation program. Korsbak outlined the principles of NIR, and how invisible light (1100 to 2500 wavelengths) can give information on feed and raw material samples.

"In the past wet chemistry was used to determine the level of phytate in raw materials. Although this process is still valid, it is rather time consuming and expensive. NIR analysis is a rapid method and is already in use by most feed millers to determine the moisture, protein, fat and starch contents in feed. It became clear to DSM that we only need to create calibration figures for NIR machines to support phytate analysis. To do this, we need to correlate wet chemistry results with the NIR spectrum data. We analysed 2000 different raw material samples to calibrate the NIR machines."

Arne Korsbak

"As we are now working with more plant meals, it is important than feed formulators have more information on the phytate P content which makes up 40% to 80% of the total phosphorus present in plant feed ingredients and is not available for the animal to access."

Phosphorus in feeds

Why is there a need to predict the phytate phosphorus (P) content in raw materials? Korsbak said that as more plant meals are being used in fish feed formulation, there would be more phytate P in diets, which the fish cannot access without the enzyme phytase. At the same time, it is important to be sure that the combinations of raw material provide the substrates for the phytase to work on.

"At the end of 2007, we had the phosphorus crisis where there was a shortage of inorganic phosphorus. Prices skyrocketed to as high as €1500/tonne from €200/tonne. The availability of phosphorus is not limitless and at the rate of consumption, may be in short supply in the future. Beside this availability issue, there is the environmental impact of excretion of unutilised phosphorus. If we can use phosphorus within raw materials in a better way, we can take out DCP or MCP to save on feed costs," said Korsbak.

"Phytates contain anti-nutritional factors (ANF). They are negatively charged and in the gut, chelate with positively charged cations and reduce the availability of minerals such as calcium, zinc, cobalt, copper, manganese, iron and magnesium. The use of phytase will not only release phosphorus but also other minerals. Therefore, already now and even more in the future, it is important to predict the level of phytate P in each diet.

"As we are now working with more plant meals, it is important than feed formulators have more information on the phytate P content which makes up 40% to 80% of the total phosphorus present in plant feed ingredients and is not available for the animal to access."

Phosphorus is required for normal growth, feed efficiency, bone mineralisation and metabolism. Deficiency of phosphorus will lead to skeletal deformities. The requirement is 0.4 to 0.9 % of the fish diet and will vary with the life stages of the fish. On average, fish require 0.6 to 0.7% of available phosphorus in their diet.

"The requirement is based on available phosphorus but this is lower in plant meals as compared to fishmeal. Availability also depends on species. For example, available P in fishmeal is higher in the trout than in carp. The main target for phytase application is to improve the ability of phosphorus from plant proteins, lower the effect of ANF and improve mineral and other nutrient availability," added Korsbak.

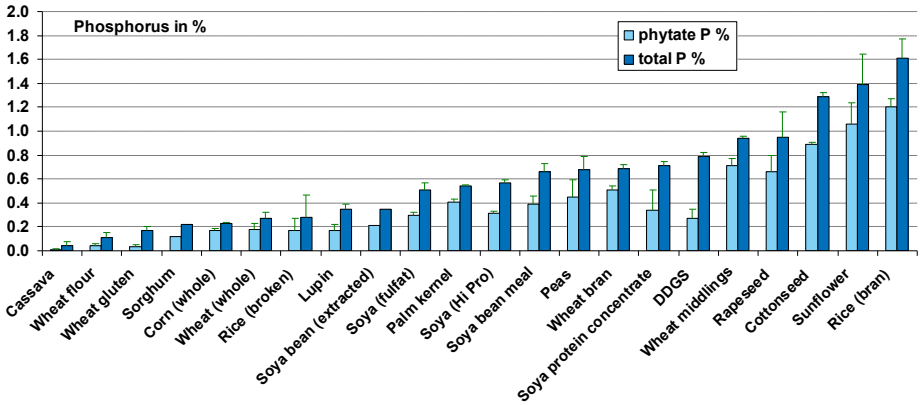
Phytate P in feedstuffs

It follows that information on phytate P in feedstuffs is essential for feed formulators to derive at optimal phosphorus concentrations in the diets. DSM has a dedicated analytical solution to support customers. Data on phytate P in cereals and plant proteins and their by-products were presented. Raw materials also show a huge variability in phytic P (calculated from phytate P) such as in oil seed meals which range from 0.15 to 0.80 mg/g for soybean meal and rapeseed meal, respectively. In rapeseed meals, it is 69% of phytate P.

"How can we use this information in a practical and easy tool in our daily work? Using a phytate calculator, in a tilapia diet, we can select various ingredients at different ratios and predict the total phytate P. A minimum phytate P level should be 0.23% to get the full benefit of phytase availability and liberate 78% phosphorus. When this information is used for a least cost formulation, I can get total phosphorus of 8.5 g/kg, phytate P 3.3 g/kg and phytase digestiblity at 59.43%."

However the prediction of phytate P in feedstuffs is not that simple as it starts with the collection of a specific constituent in a sample followed by derivation of the mathematical relationship. Reference samples are required. To compare results, samples must be standardised, such as through a standard grinding process and temperature maintenance. There can be no direct calibration since different machines are used in the industry. However, standarisation has been established for the DS2500 NIR.

Figure 5. Phytate-P and total P in main aquafeed ingredients



Intensive shrimp farming with biofloc technology

Dr Yoram Avnimelech, Technion, Israel Institute of Technology introduced biofloc technology (BFT) for intensive farming of both fish and shrimp. Avnimelech, an expert in BFT has co-authored three practical guides on the technology. The third was recently published in 2014 (see page 38).

"Aquaculture has to be more efficient in the use of water resources and one direction is in intensive aquaculture in closed systems with zero or low water exchange. However, the high biomass means high accumulation of organic matter: as in the case of shrimp, for each kg of feed with 35% protein and 54 g of nitrogen, 38 g is excreted into the water. In conventional systems, to remove nitrogenous wastes, the options are water dilution, using plant and algae to consume the nitrogenous wastes or nitrification by autotrophic bacteria. This means that culture water needs to be recycled through a series of biofilters to treat the water adding up to costs in production."

"The principles of BFT include: zero or minimal water exchange; the development of a dense microbial population as part of the pond ecosystem; and a carbon to nitrogen (C:N) ratio of 15 to control inorganic nitrogen concentration in the water. Water treatment depends on the control of heterotrophic bacteria with the culture component in tandem with nitrifying bacteria and algae. In addition, feed nutrients are recycled, doubling the utilisation of protein."

Avnimelech compares BFT with an external biofiltration system which is effective in removing nitrogenous wastes but at a high cost. "BFT is best explained as an integrated system within a pond. The bioflocs are an ecological niche containing bacteria, algae, protozoa and zooplankton feeding on fish culture residues and recycling the feed within this niche. Bacteria are small but a dense population join together in a floc. It is possible to change the size composition of bacteria in a floc. We can use microbes to degrade the wastes, part of it to carbon dioxide and about 50% to microbial biomass.

"On how much carbon is required, Avnimelech said that 20 g of carbohydrate such as from molasses, cassava etc. are needed to sequester 1 g of ammonium. "This is calculated when there is no algae and no nitrification. This is the maximum amount to add although often there are some algae in the pond. Adding too much is not harmful, just additional cost."

Commercial applications

Dr Nyan Taw, Blue Archipelago, Malaysia provided examples of how BFT is applied in commercial farms. A farm in Belize was the first to carry out vannamei shrimp farming in bioflocs. It achieved 13.5 tonnes/ha production when conventional shrimp farming in the US yielded only 3.5 tonnes/ha. At that time, biofloc was known as bacteria floc. In the early 2000s, R&D on biofloc

Avnimelech and Nyan Taw with participants from Indonesia, from left, Teddy Njoto, PT Matahari Sakti, Nyan Taw, Rika, DSM Nutritional Products Indonesia, Yoram Avnimelech, Artiningsih, DSM Nutritional Products Indonesia, Candra Yanuartin Tjan, PT Sinta Prima, Stephani, PT Wonokoyo Jaya Corporindo, Sandy and Erwin, Japfa Comfeed Aqua Feed.

systems for vannamei shrimp ponds in Indonesia produced yields as high as 50 tonnes/ha/crop. The first commercial application of biofloc in 26 semi-lined ponds yielded 22 tonnes/ha of vannamei shrimp. Feed conversion ratio was 1:1.

"Today, using full biofloc systems, commercial production of vannamei shrimp reach 20-25 tonnes/ha/crop whilst with semi-biofloc systems, the average production of vannamei shrimp is around 15-16 tonnes/ha/crop. In the US, Samocha (2009), reported production of up to 12.0 kg/m^3 (120 tonnes/ha) in closed super-intensive biofloc raceway systems of vannamei shrimp. Smith (2008) reported on semi biofloc systems with Penaeus monodon in Australia which yielded 10.0 to 12.0 tonnes/ha with stocking density of 45 PL/m^3 from stable biofloc" said Taw.

"What is usually misunderstood is that we start with a normal phytoplankton system. Molasses and wheat flour grain are added as the carbon source and there is a transition time of 4-5 weeks. There is actually a fluctuation between algae and bioflocs in ponds; pH fluctuation is narrow and alkalinity will go down. It must be clear to pond technicians that contrary to conventional farming systems, brown and foamy water in biofloc ponds are not signs of poor culture conditions and the health status of shrimp is demonstrated by shrimp actively jumping in the ponds. Biofloc populations differ in size and species composition from one pond to another.

Taw summarised the principles in shrimp farming using BFT. "This is a system for intensive culture in zero water exchange where evaporated water is replaced by treated water. In full biofloc systems, the stocking density is 130-150 post larvae (PL10)/m^2 with strong aeration (28-32 HP/ha) using 15 paddlewheels/ha running continuously for 22/24 hours. The positioning of the paddlewheel is critical to suspend the flocs and particularly essential to centralise sludge for easy siphoning out of ponds. Biofloc is controlled at 15 ml/L. Grain pellets do not act as feed but for balancing C:N ratio at more than 15 and suspended particles provide the attachment for the bacteria flocs to form larger colonies.

"Semi biofloc systems require a lower level of management at floc control of less than 5 ml/L. The stocking density is 80-100 PL10/m^2, while paddlewheel requirement is 22-24 HP/ha. Recently, we have discovered that shrimp farming in bioflocs can work well in HPDE lined, concrete lined as well as earthen ponds. In general, shrimp from biofloc systems have darker red colouration when cooked, with a score of 30-31 on the "Salmon scale," said Taw.

Both Avnimelech and Taw emphasised the advantage of the system relating to biosecurity and disease prevention, which has been supported by research output and anecdotal information. Taw quoted the case of a farm in Bali which previously had problems with white spot syndrome virus (WSSV) and infectious myonecrosis (IMNV). Since 2009, upon adoption of biofloc systems, production reached 33 tonnes/ha with no incidences of disease. The South China Sea Fisheries Research Institute in China reported that high dissolved oxygen conditions and promoting heterotrophic bacteria growth are two important methods to prevent disease outbreaks after a tropical storm in 2010.

Biofloc as feeds

In his second presentation, Avnimelech discussed the use of bioflocs as feed within the pond system and as a feed ingredient. "Suspended bioflocs in intensive systems without or with limited water exchange carry a high feed equivalent. In ponds with a biofloc of 100 mg/L, the equivalent feed potential stored in the pond is about 1000 kg/ha. Shrimp and fish can harness this feed. Research indicated that external feed can be reduced by 20%. However, what the quantity of bioflocs consumed represents is a saving on feed costs and this is the added value of the biofloc."

From left, Vilas Autade, DSM Nutritional Products India K. Venkata Raju, Avanti Feeds, India, Dr K R Salin, Aquaculture and Aquatic Resources Management (AARM), Asian Institute of Technology (AIT), Thailand and Ramakanta Nayak, Trouw Nutrition Asia Pacific.

Bioflocs contribute 35-50% crude protein and crude lipid from 0.6 to 12% (Conquest and Tacon, 2006); according to various research, bioflocs are also able to supply enough fatty acids, vitamins and trace minerals. "However, there is a deficiency in arginine, lysine and methionine," said Taw.

Feed ingredient

According to Avnimelech, "In the last few years there has been an effort to use treated bioflocs as feed ingredients. We have some data indicating some ingredients of bioflocs are better than conventionally manufactured feeds. Industry looks for recipes to reproduce biofloc as feed ingredients.

Some recent work was quoted. In Australia, Glencross et al. (2014) reported that in farm trials, monodon shrimp fed with the feed additive Novacq (from controlled production of marine microbes) grew on average 30% faster, are healthier and can be produced with no fish products in their diet. Ju and co-workers (2008) found that microbial biomass inclusion in the feed pellets raised growth rates of vannamei shrimp by 21% as compared to commercial feed.

