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