2014 updates on shrimp diseases

During his presentation at the DSM conference in 2013, **Dr Tim Flegel**, Centex Shrimp, Mahidol University and National Center for Genetic Engineering and Biotechnology (BIOTEC), Thailand gave an overview of the threats to diseases up to November 2013. In this 2014 update, Flegel said that in both *Penaeus vannamei* and *Penaeus monodon* shrimp farming in Asia, the top bacteria threat is acute hepatopancreatic necrosis disease (AHPND) or early mortality syndrome (EMS) and this has been the case since 2009 when it was first reported in China. The top

Tim Fegel

"So, we need to identify AHPND bacteria in reservoirs by PCR and attempt to remove them from culture systems. If post larvae are PCR-positive for EHP, AHPND and CMNV, please do not use them."

viral threat is white spot syndrome virus (WSSV). Following this is yellow head virus (YHV) but outbreaks seem to be limited to Thailand.

"The threat specific to the vannamei shrimp farming is infectious myonecrosis virus (IMNV) which fortunately is confined to Indonesia. We can maintain the status quo as long as stakeholders do not attempt illegal transboundary transfers. Abdominal segment deformity disease (ASDD) is not a major problem for the vannamei shrimp as the solution is to avoid using female broodstock for too long. Hepatopancreatic parvovirus (HPV) and monodon baculovirus (MBV) are threats for *P. monodon* from wild broodstock," said Flegel.

AHPND

With regard to AHPND, Flegel reported the progress to date on learning more on the bacteria *Vibrio parahaemolyticus*. A recent study (Joshi et al, 2014) showed that four independent isolates collected from an early mortality outbreak farm in Thailand showed differences in virulence and induction of AHPND. It also showed that the rate of mortality was dose dependent. These results revealed the possibility of diversity in isolates of *V. parahaemolyticus* that may cause early mortality.

"After the introduction of the two PCR (AP1 and AP2) detection methods, the research team has continued their work. Using AHPND isolates from farms in Thailand, we have been able to isolate two toxins with genes on the 69 kbp plasmid, and we can now show that they must act together to cause AHPND. Based on these toxins, we have designed the new PCR primers (AP3) which did not give any false positives or false negative results.

"AP3 was used to check AHPND in broodstock and post larvae at the hatchery and during grow-out, as well as water and sediments. Our results demonstrate some of the potential biosecurity risks. We can monitor shrimp during culture to be sure they remain free of AHPND bacteria. We are studying toxin production and are also testing ways to stop this or to neutralise the toxins. We can also screen probiotics against *V. parahaemolyticus* to determine whether they are protective or not."

New problems concurrent with AHPND

In Thailand there is now a high prevalence of shrimp with gregarine-like entities in the hepatopancreas (ATM) and native microsporidian (*E. hepatopenaei*) (EHP) infections accompanying AHPND in culture ponds. These occur within the shrimp hepatopancreas and midgut.

"From 150 ponds at an ongoing Thai epidemiology study of 200 ponds, the prevalence of ponds affected with EHP was 49% and over 80% for ATM. EHP is not found in specific pathogen free (SPF) shrimp and so we postulate that it might have originated from local hatcheries. At Centex Shrimp we are doing research on the possibility that bacteria belonging to the genus *Delftia, Rhodococcus and Leifsonia* play a role in AHPND mortality. We hypothesise that they may act in an additive or synergistic way to increase AHPND virulence." added Flegel. "Regular updates on AHPND are posted on the NACA website; also available is information on how to clean up the hatchery."

CMNV

Covert mortality nodavirus (CMNV) was recently reported in China (Qing-Li Zhang et al, 2014) and is associated with a new nodavirus. In the Thai epidemiological study, the prevalence was 43%.

"How did the virus come to Thailand?" asks Flegel. "I suspect through feeding with live polychaetes which is a weakness in our shrimp farming industry. We know very little about this new disease. In India, there were RT-PCR positive samples. We know that shrimp die at the bottom of the pond, un-noticed by farmers. There are no distinctive gross signs of disease. This is an urgent concern and we need to work together to find out more on its impact."

In his message on the way forward, Flegel believes that the future lies in modular indoor systems; and in Thailand, they are innovating with mosquito nettings. "In the case of WSSV, we can work to eliminate living carriers, but bacterial pathogens are ubiquitous and can live in the sediments. So, we need to identify AHPND bacteria in reservoirs by PCR and attempt to remove them from culture systems. If post larvae are PCR-positive for EHP, AHPND and CMNV, please do not use them. This is only an interim measure until a long term solution is developed."

Biofloc Technology - A Practical Guidebook 3rd Edition, 258 pages, November 2014

SBN: 978-188880-7226
Authors: Yoram Avnimelech, Peter De Schryver, Mauricio Emmereciano, Dave Kuhn, Andrew Ray and Nyan Taw.
Published by the World Aquaculture Society and Technion Israel Institute of Technology

Biofloc technology continues to attract researchers and the interest of farmers. New information is accumulating at a fast rate and this new technology is different now in comparison to what was available a few years ago. The science of biofloc systems has expanded and widened. New highly intensive, mostly in-house systems have been developed. Bioflocs as feeds and to prevent disease are some new areas for the technology.

"When the 2nd edition of the Biofloc Technology book was sold out rapidly, Professor Joe Tomasso, the World Aquaculture Society book editor and I decided that the factors above justify the preparation of a 3rd edition, re-written to include new information. It is exciting and inspiring to see how much information was added," said Dr Avnimelech. "The present edition was edited in a way as to include the state-of-the art information. "

He added, "In this edition, I tried to have a conversation with the reader, to communicate in a way that will help the reader understand the story of biofloc technology, simplify explanations and minimise usage of complex technical terms."

In the preface for the book, Dr Avnimelech describes how he wishes the reader to approach the book. The book is for farmers starting to manage biofloc systems to field experts, students and the academic community. It has been difficult trying to simplify the explanation on biofloc but the book attempts to do this. There are some repetitions but this is unavoidable in order to get the reader to under the system. A new chapters deal with feeding with biofloc. Chapter 11 deals with the use of bioflocs and other biological controls to prevent disease outbreaks and the information was largely from the conference on biofloc technology held in Vietnam in 2013. Shrimp hatcheries and nursery systems are covered in chapter 16 by Dr Mauricio Emmereciano. Finally in chapter 17, the authors respond with a 'what to do list' to alleviate the dilemma faced by some farmers in managing bioflocs.

The book is priced at USD70 and is available at the World Aquaculture Society website: https://www.was.org/shopping/biofloc-technology-a-practical-guidbook-3rd-edition

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Constant Flow Technology: pump automation for aquaculture

By Thomas M. Losordo and Zack Pickard

A system that will flow at a constant rate under changing conditions provides the most useful benefit to aquaculturists

It is difficult to sound non-biased when writing a short article about a new technology available for use in aquaculture when the company you work for invented the technology. However, as a participant in aquaculture research and development for the past 40 years, much of it in the public sector, I have been in a good position to see new and different technology emerge and be adopted by the industry. In this article, I will attempt to provide a neutral look at a technology that I feel holds tremendous promise for various segments of our industry.

Energy savings from variable speed technology

Variable speed pumps have been available since the invention and mass production of variable frequency drives for electric motors. Variable speed pumps can be set at a pre-specified speed to deliver the amount of water needed within a system or process at the time they are set. A variable frequency drive (VFD) is generally wall-mounted near an electric motor of a pump, controlling and holding the motor at a specific speed, generally defined by revolutions per minute (RPM). When used with a pump, a VFD can provide energy efficient flow from a pump at varied flow rates. Controlling the speed of the pump motor is more efficient than restricting the pump's flow with a valve on the outflow side of the pump where "artificial" head is produced to reduce the flow rate.

In fact, reducing a pump's motor speed by 10% can reduce the energy consumed by the pump motor by 33%. By minimizing the pump speed needed to achieve the required flow rate, significant savings can be made in a pumping system; especially when a pump is in continuous service as they are in many aquaculture applications. However, variable speed pumps cannot maintain constant flow when conditions in the system "upstream" of the pump change, such as a filter becoming clogged or a valve setting being changed.

Harnessing more energy savings

Have you ever wanted to operate a system at a constant flow rate when the system head downstream of the pump changes over time? For example, when a media filter (bead filter, sand filter, and cartridge filter) clogs with waste solids from an aquaculture operation, the pressure builds up and the flow is reduced. In many cases, the operator will need to either constantly change the speed of the pump or run the system at a flow rate higher than needed for most of the time between backwashes to maintain some predetermined minimum flow rate through the filter. Operating the system in this manner between backwash cycles wastes energy and leads to significantly higher energy costs. This has been a major problem for the swimming pool industry for years. Pool operators or owners would oversize the pump to meet the flow demand of a nearly clogged swimming pool sand filter.

Constant Flow Technology™ was created by and introduced into the residential swimming pool industry by Pentair to address this very problem. Referred to as the IntelliFlo® VF, the technology builds upon the variable speed technology of the IntelliFlo® VS, a 3-hp centrifugal pump fitted with a small "backpack" VFD. However, with the IntelliFlo® VF, an operator is able to program the backpack drive to maintain a set constant flow rate regardless of the system operating conditions upstream.

Applying constant flow technology in aquaculture

Leveraging on the proven success of IntelliFlo® in the pool industry, Pentair set out to make an aquaculture-specific pump incorporating some of the same foundational technology. We have "aquaculturised" the pump's feature set, and equipped it with stainless steel inserts, within an otherwise all corrosion resistant pump. The Sparus™ Pump with Constant Flow Technology™ (see Figure 1) is designed to operate with motor speeds of 1100 up to 3450 RPM's and is able to be set at any flow from 20 to 140 gpm (75 – 530 lpm) with increments of 1 gpm.

Figure 1. The Sparus™ with Constant Flow Technology™ can provide a constant flow to an aquaculture system even when pressures vary within the system. The "backpack" controller displays either the motor speed or pumping flow rate.

The integrated drive on this pump has an aquaculture-specific set of menus and features to address the needs of aquaculture's unique applications. The pump can be programmed to turn on and off or run at various speeds at various times throughout the day. The drive also has an integrated RS-485 port allowing for serial communication with a traditional PLC based controller commonly found in aquaculture facilities and aquaculture monitoring systems.

However, being able to have the confidence that a system will flow at a constant rate under conditions that change is what provides the most useful benefit to the aquaculturist.

Media filters such as the air-washed bead filter in Figure 2 are excellent applications for the use of Constant Flow Technology™.

As the filter clogs with waste, the pump will speed up to maintain a constant flow rate through the filter. Constant Flow Technology™ can also be used to improve other processes within

Figure 2. Media filter such as this air washed bead filter are perfect applications for the use of a constant flow pump.

aquaculture. Another example uses within components that add oxygen to the water of a fish culture system. These systems, depending on the size and configuration, have optimised oxygen gas flow and water flow rates at specific pressures.

An example of one configuration is the Pressurized Packed Column (PPC) shown in Figure 3. A Sparus™ Pump with Constant Flow Technology™ and a solenoid gas control valve can be controlled by a Programmable Logic Controller (PLC) with real-time oxygen measurement to provide near optimum performance of a PPC; all the while maintaining the minimum flow rates required for the process.

Figure 3: Pressurized Packed Column Oxygenators can be combined with Constant Flow Pump Technology and Programmable Logic Controls to provide efficient oxygen addition to a wide variety of aquaculture systems.

Perspectives

These are just a few examples of the usefulness of a pump that can maintain a constant flow. Perhaps the last question is; when will this technology be available to users with needs for pumps larger than 3hp?

Thomas M. Losordo, Ph.D is principal scientist & chief engineer, Aquaculture Systems Engineering and **Zack Pickard** is product manager, Pentair Aquatic Eco-Systems, Inc, USA. Email: tom.losordo@pentair.com

Commercialisation process of probiotics bacteria for aquaculture systems

By Prasenjit Barman, Pradeep K. Das Mohapatra and Partha Bandyopadhyay

With the increase in the intensification of commercial aquaculture comes many challenges, such as combating diseases and epizootics, broodstock improvement and domestication, development of appropriate feedstuffs and feeding mechanisms, hatchery and grow-out technology, as well as water-quality management (Iman *et al.,* 2013). Of these, disease outbreaks are one of the important challenges affecting aquaculture production, suppressing both economic and social development in many countries (Qi *et al.,* 2009).

The regular or indiscriminate use of antibiotics or chemotherapeutic agents in aquaculture has led to problems of drug resistance in pathogens (Balcázar *et al.,* 2006a). Some reports suggested that probiotic supplementation can reduce disease outbreaks by enhancing the immune system of fish and shrimp (Mohideen *et al.,* 2010; Wang and Gu, 2010; Bandyopadhyay and Das Mohapatra, 2009). Probiotic supplementation can decrease culture costs by improving the growth and feed efficiency of fish (Wang and Xu, 2006; Soundarapandian *et al.,* 2010; Faramarzi *et al.,* 2011; Mohapatra *et al.,* 2012; Peterson *et al.,* 2012).

Types and sources of probiotics

Probiotics are obtained from various sources such as bacteria, brown and red algae, and terrestrial fungi and marine yeast. Many gram positive obligate or facultative anaerobes are found in the gastrointestinal tracts of terrestrial animals, whereas gram-negative facultative anaerobes prevail in fish and shellfish. Symbiotic anaerobes may be dominant in the posterior intestine of some herbivorous tropical fish (Clements 1997). Bacteria genera also differ between fresh water and marine water species. *Vibrio* and *Pseudomonas* are the most common genera in crustaceans (Moriarty 1990), marine fish (Sakata 1990), and bivalves (Prieur *et al.,* 1990), whereas Aeromonas, *Plesiomonas*, and *Enterobacteriaceae* are dominant in freshwater fish (Sakata 1990). Microbial populations may be influenced by temperature and salinity changes (Hamid *et al.,*1978). According to Gatesoupe (1999), intestinal microbial populations of aquatic animals may change rapidly with the intrusion of microbes coming from water and food. Most probiotics used in the aquaculture industry contain nitrifying bacteria and/or *Bacillus* spp., primarily used for the improvement of water quality (Gomes *et al.,* 2009). Generally, probiotic products are composed of highly concentrated bacteria, vitamins and nutrients (Gatesoupe 1999; Verschuere *et al.,* 2000).

Selection of probiotic strain(s)

For the selection of microbial strains to be used as probiotics, certain criteria must be used for purposes of safety in production/manufacturing, administration and application as well as for survival and colonisation in the host. *In vitro* experiments are available to investigate whether the microbial strains fulfil the above criteria. The stationary phase of a bacterium is the most critical in its consideration of acceptance as a probiotics candidate. A bacterium with a long stationary phase can retain its probiotics activity for a long time. During this period, it inhibits the growth of pathogenic bacteria in the intestine whilst adhering to the gut wall for a long time. This implies that probiotics bacteria with a long stationary phase are good candidates for aquaculture commercialisation. For example, in the growth profile in Figure 1, *Bacillus* sp. PB 15 showed a longer stationary phase which means that its probiotics activity will last a longer time. Temperature, pH and salt tolerance are other important parameters for probiotics bacteria.

Figure 1. Growth profile of four different probiotics bacteria.

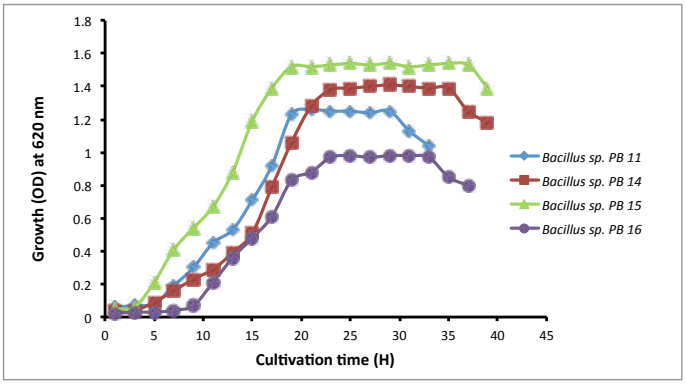
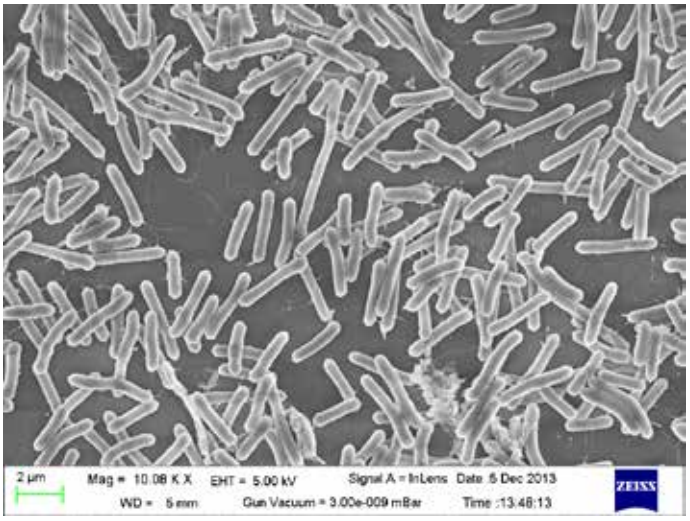


Figure 2. SEM view of a probiotic bacterium.



Aquatic probiotics bacteria must show maximum growth at temperatures ranging from 30-35 °C since this range is the optimal range for the growth of aquatic species. Normally, a pH range of 7.5-8.5 is best for fish growth. Good probiotics bacteria must have the potential to grow at a high salt concentration. Table 1 shows the maximum probiotic growth at different temperatures, pH and salinity (NaCl concentration). Based on these selection criteria, validated by in *vitro* experiments, it is possible to screen microorganisms for their potential as probiotics using scanning electron microscopy (Figure 2), and bio-chemical tests. The

ideal process of identifying probiotics strains is described in a schematic representation in Figure 3. Further validation can be done for these microbial strains with animal trials. It was observed that probiotics work better in black tiger shrimp culture (Figure 4) along with proper water quality and suitable plankton blooms.

Figure 3. Flow diagram of economically viable probiotics bacteria isolation.

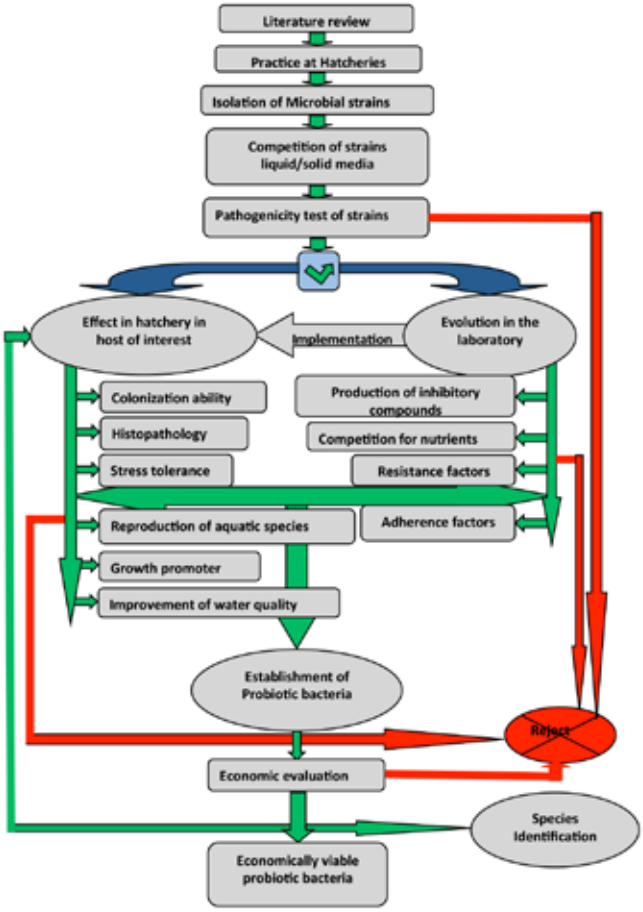


Figure 4. Fresh, healthy and well developed *P. monodon* raised with the help of probiotics bacteria.

Table 1: Temperature, pH and salt concentration profile of some probiotics bacteria

Parameter		Probiotics organisms (OD value at 620 nm)			
		Bacillus sp. PB 11	*Bacillus* sp. PB 14	*Bacillus* sp. PB 15	*Bacillus* sp. PB 16
Temperature (°C)	10	0.328	0.219	0.241	0.172
	15	0.682	0.479	0.418	0.431
	20	1.178	0.864	0.783	0.714
	25	1.571	1.348	1.128	1.281
	30	2.284	1.982	1.680	1.518
	35	2.681	2.281	1.484	1.647
	40	1.084	0.814	0.572	0.278
	45	0.218	-	0.147	-
	50	-	-	-	-
pH	6.0	0.476	0.284	0.171	0.187
	6.5	0.879	0.376	0.471	0.578
	7.0	1.568	0.874	0.874	0.879
	7.5	1.987	1.481	1.745	1.452
	8.0	2.564	1.604	1.214	1.126
	8.5	1.647	1.312	0.571	0.571
	9.0	0.842	0.172	0.147	0.134
	9.5	0.429	0.071	0.027	0.054
NaCl (%)	2	1.217	1.189	1.897	1.482
	3	1.003	1.117	1.471	1.109
	4	0.944	0.845	1.081	0.671
	5	0.900	0.678	0.317	0.428
	6	0.744	0.317	0.107	0.135
	7	0.637	0.209	-	-
	8	0.250	-	-	-
	10	-	-	-	-

Probiotics formulations

Probiotics supplements must have probiotics strains which are generally recognised as safe (GRAS). Multi-strain and multi-species probiotics have better functionality when compared to a single strain, provided they are not competitive inhibitor to each other. Undocumented high potency probiotics: multi-strain and/or multi-species must not be included in probiotics formulations. Probiotics are strain specific, condition specific and dose specific. Excipient mixed with probiotics strains in the formulation must contain low moisture and low water activity.

Quality control

Commercial probiotics products must undergo quality control for the following:

- Genes, species must be identified and viable microorganisms must be expressed as CFU/g for every batch of probiotics manufactured
- Viability of microorganisms at manufacturing and expiry date must be stated
- Pathogens and heavy metals in the probiotics culture and the finished product(s) must be analysed
- Contamination of probiotics products with undesirable microorganisms in uncontrolled fermentation must be avoided

- Blending and packaging equipments which may contribute to probiotics product contamination must be avoided in the manufacturing process.

Storage, handling and shipping

The storage of probiotics supplement below 25 °C is recommended to maintain the viability of the microorganisms and they should be used prior to the expiry date of the product (all probiotics supplements must show an expiry date). Finished goods must be kept in the shade and in a cool and dry place. Standardisation up to 35 °C is mandatory for sustainability and actual viability during the commercialisation process. The storage and shipping requirements conditions of the probiotics must also be met.

Probiotics labelling guidelines

According to the International Probiotic Association (IPA) and World Health Organization (WHO) The probiotics food and supplement label should contain the following information:

- Genus, species and strain designation
- Functionality of the strains(s)
- Minimum viable numbers of each probiotics strain (CFU/g) at the end of the shelf-life.
- The suggested serving size must deliver the effective dose of probiotics as claimed in the label
- Total servings per container
- Health claim(s) if any (substantiated with scientific research)
- Manufacturer's name and address.

Conclusion

Presently, there are several commercial probiotics preparations available for application in aquaculture farms. However, information on isolates of probiotic strains of microflora from aquatic ponds, which have potential antagonistic properties against common aquatic pathogens is scanty. It is clear from the study that probiotics have immense potential in aquaculture and have additional advantages of enhancing growth, immunity and survival of both fresh water fish and marine water shrimp. The identification and commercialisation of the potential probiotics bacteria for aquaculture species using modern molecular techniques will surely be helpful.

References are available on request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Biosecurity in aquaculture Part III: Producers level

By Leonardo Galli, Don Griffiths, Pikul Jiravanichpaisal, Nattawadee Wattanapongchart, Oranun Wongsrirattanakul, Wimonthip Jarupheng and Andy Shinn

This is the final part in a series of three articles focusing on biosecurity in aquaculture with the objective of providing baseline information for stakeholders throughout the aquaculture community. The first article (issue July/ August 2014, p 41-42) focused on biosecurity at the international level, whilst in the second (issue Nov/Dec p 16-17) we considered practices that could be implemented at a national level.

In this final part, the focus will be on the producer, i.e. on biosecurity measures that could be implemented within hatcheries and farms. Due to the immense variation in infrastructure and system design between the two types of production unit, it is not possible to define one precise biosecurity plan that fits all. Instead, the following provides a series of general guidelines that can be adapted to each circumstance.

Biosecurity at the level of producers

In order to get the benefits of a biosecurity plan, biosecurity should be looked upon as part of the overall management system. This means that many aspects of the production pipeline must be taken into consideration, which will include: 1) broodstock source, quality and management; 2) larvae (post-larvae) quality; 3) stocking densities; 4) feed and feeding regimes; 4) hatchery disinfection and management; 5) pond/system preparation; 6) monitoring of water and soil parameters; 7) disease surveillance; 8) training and record keeping, etc.

Here we take a closer look at four critical steps that should be considered in establishing a comprehensive biosecurity program.

Infrastructure

The infrastructure is an important component in any biosecurity plan. Ideally the land surrounding the production unit should be fenced which may be easier for hatchery units and small farms but may not be achievable for larger farm sites. Fencing is used to prevent the entry of wild animals and to deter unauthorised personnel from gaining access to the facilities. The layout of the facility must be planned in such a way so as to minimise cross contamination among different sections. In hatcheries, for example, it is helpful to have a footbath (with an appropriate disinfectant that is changed on a regular basis) and hand disinfectant containers at the entrance of each room. Each unit should have its own equipment, i.e. buckets, jars, etc, and these must be properly identified and should not be removed for use in other areas.

Both the incoming and outgoing water should be treated to minimise pathogen introduction. This should be the case for the incoming water supply, and also for the discharged water to prevent pathogen introduction via effluent water into local watercourses. The use of a recirculating water system, with an appropriate integral water treatment/management system, can be an effective means of reducing the risk of pathogen

A well designed system for the culture of livestock can allow for the isolation of part of the system to be disinfected or treated (in the case of a disease event) without the need for a total shut down in production.

introduction into production areas. Investing in a spare set of hatchery water supply pipes, which can be changed and sterilised allows hatcheries to disinfect effectively while minimising the idle time when a hatchery is not producing seed.

Biosecurity protocols

Written standard operating procedures (SOPs) must be in place before defining biosecurity procedures. A procedure similar to the Hazard Analysis and Critical Control Points (HACCP) can be used to elaborate the biosecurity protocol. The first step is to prepare a production flow diagram (i.e. the movement of animals, water, fresh food and personnel through the on-site systems) and then to identify where there are potential risks of pathogen introduction. Generally, the main source of pathogens is via aquatic animals such as larvae, post larvae, broodstock, insects, water, fresh and live food (e.g. larval feeds, polychaetes, fish etc) and the personnel managing operations. Once the critical control points where pathogen introduction may occur have been identified, it is then possible to establish acceptable limits (i.e. what are the maximum number of pathogens acceptable at each point), to establish a control system (i.e. which mechanisms will be used to detect and quantify the pathogen), to establish corrective actions (i.e. what to do once the predetermined pathogen threshold levels have been reached), and, to maintain a sufficiently detailed record of activities so that the impact of corrective management actions can be assessed and refined as necessary.

When defining a protocol, it should be as specific as possible. If, for example, a disinfectant or a medicant is being used, then it is vital that the protocol specifies the dosage, the duration of application and the regime. For each activity where a risk has been identified, there should be a log that details the name of the person responsible for the job, the date, the time of execution and any observations that were made. Once the protocol is finished and approved, this must then be communicated to the entire team, including security guards, kitchen personnel, maintenance staff, gardeners, etc. The workers must sign the document confirming their participation in the communication meeting to demonstrate that they understand the new protocol and will comply. These protocols, however, should be regarded as "flexible" documents that can be refined and updated whenever needed. It is important that whenever a procedure is revised and updated, it will be communicated to all personnel.

Health surveillance

The third critical step within a comprehensive biosecurity program revolves around a health surveillance system which regularly monitors and controls the sanitary status of all aquatic livestock on site. Likewise, the surveillance system should be clearly defined and appropriately detailed so that it can be followed without ambiguity. The surveillance system that is used can range from a simple visual observation of the stock to the assessment of aquatic livestock samples and tissues using a sophisticated battery of laboratory techniques, including histology and PCR. This will depend on the capacities of each laboratory establishment. The frequency of monitoring and the analyses to be carried out should also be defined and all the results recorded in a farm health log. A traceability system, i.e. of feed, treatment products and, specifically, of all stock movements on, off and around the site, must be in place.

Technical qualifications

The fourth key step is that the managers and technicians responsible for production operations should have sufficient experience, training and knowledge to be able to properly guide those working under them. Periodic meetings with site personnel should be organised by the person responsible for each section, in order to refresh procedures, to ensure effective knowledge exchange and to uphold proficiency in husbandry.

Regular health checks to monitor and control the sanitary status of all aquatic livestock on site is critical.

Underpinning each of these recommended steps is the responsibility of the site personnel. The effectiveness of a biosecurity plan may be measured through the absence of disease and mortality events, while its success is based in effective training, communication, proficiency and compliance. Staff bonus schemes can be used to incentivise effective implementation of the hatchery and farm health plans and biosecurity protocols.

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Ways to sustainable aquaculture

At the sustainable aquaculture workshop in Taiwan, co-development in ASEAN
Part 1: Challenges to sustainability, genetics and intensification of culture.

In November 2014, under the collaborative platform for sustainable aquaculture, the Department of Aquaculture (DOA), National Taiwan Ocean University (NTOU) invited 30 delegates from the region to deliberate on sustainable aquaculture activities in several ASEAN countries. The 9-day program started with 2 days of presentations followed by field visits to central south Taiwan. This gave the opportunity for workshop participants to discuss challenges of sustainable aquaculture along the supply chain. Part 1 of this report focuses on strategies for sustainable aquaculture, genetics and intensification of culture systems.

Cambodia and Myanmar

As they begin to expand aquaculture, fisheries authorities in Cambodia and Myanmar have put in place strategies for sustainable development. In his presentation, **Chann Aun Tob**, Inland Fisheries Research and Development Institute, Fisheries Administration Cambodia said that the strategy on sustainable fisheries production in Cambodia will see production from capture fisheries capped at 500,000 tonnes.

"Future production will be from aquaculture where the target is a 15% annual growth to 200,000 tonnes by 2019 and inland fisheries from rice field increasing at 15% annually . There is call for investment into the aquaculture industry in Cambodia. Two new projects are on on cage farming of marine finfish with investments from the Middle East.

He added, "Aquaculture is important as fish supply 82.1% of total animal protein intake at 62.95 kg per person per year. The estimate of the total aquaculture production in 2014 was 90,000 tonnes up from 70,000 tonnes in 2012.

"Currently, there are small holders farming tilapia, carps and pangasius in extensive and intensive polyculture systems with yields ranging from 3.5 - 5.5 tonnes/ha/year. In the lower productivity system, 75% of the production is for home consumption. Small companies farm hybrid catfish *Clarias gariepinus*, catfish *Pangasius sutchi* and snakehead *Channa* sp in intensive pond systems as well as polyculture of pangasius and carps. Average yields in ponds range from 265 tonnes/ha/year of hybrid catfish to 87 tonnes/ha/year of the snakehead. The government has recently banned the culture of the giant snakehead which uses low value fish as feed.

"Market oriented production is in cages. There is the polyculture of pangasius and carps and monoculture of pangasius and snakehead in freshwater cages. Average yields range from 35 kg/m^3/year for the carps and pangasius production is as high as 94 kg/m^3/year of snakehead. Cage farming of the seabass and groupers uses trash fish as feed. Average yield ranges from 2-7 kg/m^3/tonnes/farm/crop. Fingerlings are imported from Thailand and Malaysia," said Chann.

Similarly, fish consumption is high in Myanmar at 56 kg per capita in 2013, said **U Htun Win**, deputy director general, Department of Fisheries. The government policy is to expand both freshwater and marine aquaculture throughout the country which has numerous riverlets and 800 islands. In 2013, total aquaculture production was 964,260 tonnes. Exports were led by the rohu *Labeo rohita* at 70,989 tonnes, followed by the mud crab at 12,000 tonnes.

"The sustainability challenge is with the monodon shrimp which was introduced 25 years ago and now utilises 91,000 ha of pond area for its culture. When white spot syndrome virus (WSSV) brought down production, farms changed to *Penaeus vannamei* culture. Low density culture with the vannamei shrimp is still at the exploratory stage. With the threat of early mortality syndrome (EMS), we have banned the import of broodstock and post larvae from Thailand but it is difficult to control the imports

Sorting ayu sweetfish Plecoglossus altivelis altivelis by sex and size at a restaurant cum farm in Ilang Yuansan. Taiwan farms this high value freshwater fish for the Japan market. Ayu fish are as Japanese as cherry blossom, according to the Japan Times.

NTOU signed two MOUs for research and training cooperation. In this picture, on the left, Dr Phan Thi Van, director, Research Institute for Aquaculture No 1 (RIA1), Vietnam and Professor Ching-Fong Chang, president NTOU.

Agung Sudaryono (right) with Dr Y-H Chien

of post larvae and broodstock at the porous borders with Bangladesh, Thailand and China," said Htun Win.

"Our future focus is on exploring new species and markets, and replenishing fisheries with restocking inland water bodies. We are also expanding R&D and enhancing human resources development in aquaculture."

Sustainability challenges

In countries where aquaculture is already well developed, albeit still fragmented and dominated by small farms, industry faced a different set of challenges. "In Indonesia, the blue economy concept is to manage and sustain resources through an environmental stewardship, business sustainability, social inclusiveness and innovation," said **Agung Sudaryono**, associate professor in aquaculture at Diponegoro University, Semarang.

"Long term sustainable aquaculture and fisheries is essential to fulfil the roles of income from exports, protein source and employment. In 2013, aquaculture accounted for USD 1.3 billion of export earnings, and employed 2.7 million people. Per capita fish consumption is expected to increase from 35.62 kg in 2013 to 38 kg in 2014. Fish supply must keep up with the increasing demand, as the middle class expands to 130 million by 2020 from the current 45 million. According to the National Aquaculture Statistics (2012), freshwater fish such as the tilapia, milkfish, catfish and carp has the lowest cost protein per gram at IDR 120-200," said Sudaryono.

Sudaryono ranked issues faced by the industry as follows; shrimp and fish diseases (both viral and bacterial), production costs and effective feeds, disease free broodstock, genetic improvement for an available supply of quality seed stock, access to credit and in marketing, prices and trade barriers. "Capacity building is crucial for these development plans," said **Santoso**, Training Program, Ministry of Marine Affairs and Fisheries (MMAF), Indonesia. in his presentation on competency based training programs. In 2015, the program will expand and involve the fishery business community and use online training across the archipelago.

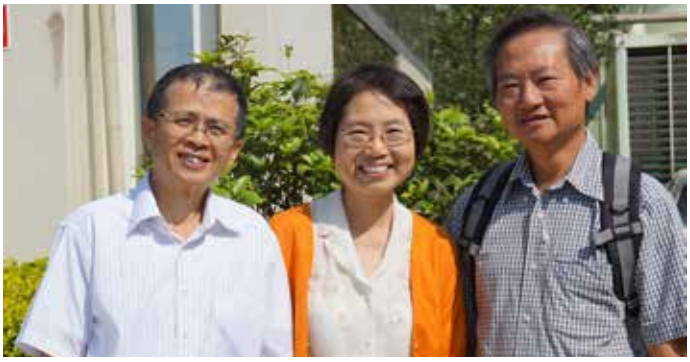
In Vietnam's marine finfish farming, **Pham Quoc Hung**, Nha Trang University said that there are ample opportunities for a sustainable industry. The national strategy to increase production does not focus on new areas but through intensification. The target is to increase finfish production to 145,000 tonnes. The production in 2013 was 100,600 tonnes (Vasep.com). Besides policies to encourage investments in fish farming, the strategies for sustainable development include applications of advanced marine farming technology, offshore cage culture, better quality and availability of seedstock for cobia, sea bass, groupers and pompano and substitution of trash fish with pelleted feeds. Today, most of the fry and fingerlings for marine finfish farming are imported from Taiwan, Malaysia and Indonesia.

"Although our strengths are our long coastline, favourable temperatures for high fish growth rates, skilled human resources and strong R&D support from various research institutes and universities, we are pulled down by small scale farming structure, low quality and insufficient fry and fingerlings, lack of capital and experience in offshore farming and poor cooperation among farmers and other stakeholders. Poor water quality and disease are problems with the use of trash fish."

Small scale aquaculture by AwF

Aquaculture Without Frontiers (AwF) was established in 2003 as an independent non-profit organisation promoting responsible and sustainable aquaculture in the alleviation of poverty and improving livelihoods in developing countries. In his written message, Mr Michael New, OBE, founder of AwF thanked the organisers for using AwF as an example of "work that can be done with small sums of money to run aquaculture projects". The keynote address by **Dr Ram Bhujel**, Asian Institute of Technology, Thailand on AwF's projects in Nepal illustrated the scope of work and nature of activities of AwF.

Bhujel related how AwF helped farmers to manage small scale aquaculture, some of which was scaled up to commercial level. The first phase (2008-2009) was based on the "Women in Aquaculture (WiA) program conducted by AIT and the Institute of Agriculture and Animal Sciences (IAAS), Nepal. AwF provided fry/fingerling of four species of carps (common, grass, silver and bighead carps) and transportation of the first crop whilst farmers were responsible for feed and fertiliser supply. AwF extended this for another two years and the project expanded to 250 households. The district government of Nepal took up the idea and formed a "District Fish Farmers Association". Via the social media, interest increased in fish farming and overall, Bhujel said that this AwF initiative was instrumental in the development of small scale aquaculture in the mid-hills of Nepal and elsewhere with pangasius, trout (more in the uplands) and tilapia. Fish is sold live in local markets. This also initiated the entry of fish vendors and live fish shops into the supply chain.



Dr Boonsirm Withyachumnarnkul (right) with researchers at the Grobest Research Centre, Tao-Yuan City

Culture systems and disease prevention

"In Indonesia, the super intensive culture of the catfish *Clarias gariepinus* in biofloc systems is the answer to demands for high production of catfish," said **Moch Muchlisin**, Marine and Fisheries Training Program, MMAF, Indonesia. In the system presented, stocking density at 3,000 fish/m^3 produces 270 kg/m^3. In conventional systems only 300 fish/m^3 are stocked. Bacteria are recycled into protein which serves as feed for the catfish. In round tanks, water circulation is better than in square or rectangular ponds. Ponds can be small at 2-3 m^2. The system has the advantage of using less water and a small footprint. Muchlisin also said that flesh quality is better with less fatty fish. Waste water is used for agriculture.

The use of probiotics was suggested for intensive vannamei shrimp culture in Lampung province by **Mochammad Farkan**, Marine and Fisheries Training Centre, MMAF, Indonesia. He detailed the pond preparation and pond management protocols. With the monodon shrimp, **Dr Boonsirm Withyachumnarnkul** described the protocols at the Shrimp Genetic Improvement Center (SGIC), Surat Thani, Thailand which has prevented shrimp from being infected with the bacteria causing EMS or acute hepatopancreatic necrosis disease (AHPND) (see page 26).

In India, Professor **C Mohanakumaran Nair**, Kerala University of Fisheries and Ocean Studies described the rotational farming of rice with freshwater prawn as a sustainable farming model. Rice is cultivated during the rainy monsoon season from November to February and the prawn from March to October. Fields ranged from 2 to 400 ha and yields from 150-250 kg/ha of 20-250 g prawn. The production is certified organic by Indocert and Naturland. One requirement is that maximum stocking density is 25,000 post larvae/ha. Nair showed the results on revenues over 3 years. The cost of production for organic prawn is 17% higher than conventional farming but the price of organic prawn is higher than conventionally farmed prawn.

Breeding and genetics

Intensive aquaculture requires domestication and genetic stock improvement to meet production targets and long term sustainability. Several presentations covered the progress in domestication and selective breeding. According to **Dr Nguyen Van Hao**, Research Institute for Aquaculture No 2 (RIA2), it is without doubt that selective breeding contributed to sustainable aquaculture development in the Mekong Delta, Vietnam. The Delta produces 70% of the annual aquaculture output which was 3.2 million tonnes in 2013. RIA2 is carrying out several selective breeding programs. In the case of *Pangasius hypophthalmus*, the selective traits are growth, fillet yield and resistance to the disease caused by *Edwardsiella ictaluri*.

"The realised response to growth was 5.4 to 18.2% per generation and by 2012, we have distributed 100,000 genetically improved pre broodstock to hatcheries in the delta," said Hao.

Dr KR Salin, Asian Institute of Technology, Thailand said that the requirement is that genetic gains needs to be permanent. For example in India, the breeding programs with the common carp and catla showed some improvements in faster growth rate and disease resistance for the catla and late maturity for the common carp. However, success was limited with constraints in production of large numbers of families. In the case of the rohu *Labeo rohita*, the new commercial strain showed a 17% increase in growth rate.

Tilapia and freshwater prawn

On the breeding of the tilapia *Oreochromis niloticus* at RIA2, Hao said that work in collaboration with the WorldFish Center and Wageningen University is now at the sixth generation. The selected trait is body weight at harvest. Growth and colouration are the selected traits for the red tilapia *Oreochromis* spp which is now at the fifth generation stage. At Research Institute for Aquaculture No 1 (RIA1), **Dr Phan Thi Van** reported that the work on genetic improvement of the tilapia which began in 1999 also focussed on growth. The new genetic line based NOVIT4 using the GIFT strain showed a higher growth rate (36-40%) than the control. However, it did not perform well under brackish water conditions or low water temperature (15-20°C). Therefore, another program was initiated in 2007 to develop a new genetic line for tilapia selected for tolerance in brackish water.

Salin said that domesticated broodstock of the freshwater prawn *Macrobrachium rosenbergii* are far smaller than wild types (less than 40 g versus more than 100 g, respectively). In ponds, males grow faster and farmers separate males from females physically. In Israel, sex reversal was achieved with manipulation of the androgenic gland paving the way for all male culture with higher productivity. However, in Asia, the focus is with fast growth, such as the work at RIA2 in Vietnam.

"The genetic improvement of the freshwater prawn, a Vietnam-Australian collaboration showed low to moderate gains from selective breeding. There appears to be a heritable component in male morphotypes, and genetic control of body weight is different in males versus females. The mismatch appears when hatcheries need blue clawed broodstock (with high reproduction) males but farmers need orange clawed males for fast growth," said Salin.

Triploid monodon shrimp

With regard to genetic protection and skewing sex ratios, Dr Boonsirm Withyachumnarnkul at Centex Shrimp, Mahidol University said that polyploidy is the only known technique. At the centre, triploid induction has been successful and produces a high proportion of female *Penaeus monodon*. In penaeids, growth is larger in females than in males. Triploidy is via the application of cold shock post hatching. Female triploid shrimp grew 35-45% faster. The ongoing research is now to produce triploid shrimp on a mass scale and next will be to investigate the molecular aspects of the shrimp and determine whether there are defence mechanisms against WSSV and AHPND.

Next issue: Part 2: Institutional and R&D support for sustainable aquaculture in ASEAN.

China Fisheries Seafood Expo 2014

China's seafood buyers and consumers targeted by a record number of 1,260 exhibiting companies

OMARSA, a family owned shrimp exporting company in Ecuador is the first company in the world to gain Aquaculture Stewardship Council (ASC) certification for its product

The China Fisheries and Seafood Expo is without doubt Asia's largest seafood trade exposition as well as the second largest seafood exhibition in the world, after the Global Seafood Expo in Belgium. This 19th Expo was held in the Qingdao International Convention Center from November 5-7 2014. According to the overseas organisers, Sea Fare Expositions, the show sold out again this year even after adding more halls and overseas pavilions.

The number of exhibitors has been increasing over the years, and 2014 is a record as 1,260 companies took part in the expo. Total exhibit space was 25,625 m2 and 27,495 visitors from 114 countries visited the Expo. Chinese seafood displays dominated the expo, occupying five of the six seafood exhibition halls. One hall was devoted to seafood processing equipment. A record number of 20 national pavilions participated with the Canadian pavilion occupying the largest floor space. "We're selling 11 species in China now, more than any other country," said Martin Sullivan of Newfoundland-based Ocean Choice International. "This is a market that is growing fast."

While the quantity of buyers was impressive, so was the quality. "There were more heavy hitters here this year," said Greg Hart of Australian-based Wild Oceans Pty. Ltd., a regular exhibitor. "There's a great range of buyers. Not just from China, but from Korea, Japan and Southeast Asia. This is really an Asian show. The quality of the buyers just keeps getting better."

China's seafood trade goes up

According to Mr Niu Dun, China's Vice Minister of Agriculture, China's seafood trade "maintained a rapid and stable growth" for the first three quarters of 2014, reaching USD22.4 billion. "Imports are expected to grow about 20% and reach USD 10 billion for the full year," he said, while addressing foreign and Chinese dignitaries the opening of the expo.

"For the foreseeable future China will need a lot more seafood to meet its demand," said Peter Redmayne, president of Sea Fare Expositions. "One of the more exciting trends is that Chinese companies are using ecommerce to sell imported seafood directly to consumers. China's ecommerce sales dwarf that of the US and this gives Chinese consumers an alternative to ordering seafood at high-priced restaurants."

He also noted that 100 million Chinese tourists travelled abroad each year and they acquired an appetite for various seafood which they also want to be able to enjoy back in China. Redmayne added that in 2013 China's reported seafood imports reached USD8.6 billion, an increase of about 10% over the previous year. "The actual value of China's seafood imports is much higher, however, as large volumes of imported seafood enter the China market through Hong Kong and Vietnam and are not reported. Amidst this great appetite for seafood from the Chinese market, the exhibiting companies were eager to gauge the Chinese demand for 2014 for imported products like salmon, lobster and crab."

Redmayne also said that the global seafood market presents its own unique challenges among which are a lack of product knowledge at both the wholesale and consumer levels and changing regulations. "A show such as the China Fisheries Seafood Expo provides a chance for buyers, sellers and government officials to meet face-to-face and explore new opportunities and find solutions to existing challenges."

Common and unique seafood

About 67 finfish and 34 invertebrate species were promoted over the days. Freshwater fish species and the associated processed products were exhibited mainly in the Chinese Exhibit Hall. The tilapia, remains a major export commodity for Chinese producers although most of the tilapia produced is now channelled into the domestic market. Exports increased 13% in 2014 in comparison to the same period in 2013, with 52% comprising frozen fillets. Africa is a major market. (Globefish, 2014). Tilapia is marketed in several forms such as by Xiamen Taiseng Seafoods Co, Fujian, China; from gutted and scaled to gutted, scaled and gilled with fins and tails off, shallow skinless fillet; skin-on fillet and deep-skinned fillet. Apart from the Chinese displays, Myanmar Phoenix Manufacturing Company also promoted frozen Indian carps, tilapia and shad (Hilsa) in their booth.

Ocean Giant Intl Corp promoting sea cucumbers from the Mediterranean countries

Gavin Hodgins, general manager (left) and Peter Rankin, research and business development manager (right) of Fishpac Pty. Ltd Australia

Teng Hoong Too (left), visitor from Malaysia and Jason Wang, president Golden Sea Inc., USA at the Aqua Culture Asia Pacific pavilion

The overseas pavilions from Europe and America exhibited products exotic to China. Apart from the more common exhibits of salmon, Alaska P Pollock and cod, the less commonly known species in Asia such as the Patagonian toothfish *(Dissostichus eleginoides)*, Greenland halibut *(Reinhardtius hippoglossoides)*, arrowtooth flounder *(Altheresthes stomias)*, mahimahi *(Coryphaena hippurus)*, Canadian hake *(Urophycis chuss; Urophycis tenuis)*, lumpfish *(Cyclopterus lumpus)* and the monkfish *(Lophius litulon; Lophius americanus)* were also actively promoted.

China has an insatiable appetite for sea cucumbers which are also viewed as a functional health food. Apart from their own production of the spiky temperate sea cucumber, *Apostichopus japonicas*, China has also traditionally sourced for their supply of sea cucumbers from countries in tropical waters such as the Philippines, Indonesia and the Pacific island countries. With tropical sea cucumber resources declining from overfishing, temperate species from Canada, the United States of America, Europe and South America were being promoted at the expo to attract Chinese buyers.Sea cucumbers are no longer solely marketed as beche-de-mer in the dried form; newer product forms include cooked, salted sea cucumber that are vacuum packed, and ready to eat snack like honey instant sea cucumber marketed by Haeser Products Co., South Korea.

Packaging seafood

Apart from seafood samples, new technologies exhibited included the Nano-Bubble, a system used to preserve the freshness of seafood marketed by Nanox Co. Ltd, Japan, and the Fish Pac live fish road transport oxygen system marketed by FishPac Pty Ltd, Australia. The Nanox technology works by basically replacing dissolved oxygen in seawater with nitrogen nano-bubble. In addition, the nitrogen nano-bubble infiltrates into the fish, keeping the oil and fat free from oxygen. This system thus prevents deterioration in fish quality without the use of chemicals and increases the value of the fish.

The heart of the FishPac™ design is the patented FishPacTM regulator where oxygen flows through approved cylinders from 0.5-3.5 litres per minute and the oxygen is dispersed via an oxygen diffuser positioned at the bottom of the bin used for transporting the live fish. This system claims to be able to transport live aquatic animals for more than 32 hours with no mortality and with payloads up to 500 kg.

Xuzhou Caixin Aluminium Product Co. Ltd marketed an aluminium alloy freezing box. Freezing boxes presently available in the market are made of plastics and stainless materials which are bad heat conductors, and big energy consumers coupled with low thermal efficiency. The aluminium alloy freezing box invention can overcome these technological effects, and freezing time is about 20 minutes which is less than the other older designs.

Certification, sustainability and traceability

More emphasis was evident on certification, sustainability and traceability of products than in past years. The Scottish pavilion proudly announced that all herring caught by the Scottish fleet from the North Sea and Atlanto-Scandian fisheries is certified by the Marine Stewardship Council (MSC). The rope grown mussel *(Mytilus edulis)* from Scotland was aggressively promoted as a product with MSC certification. United Trans Limited, Canada announced that they have adopted dockside monitoring and have added a "Catch Certification" program which promotes their fishery within internationally accepted harvesting regulations. This Catch Certification helps to combat illegal, unreported and unregulated fisheries, which result in unsustainability in the capture fisheries industry.

OMARSA, the Ecuadorian shrimp-producing company announced that it has been awarded the Aquaculture Stewardship Council (ASC) certification in October 2014, and is the first shrimp farm in the world to be accorded this status. The company currently supplies countries in Europe, USA, Canada, South America and Asia. Its ASC labelled products was scheduled to hit the market in November 2014, with its first shipment to Scandinavia.

Expo in 2015

"Next year we will celebrate 20 Years of Discovery by moving to a new convention center in Qingdao," says Yang Hong, general manager of Beijing-based Sea Fare (China) Ltd. The new venue, Qingdao International Exhibition Center, is located on Aoshan Bay about 40 minutes north of downtown Qingdao. With 10 halls and more than 50,000 m^2 of net exhibit space, the facility is one of the most modern, largest exhibition halls in China.

"The move will allow us to double the size of the show over time," says Jennie Fu, marketing manager for Sea Fare Expositions, Inc. "This is a great facility. The halls have no pillars and everything is first class. We think people will welcome this move to a much better-designed facility." There are new five-star hotels nearby and shuttle buses will run to downtown Qingdao during the show. A light rail to downtown is scheduled to be completed in 2016, she says.

China Fisheries Seafood Expo 2015 will be from November 4-6, 2015

Developing a global sustainable seafood supply chain

Stakeholders shared issues related to seafood sustainability and the roles of MSC and ASC in China

Ichiro Nomura

The global seafood market has seen continuous growth in the last few decades, with global production and trade increasing steadily over the years. However, this steady growth is due almost entirely to aquaculture production since supply from capture fisheries have stagnated over the last few decades.

While the aquaculture sector has continued to grow at a fast rate, overall the seafood sector is sailing into choppy waters. The global seafood market is affected by overfishing of marine resources, ocean temperature changes, and fluctuating seafood prices. In these uncertain times, the need to ensure sustainable development and to ensure sustainable seafood supply chain is imperative, and it is crucial that all stakeholders come together to discuss how sustainability development can be achieved.

China Aquatic Products Processing and Marketing Alliance (CAPPMA), World Wildlife Fund (WWF), Marine Stewardship Council (MSC) in partnership with Aquaculture Stewardship Council (ASC), co-organised the Sustainable Seafood Forum 2014 on November 4, 2014, the day before the China Fisheries Seafood Expo.

CAPPMA is a national non-profit organisation under the Ministry of Agriculture in China. It consists of seafood producers, processors, distributors, suppliers, and institutions for fisheries research and education, as well as relevant social entities that provide various services for seafood processing and marketing. Dr Cui He, CAPPMA's vice executive president and secretary general said, "It is rewarding to see that this forum is now providing a unique platform for stakeholders in China, who produces over a third of global seafood, to gain a global perspective on the latest development in sustainability and to share with the rest of the world our challenges and progress."

More than 250 participants attended the forum including industry experts and representatives of commercial and research bodies. The objective of the forum was to draw attention to promoting sustainable practices in the global seafood market. Global and local leaders in the seafood sectors were invited to share experiences on how to strengthen the sustainable seafood supply chain in China, the wider Asian region and globally. There was also a special business to business discussion on challenges for seafood industry in the 21st century.

Cui He

Kelvin Ng

Dr Tejas Bhatt

Shirley Zhu

Global and China perspectives on sustainable seafood

Ichiro Nomura, fisheries policy advisor to the Indonesian Ministry of Maritime Affairs and Fisheries set the scene to sustainable fisheries in his presentation on "Global response to responsible fisheries". Amidst declining global capture fisheries resources, Nomura stressed the importance of Marine Stewardship Council (MSC) certification and how it can help to sustain fisheries. MSC can support government management actions, and encourage dialogue and transparency between government, industry and environmental non-governmental agencies. "MSC supports government actions by providing incentives and reward to industry through the provision of market added value, generation of export earnings, employment and international recognition," stressed Nomura.

China's progress in sustainable fisheries was discussed by Cui He who said that China's strategy is to place more emphasis on sustainable aquaculture and to decrease its reliance on capture fisheries. "We advocate advancing low trophic species cultivation and polyculture – culture systems that have long been practised in China and which we will further improve."

Kelvin Ng, MSC regional director Asia Pacific said that MSC is committed to delivering their program in China. "As of June 2014, there are 224 MSC certificate holders in China, and at the moment, there are two certification bodies that are conducting assessments based on MSC standards." He added that there is relatively low awareness and understanding of MSC in China. MSC is partnering with various stakeholders to ensure a strong foundation for its future expansion in China.

Chris Ninnes, CEO of ASC spoke on the "New movement to sustainable aquaculture". He said that ASC is an independent, not-for-profit certification and labelling program that recognises and rewards responsible fish farming, support purchasing of certified farmed seafood, and transform seafood markets towards sustainability. "ASC wants to achieve a world where aquaculture plays a major role in supplying food and social benefits for mankind whilst minimising negative impacts on the environment."

A sustainable seafood supply chain

Shirley Zhu, representative of food and consumer goods industry research and training organisation, IGD, stressed that shoppers want more transparency and are keen to know more on where their groceries come from and how they are produced. "Transparency in business translates to quality, better choices and trust," she explained. She added that shoppers place priorities on value, origin, health, personalisation and environmental sustainability when making a purchase. "Consumers are increasingly more willing to pay more for goods whose production is more transparent, as transparency is key to establishing trust on food safety," she said.

The Hyatt Hotel group have traceability and sustainability of seafood production as their top two priorities when they source for their supplies. Marco Avitabile, regional vice president of food and beverage with Hyatt Asia Pacific operations said, "We will continue to increase our seafood purchase from sustainable sources, and we are targeting to achieve no less than 50% of our purchase from such a source by 2018."

Chris Ninnes

Marco Avitabile

Traceability in seafood

What is traceability and what is not traceability? In his presentation on the landscape of global traceability today, Dr Tejas Bhatt, program director for the Global Food Traceability Centre, Institute of Food Technologists (IFT) said, "Traceability is just not about data, identifiers, bar codes, RFID, tags and any information that needs to be linked together to make traceability possible. Traceability is about the systematic ability to access any or all information relating to a food under consideration, throughout the entire life cycle, by mean of recorded identification."

In the panel discussion, Cui He emphasised that the increase in the number of certified products in China underpins the changes in consumer awareness. Demand for sustainable production and certification is a market choice.

Aquatic Pavilion at VIV Asia 2015

A dedicated area for services and suppliers in aquaculture at BITEC, Bangkok, Thailand from March 11-13 2015.

Aquatic will be one of the Special Events at the biennial trade show VIV Asia 2015, from March 11 – 13 in Bangkok, Thailand. The dedicated pavilion in the Welcome Hall of the BITEC exhibition centre has companies active in aquaculture in the spotlight. The co-organised conference will feature topical presentations from exhibitors such as Bayer, Addcon and Blue Aqua International.

With this move, the VIV organisers give buyers and suppliers in aquaculture in Asia-Pacific a unique opportunity to meet key contacts active in aquaculture only or with a joint-interest in both aquaculture and animal nutrition, health and production. This event with 17 participating companies will be the third edition dedicated for the aquaculture industry in Asia. Whilst at the rest of VIV Asia 2015, organisers have indicated more than 800 exhibiting companies and country pavilions for Belgium, China, France, UK, Israel, Italy, Korea, Spain and USA.

The Aquatic pavilion offers companies direct exposure to target groups involved in aquaculture; from aquafeed ingredients and additives to health, production and other services. The Aquatic conference will be held near to the Aquatic area. Coffee breaks and closing drinks will be held at a specially created bar in the centre of the Aquatic area, providing a great opportunity to contact a dedicated audience. More information: www.vivasia.nl

Axcentive SARL is presenting Halamid®, the universal disinfectant for shrimp and fish farming applications. In 2014, Halamid was approved by the US FDA for use with the salmonids. In Asia, Halamid is used with shrimp and high value fish such as grouper, sea bass and barramundi. The unique properties of Halamid allow its use with fish at concentrations that effectively kill disease causing pathogens such as Vibrio parahaemolyticus. Most other disinfectants have to be used at sub-biocidal concentrations because of their toxicity and are therefore of little use. Halamid® also has a prolonged activity, even in waters rich in organic matter!

Booth WH.C005
Web: www.halamid.com
Barbara Jean
Customer Service - Sales Assistant
(b.jean@axcentive.com)

Blue Aqua International is a one stop solution provider for aquaculture industry in Asia Pacific. It manufactures and distributes specialty products and services. The innovative and holistic solutions help customers increase their profits and operate their business sustainably and environmentally friendly.

The company will intrioduce the mixotrophic system, a patent pending culture system developed for the management of super-intensive and intensive culture of shrimp and fish in outdoor environment. The protocol provides guidelines on how to successfully manage and balance of nutrient cycles and microorganisms in the pond in different stages during the culture for super-intensive and intensive culture. It comprises of three fundamental areas for high yield production and disease management: biosecurity implementation, feeding management, and water and soil quality management.

Booth WH.C009
Web: www.blueaquaint.com
Amornrat Boonchuay
Vice President
(amornrat.boonchuay@blueaquaint.com)

Fish Vet Group provides evidence-based field veterinary services, diagnostic technologies and environmental monitoring for the aquaculture sector. It provides the following services; hatchery and farm health risk assessments; parasite identification from images and histology slides; parasite treatment/ management consultancy; training on shrimp histopathology, immunology and disease; bespoke engineering designs for aquaculture issues; bacteriology analysis, isolation and identification; antibiograms and MIC; histology (classical staining H&E and special staining; gram, giemsa, etc.); digital slide scanning; PCR and qPCR analysis for pathogen identification and quantification; feed evaluation and challenge testing; vaccine, immunostimulant and probiotic efficacy testing; LC50 determination for biocides and ad hoc test services as required.

Booth WH. A019
Web: www.fishvetgroup.com
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Nattawadee Wattanapongchart
Business Administration Manager
(nattawadee.w@fishvetgroup.com)

INVE Aquaculture, founded in 1983, is a global supplier of health and nutritional products for fish and shrimp hatcheries and farms. From being the first to market Artemia cysts with specific characteristics, over launching the first dry diets for use in fish or shellfish hatcheries, to offering today's best balance between the use of live feed and formulated diets, the company has always strived to offer products that will maximize the customers' profitability and improve the industry as a whole. In short: INVE Aquaculture offers total quality to the market.

Booth WH.A024
Web: www.inveaquaculture.com
Rudi Bijnens
Regional Sales Director Asia
(r.bijnens@inveaquaculture.com)

Leiber GmbH's 'prevention is better than cure' mindset is vital in today's aquaculture. The health products add value to aquafeeds by prophylactically strengthening the animal against stressors during husbandry. These are:

- Leiber® Beta-S, a highly purified ß-glucan for strong, immunocompetent fish
- Biolex MB40®, mannanoligosaccharides (MOS) for gut protection and health
- Leiber® ExCel, nucleotides for optimal cell regeneration and repair

For 60 years Leiber globally supplies real brewers' yeast products which are made in Germany. The production sites in Germany, Poland and Russia has over 180 dedicated specialists to manufacture a product range of the highest quality making it the specialist in refining brewers' yeast.

Booth: A005
Web: www.leibergmbh.de
Nikolaus Jungbluth
Business Unit Director Animal Nutrition
(n.jungbluth@leibergmbh.de)
Dr. Holger Kühlwein
Key Account Manager Aquaculture
(h.kuehlwein@leibergmbh.de)

Soleval is the ingredients division of Akiolis Group a subsidiary of Tessenderlo Group. The group is a specialist in rendering safe animal by products that are fit for human consumption. Soleval develops, produces and markets a broad range of animal fats and ingredients for aquaculture and petfood.

This is the third time for Soleval in an exhibition in Asia. This year the group will meet key contacts for aquafeed business development in Asia. Their flagship product during the show will be; Hypro, a special hydrolysed feather meal with very high digestibility.

Booth WH.A001
Web: www.soleval.akiolis.com
Damien Duchenne
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Christian Roques
(christian.roques@akiolis.com)

BIOMIN will be at VIV Asia 2015 to show the latest trends in aquaculture health and nutrition. It will also discuss with clients FUMzyme®, part of the well-established Mycofix® product line of Biomin, which is the first-ever purified enzyme authorized by the European Union (EU) proven to biotransform fumonisins into safe, non-toxic metabolites.

Biomin in joint collaboration with Reed Business and VNU Exhibitions, will host a special Mycotoxin Seminar on 12 March. It will also hold its renowned exquisite Austrian wine tasting event thereafter, where all are welcome.

Booth: Hall 102, J002
Web: www.biomin.net
Justin Tan
(justin.tan@biomin.net)
Amelia Low
(amelia.low@biomin.net)

Nutriad International NV headquartered in Belgium, delivers products and services to over 80 countries worldwide through a network of own offices and distributors, supported by four application laboratories and five manufacturing facilities located on three continents. Nutriad is an industry leading specialist in the development, manufacture and marketing of animal and aqua feed additives worldwide.

The business unit Aquaculture offers species-specific R&D capabilities, innovative products and nutritional/technological expertise for the aquaculture industry. Key products include AQUAGEST® (species specific digestive/metabolic enhancers to reduce feed cost and improve performance in fish and shrimp), AQUABITE® (palatability enhancers and attractants) and a broad range of additives supporting the prevention of diseases and parasitic infections (SANACORE® GM, AQUASTIM®, APEX®AQUA, BACTINIL® AQUA).

At the show, Nutriad will focus on three innovative feed additives: SANACORE® GM, to promote growth, improve gut health and modulation of gut microflora, based on natural bacterio-static and quorum sensing inhibition actions. APEX® AQUA is a phytobiotic product with broad-spectrum anti-microbial, anti-parasitic and anti-viral activities. BACTINIL®AQUA, a natural anti-microbial using synergistic actions of short and medium chain organic acids.

Booth H102.J022
Web:www.nutriad.com
Allen Ming-Hsun Wu
(wu@nutriad.com)
Peter Coutteau
(p.coutteau@nutriad.com)

Tyson Animal Nutrition Group (TANG) is an innovative division of Tyson Foods, Inc. USA. It is a supplier of aquaculture feed ingredients. TANG is a leading producer of 100% chicken-based protein meals, chicken fats and wet pet ingredients. The experience, knowledge, commitment to quality and strong customer relationships have made TANG one of the most respected names in animal nutrition.

Tyson's vertically-integrated structure gives control over all stages of the life cycle of their chickens, from hatching-egg production to distributing the finished product. In addition, because all of the raw materials come from USDA-inspected processing plants, the ingredients are consistent, traceable and to specifications. TANG understands the importance of superior nutritional quality and track and traceability for feed ingredients as well as the value of working with a supplier with more than 80 years experience in feeding people and their animals. At VIV Asia 2015, Tyson will be located at the USA pavilion.

Booth C060 in the USA Pavilion
Web: www.TysonAnimalNutritionGroup.com
Andy Dilatush
(andy.d@tyson.com)

The ADDCON group of companies from Germany have the Green Chemistry concept which secures best results in modern farming. Using state of the art innovation in chemistry, Addcon´s safe product range prevents feed spoilage, promotes health of animals and ensures best performance. More information on AQUAFORM, FISHFORM and ADDCON XF Superfine is available during the show

Booth Hall 103 Stand D 308
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Kurt Wegleitner
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Dr. Kai-J. Kühlmann
(kai.Kuehlmann@addcon.com)
Dr Christian Lückstädt
(Christian.Lueckstaedt@addcon.com)

Seminar

A one day seminar under the umbrella of Aquatic Asia at VIV in co-location with the VIV at Bitec in Bangkok will be organised by ADDCON, Biorigin and Phytobiotics. The theme is "Safe Fish! Consumer demand drives sustainable aquaculture".

The event will be on 12 March. Registration for participants is expected to open at 11:00am. Internationally renowned independent speakers from the Universiti Sains Malaysia in Penang as well as from the Southeast Asian Fisheries Development Center – Aquaculture Department in the Philippines will give keynote lectures on functional feed additives for sustainable aquaculture as well as for sustainable formulations in aqua diets. Another speaker will concentrate on production techniques for safe feed for fish and shrimp. The participating companies will give an in-depth view of their R&D activities in their respective fields of interest.

The event will close in the evening with an aqua-site visit as well as a reception. More information: email: Christian.Lueckstaedt@addcon.com

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Olmix collaborates with Kasetsart University in feed additive research

Olmix, supplier of natural feed additives from France, is approaching Kasetsart University in Thailand to propose a collaborative research on growth and performance of tilapia fed diets containing Mfeed+, a clay and seaweed based feed additive designed to optimise efficacy of enzymes in the intestine. Olmix launched MFeed+ at Eurotier 2014 in November 2014 in Hanover, Germany.

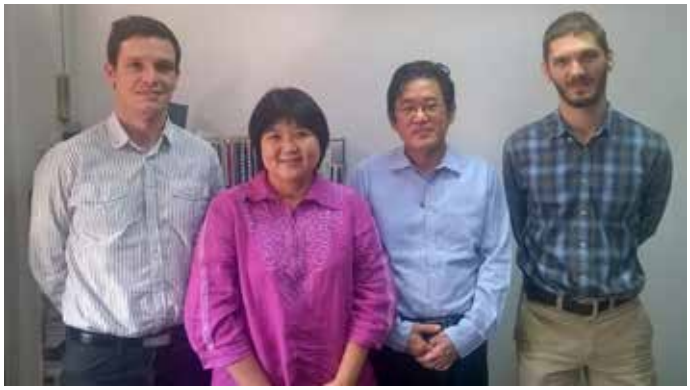
The trial with Kasetsart University will evaluate the efficacy of Mfeed+ in improving growth performance of the fish. In doing so, researchers will compare the performance of two groups of tilapia: one fed with a standard diet commonly used in Thailand and the other fed with the diet containing low quality raw materials plus Mfeed+.

"Based on the results of previous trials, the inclusion of Mfeed+ has been shown to improve growth performance of the fish fed cheaper, low quality raw materials to the same level as those fed with more expensive, high quality raw materials. This results in better cost savings as well as reduce wastes released into the environment as most of the nutrients in feed is completely digested," said Jean Peignon," Olmix's Aquaculture Support manager Asia.

Starting in March 2015, the trial will be designed by Dr Orapint Jintasataporn of the Department of Aquaculture at Kasetsart University's Faculty of Fisheries. The trial will be conducted at the department's facility in the campus.

MFeed+ was developed by Olmix using a new technology that associates particles of clay with different seaweed extracts and as a result, it acts as a matrix for enzymatic reactions to occur. It is the meeting point of enzymes and feed in the intestine.

Moreover, MFeed+ also provides many diverse metallic ions, which are sometimes absent in the feed. These metallic ions are required co-factors for activation of the enzymes. By optimising the efficacy of enzymes in the intestine, MFeed+ allows a better use of the feed. In the field, this improvement translates into better growth performance and a decreased feed conversion ratio. Olmix will be at VIV Asia 2015 at Booth no: H102.L063. More information: www.olmix.com



From left: Thomas Guillaume, Olmix Thailand, Dr Orapint Jintasataporn, Dr Monthai Wanichnatee, Daika, (Thai) and Jean Peignon.

IMV Technologies acquires Genotop

Gilles de Robert de Lafregeyre and Richard Le Boucher

In November 2014, IMV Technologies, leader in reproduction biotechnologies, acquired the aquaculture genetics company Genotop. Facing the fast technical progress in the aquaculture sector, the companies decided to offer a whole new approach combining services in genetics and products in reproduction management.

IMV Technologies represents half a century of history in assisted reproduction. The French company designs, manufactures and distributes the technical and material solutions to help breeders improve their population. In aquaculture, IMV is well-known for solutions in preservation, activation and cryopreservation of aquatic species semen. IMV products have now become a standard for aquaculture cryobanking as well as French national breeding programs.

Founded in France in 2013, Genotop helps hatcheries implement their breeding programs (growth, yields, resistance to disease etc). From the design to the indexing of breeding values, the company provides audits, training and consultancy in 45 countries and 15 species.

Gilles de Robert de Lafregeyre, CEO of IMV Technologies: "We observed that access to genetics was uneasy in aquaculture, compared to terrestrial species. However, the potential of genetic improvement in aquatic species is high. We want to unlock this situation and transfer our knowledge in reproduction together with an integrated support in genetic management."

Richard Le Boucher, founder of Genotop and now Aquaculture manager at IMV, said, "This is a major issue for aquaculture hatcheries to address challenges of genetics. However, a good reproduction management system is often an underestimated lever. The experience of IMV associated with Genotop's vision and approach will undoubtedly boost the productivity of the sector."

"In the aquaculture industry, IMV has been mainly involved in salmonids reproduction during the 1990s. Based on its strong experience in cryopreservation, IMV has provided machines, extenders and straws to multi-species (bass, bream, barramundi, turbot, catfish, oysters etc) freezing processes. This encompasses hatcheries, cryobank, laboratories and also endangered species restoration programs. Our future R&D will explore shrimp cryopreservation and optimise semen extender to adapt to more species. With the experience of Genotop, this now comes with advice in genetic management, inbreeding control and breeding program designs," added Le Boucher. More information: Web: www.imv-technologies.com

New team at DSM Nutritional Products Asia Pacific

To support the strong growth, development and commitment to the Asia Pacific Aquaculture segment, DSM has announced the appointment of **Dr Guo Fuci** as Regional Aquaculture Manager, and **Dr Ooi Ei Lin** as Regional Technical and Research Manager.

Dr Guo Fuci

Dr Guo Fuci holds a Ph.D in Fish Health from University of Guelph, Canada, Masters of Science in Fish Physiology from National University of Singapore and Bachelor of Aquaculture from China Ocean University. Prior to joining DSM, he spent three years providing nutrition and health solutions to feedmills and integrated farms in Asia Pacific region, and five years in fish vaccines and sea lice research in Canada and Europe. In his new role, Fuci will be responsible for understanding customer needs, developing and applying nutritional solutions and concepts to meet the expectations of customers in aquaculture across Asia Pacific.

Dr Ooi Ei Lin

Dr Ooi Ei Lin received her PhD in Aquatic Biosciencces from Tokyo University of Fisheries, Japan, MSc in Aquatic Pathobiology from University of Stirling, Scotland, and BSc in Marine Biology from University of Guelph, Canada. She played a key role in establishing and heading the Novus Aqua Research Centre in Vietnam. Her work involves developing and applying science-based technologies for the improvement of aquatic animal health and nutrition through research collaborations with scientists globally. With this new appointment, Ei Lin will continue to partner with the academic, governmental and private sectors to develop innovative solutions to maximize the health, performance and well-being of aquaculture animals. She will be based at the DSM Aquaculture Centre Asia Pacific in Bangkok, Thailand.

Dr Jacques Gabaudan has announced his retirement after more than 30 successful years with Roche and DSM. His technical expertise on aquaculture nutrition and functional feeds has contributed to the rapidly growing aquaculture industry in Asia.

New commercial director Asia Pacific

Ramakanta Nayak

Since August 2014, Ramakanta Nayak is the Commercial Director Asia Pacific for Trouw Nutrition and Nutreco Feed Additives. He is based in the new regional office for the Asia Pacific region in Bangkok, Thailand. Ramakanta leads the sales and marketing activities for Feed Additives and Trouw Nutrition for the Asia Pacific region. He will be managing and developing all Nutreco animal nutrition businesses in Asia Pacific (primarily focusing on Feed Additives, but also Premixes and Young Animal Feeds) and will be managing the Country Managers in ASPAC as well as the Regional Feed Additives Product Managers, Species Managers, Nutritionists and the Application laboratories.

Ramakanta is an Indian national living in Bangkok, Thailand. He had 15 years of experiences in the industry especially for Asia Pacific. He holds MBA degree majoring in international marketing on top of a Master Degree in Fisheries Science. Ramakanta will report hierarchically to the General Manager Trouw Nutrition Asia Pacific, Haiko Zuidhoff and functionally to the Managing Director Business Unit Feed Additives, Martijin Adorf.

Trouw Nutrition is a Nutreco company and is the global leader in premixes, innovative feed specialties and nutritional services for the animal nutrition industry. The company has locations in 25 countries and around 3,000 employees. Since 1931, its feed to food solutions have met the needs of feed producers, integrators, distributors and home mixers. More information: adhysta.prahaswari@nutreco.com

NEXT ISSUE

March/April 2015

Issue focus: Nursery Technology

Industry review: Tilapia

Fish meal/fish oil replacements & novel feed ingredients

Disease biotechnology

Distribution: Tilapia 2015, April 2-4, Kuala Lumpur, Malaysia; Middle East Aquaculture Forum, April 5-6 Dubai, UAE; Global Seafood Expo, April 21-23, Brussels, Belgium

Deadlines: Articles - January 26, Adverts - February 2

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

4th International Trade and Technical Conference and Exposition on Tilapia

2 – 4 April 2015, Kuala Lumpur, Malaysia

With a global production close to 7 million tonnes in 2012, the tilapia is poised to be the fish for the future. Production is increasing significantly, as major producers expand to meet demand. TILAPIA 2015 is the fourth in the series of highly successful international technical and trade conferences on tilapia organised by INFOFISH, the intergovernmental organization providing market information and technical advisory services to the fishery industry in the Asia-Pacific region and beyond from its headquarters in Malaysia.

Internationally renowned speakers will address issues of relevance to the industry, from industry situation and outlook, production and processing to markets and marketing, technological developments and related issues. Tilapia 2015 will be held at the Palace of Golden Horses, Kuala Lumpur, Malaysia.

There will be an accompanying trade show featuring buyers, sellers, farmers, processors and exporters, as well as suppliers of fishing and aquaculture equipment, goods and services, processing equipment, and transport and distribution services. A post conference trip to tilapia farms and other places of aquaculture interest will be organised and details will be available at a later date.

Registration fees will be as follows: Infofish member countries (Bangladesh, Cambodia, Fiji, India, Iran, Malaysia, Maldives, Pakistan, Papua New Guinea, Philippines,Solomon Islands, Sri Lanka and Thailand) -USD 375 (before 1 February 2015) and USD 475 (after 1 February 2015). Other Countries: USD 500 (before 1 February 2015) and USD 600 (after 1 February 2015). More information: www.infofish.org/tilapia2015 email: infofish@infofish.org

Conference Programme Highlights

Session I: Industry Situation and Outlook
- Asia; China and Indonesia
- Latin America; Brazil and Ecuador
- Africa

Session II: Products, Markets and Marketing
- Global supply and demand
- The US tilapia market
- Tilapia in the European markets
- The African markets
- Trends and prospects for the tilapia in Asian markets
- Tilapia in the catering trade
- By-products of tilapia

Session III: Industry Experiences across the Globe
- China • Indonesia • Malaysia • Philippines
- Taiwan's technological and marketing initiatives
- Latin America

Session IV: Aquaculture and Certification
- Recent developments in tilapia culture system
- Developments in tilapia feed
- Disease management in tilapia farming
- Standards and certification

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Towards sustainable aquaculture in the Middle East at MEAF15

Middle East Aquaculture Forum (MEAF), Dubai, UAE, 5-6 April 2015

The Middle East Aquaculture Forum (MEAF) has been created to bring together aquaculture industry experts and academics from the Middle East, to showcase the latest products and offer industry professionals a state-of-the-art platform to interact. This first edition will have the theme, "Towards Sustainable Aquaculture in the Middle East" which will focus on vital industry issues affecting the key Middle Eastern aquaculture producing countries. It will be held at the Dubai World Trade Centre from 5-6 April. It will comprise a conference and trade show.

Activities will include specific topical industry sessions, technical sessions, facilitated workshops and panel discussions. Industry professionals will be able to interact and network in designated meeting space. MEAF will provide a unique networking platform for aquaculture academic and industry experts from the Middle East. Industry authorities and academics will jointly address some of the major topics in aquaculture, such as:

- Outlook of aquaculture in the region
- Pre and probiotics
- R&D aquaculture
- Breeding and genetics
- Production systems
- Shrimp
- Health & nutrition
- Algae & cucumber
- Water conservation (RAS)
- Seafood market
- Tilapia
- Aquaculture & finance/investment
- Freshwater and marine fish

MEAF15 will strongly focus on the crucial developments of marine aquaculture in the Middle East.

Albert Tacon

Dr Albert Tacon will give a plenary talk on "Future feeds for a growing aquaculture sector in a hungry world" while Michael Schwarz focusses on the Middle East with Trends in Global Aquaculture. MEAF15 is also proud to welcome the National Aquaculture Group (NAQUA), Saudi Arabia at the Forum. Dr Ahmad Al Ballaa, Managing Director of the National Aquaculture Group will give a plenary talk. Dr Muhammed Alsaiady, ARASCO, will give a keynote presentation and will be chairing the nutrition session.

This event is sponsored by the European Aquaculture Society and the World Aquaculture Society, with the Arab Aquaculture Society, Pakistani Aquaculture Society and Saudi Arab Aquaculture society as affiliate sponsors. Organisers has invited these societies to hold their annual meeting at this event and invite all their members to MEAF in Dubai. Abstract submission is open until 15 February 2015. More information; Web: www.meaf.ae Email: info@meaf.ae (general information); mario@marevent.com (exhibitors).

Asia-Pacific Aquaculture Expo 2015 (APAEXPO 2015)

Xiamen City, China, 25-27 May, 2015

China Aquatic Products Processing and Marketing Alliance (CAPPMA) has announced that Asia-Pacific Aquaculture Expo 2015 (APAEXPO 2015) will be held from 25-27 May, 2015 at the Xiamen International Conference and Exhibition Center, Xiamen City, Fujian Province, China. This is the first aquaculture industry gathering in China targeting the industry in China as well as the global aquaculture industry. The expo will be co-located with the 10th China International (Xiamen) Fisheries Expo.

The Asia-Pacific region is the core area of aquaculture industry in the world, occupying 85% of global aquaculture output. China's aquaculture production contributes two thirds to world output of aquaculture products. CAPPMA believes that it is important to have the industry gathering in China which also is a large consumption market, with imports of seafood increasing year by year.

The event will provide an international exchange and cooperation platform and a perfect channel to exhibit technology and equipment to China and other aquaculture countries in the world. In conjunction with the expo, there will be the Global Aquaculture Forum, co-hosted by CAPPMA and the Global Aquaculture Alliance (GAA) and sponsored by the American Soybean Association (ASA). Together with China Shrimp Industry Technology System, CAPPMA will also co-host the 7th International Shrimp Industry Development Forum. Other activities include B2B trade and on site brand promotion. The range of exhibits will include:

- aquaculture supplies such as aquatic seed stock, hatchery, aquafeeds, chemicals for disease treatment and water quality diagnostics.
- machinery & equipment will include hatchery equipment, net-cages, aerators, autofeeders, pond cleaning machinery, aquaculture pumps, industrial aquaculture facilities etc
- new technologies for breeding, industrial aquaculture, intensive aquaculture, alternative technology for fishmeal, computerisation etc.
- related sectors; recreational fishery, ornamental aquaculture etc.

More information:
Web: www.apaexpo.com.cn
Email:apaexpo@chgie.com (Ping Yang, Dr Lisa Pang)

What to look forward to in Aqua Culture Asia Pacific in 2015

Our editorial calendar reflects the new and existing issues in aquaculture in Asia Pacific which we see as most relevant to the industry. We will continue to present trends and update you with technologies to help the aquaculture industry in Asia Pacific move to the next level.

Volume 11 2015					
Number	2 – **March/April**	3 – **May/June**	4 – **July/August**	5 – **September/ October**	6 – **November/ December**
Issue focus *Recent developments and challenges for the next step*	Nursery Technology	R&D & Genetic Selection	Industrialisation & Aquaculture Insurance	Health Monitoring & Disease Management	Biofloc Technology
Industry Review *Trends and outlook, demand & supply*	Tilapia	Aqua Feed Production	Catfish	Marine fish	Freshwater Fish/ Prawn
Feeds & Processing Technology *Technical contributions from feed industry*	Fishmeal & Fish Oil Replacements & Novel Feed Ingredients	Extrusion & Processing Technology	Feed Enzymes, Additives & Probiotics	Feed Safety & Hygiene Processing & Environment	Nutrition & Formulation
Production Technology *Technical information and ideas*	Disease Biotechnology	Recirculation Aquaculture Systems	Sustainable & Responsible Aquaculture	Genetics in Fish/ Shrimp	Aeration Technology & Waste Removal
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	**January 26**	**March 30**	**June 1**	**July 27**	**September 28**
Deadlines Advert bookings	**February 2**	**April 6**	**June 8**	**August 3**	**October 5**
Show Issue & Distribution at these events as well as local and regional meetings ****Show preview***	**Global Seafood Expo 2015** April 21-23 Brussels, Belgium **Tilapia 2015** April 2-4 Kuala Lumpur, Malaysia	***World Aquaculture 2015** May 26-30 Jeju, Korea	**The Aquaculture RoundTable Series (TARS 2015)** **Aqua Feeds 2.0; From Farm to Plate** August 19-20 Hanoi, Vietnam **Vietfish 2015** August 24-26 Ho Chi Minh City, Vietnam	**20th China Seafood & Fisheries Exposition 2015** November 4-6 Qingdao, China **10th Philshrimp Congress** General Santos (TBA)	

Tenth Symposium of World's Chinese Scientists on Nutrition and Feeding of Finfish and Shellfish

October 22-26, 2015, Wuhan, China

The Tenth Symposium of World's Chinese Scientists on Nutrition and Feeding of Finfish and Shellfish (SWCSNFFS) will be the largest gathering for global Chinese aquaculture nutritionists, from academy to industry. Since its inception in 1992, it has become one of the largest and well-rounded communication platforms for exchanging ideas, sharing achievements and discussing advances in nutrition, feed and feeding of finfish and shellfish. The aim of SWCSNFFS is to improve the close cooperation between industry, education and research. It will focus on high 'quality, safety and accuracy' in aquaculture. The symposium will organise an industry forum as well as a student forum for the communication of some hot topics between major companies, researchers and young scientists. This symposium will cover the following topics.

- Nutrient requirements and ingredient utilisation
- Nutritional physiology and animal health
- Food safety and animal quality control
- Feed quality control and processing
- Feeding physiology and technology

SWCSNFFS is organised by the subcommittee of Aquaculture Nutrition and Feeds of the China Society of Fisheries, the Hinter Group and several co organisers comprising, Huazhong Agricultural University, Wuhan Polytechnic University, Institute of Hydrobiology, Yangtze River Fisheries Research Institute and Freshwater Fisheries Research Centre of the Chinese Academy of Sciences.

The Symposium is calling for manuscripts on the above mentioned topics. Submitted manuscripts will be reviewed by the scientific committee and selected for oral or poster presentation. More details are on the website (www.10swcsnffs.com) or email: SWCSNFFS2015@ihb.ac.cn

2015

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**

February 19-22
Aquaculture America
New Orleans, USA
Email: mario@marevent.com (Mario Stael for trade show)
Web: www.was.org

February 20-22
Aqua Aquaria India 2015
Vijayawada, India
Email: mpeda@mpeda.nic.in
Web: www.aquaaquaria.com

February 20-22
Shrimp 2015
Vijayawada, India
Email: info@infofish.org
Web: www.infofish.org

March 11-13
VIV Asia 2014/Aquatic Asia
Bangkok, Thailand
Web: www.vivasia.nl

March 16-18
Aqua Middle East-AquaME
Dubai, UAE
Web: www.aqua-middleeast.com
Email: aquame@informa.com

March 17-19
International Conference on Marine Science & Aquaculture (ICOMSA 2015)
Kota Kinabalu, Malaysia
Email: icomsa@ums.edu.my
Web:www.ums.edu.my/ipmb/icomsa

March 25-27
Aquafeed Extrusion Technology Short Course
Arboretvn, Norway
Web:www.foodstream.com.au/events/event/aquafeed-extrusion-technology-norway/

April 2-4
Tilapia 2015
Kuala Lumpur, Malaysia
Email: info@infofish.org
Web: www.infofish.org

April 5-6
Middle East Aquaculture Forum
Dubai, UAE
Email:info@meaf.ae
Web: www.meaf.ae

April 21-23
Seafood Expo Global
Brussels, Belgium
Web:www.seafoodexpo.com/global

April 22-24
2nd International Symposium on Aquaculture and Fisheries Education (ISAFE2)
Shanghai, China
Email: l_li@shou.edu.cn; ttzhou@shou.edu.cn
Web: http://isafe2.shou.edu.cn

May 20-24
World of Seafood
Bangkok, Thailand
Web:www.worldofseafood.com

May 25-27
Asia-Pacific Aquaculture Expo 2015 (APAEXPO 2015)
Xiamen City, China
Email:apaexpo@chgie.com (Ping Yang, Dr Lisa Pang)
Web: www.apaexpo.com.cn

May 26-30
World Aquaculture 2015
Jeju Island, Korea
Email: mario@marevent.com (Mario Stael for trade show)
Web: www.was.org

May 26
World Aquaculture Aquaforum 2015
Jeju, Korea
Email: mario@marevent.com
Web: www.was.org

June 9
8th Aquafeed Horizons
Cologne, Germany
Web: www.feedconferences.com

June 9 – 11
FIAAP VICTAM GRAPAS International 2015
Cologne, Germany
Email: patriciaheimgartner@victam.com.
Web: www.victam.com

July 20-22
International Conference on Aquaculture & Fisheries
Brisbane, Australia
Email: aquaculture@conferenceseries.net
Web: www.aquaculture-fisheries.conferenceseries.com

August 19-20
The Aquaculture RoundTable Series (TARS 2015)
Hanoi, Vietnam
Email: conference@tarsaquaculture.com
Web: www.tarsaquaculture.com

August 24-26
Vietfish 2015
Ho Chi Minh City, Vietnam
Email: quocthanh@vasep.com.vn/tienloc@vasep.com.vn
Web: www.vietfish.com.vn

World Aquaculture 2015

Aquaculture for Healthy People, Planet and Profit

www.was.org

WORLD AQUACULTURE Society

WA2015 - Jeju Island Korea

May 26-30, 2015

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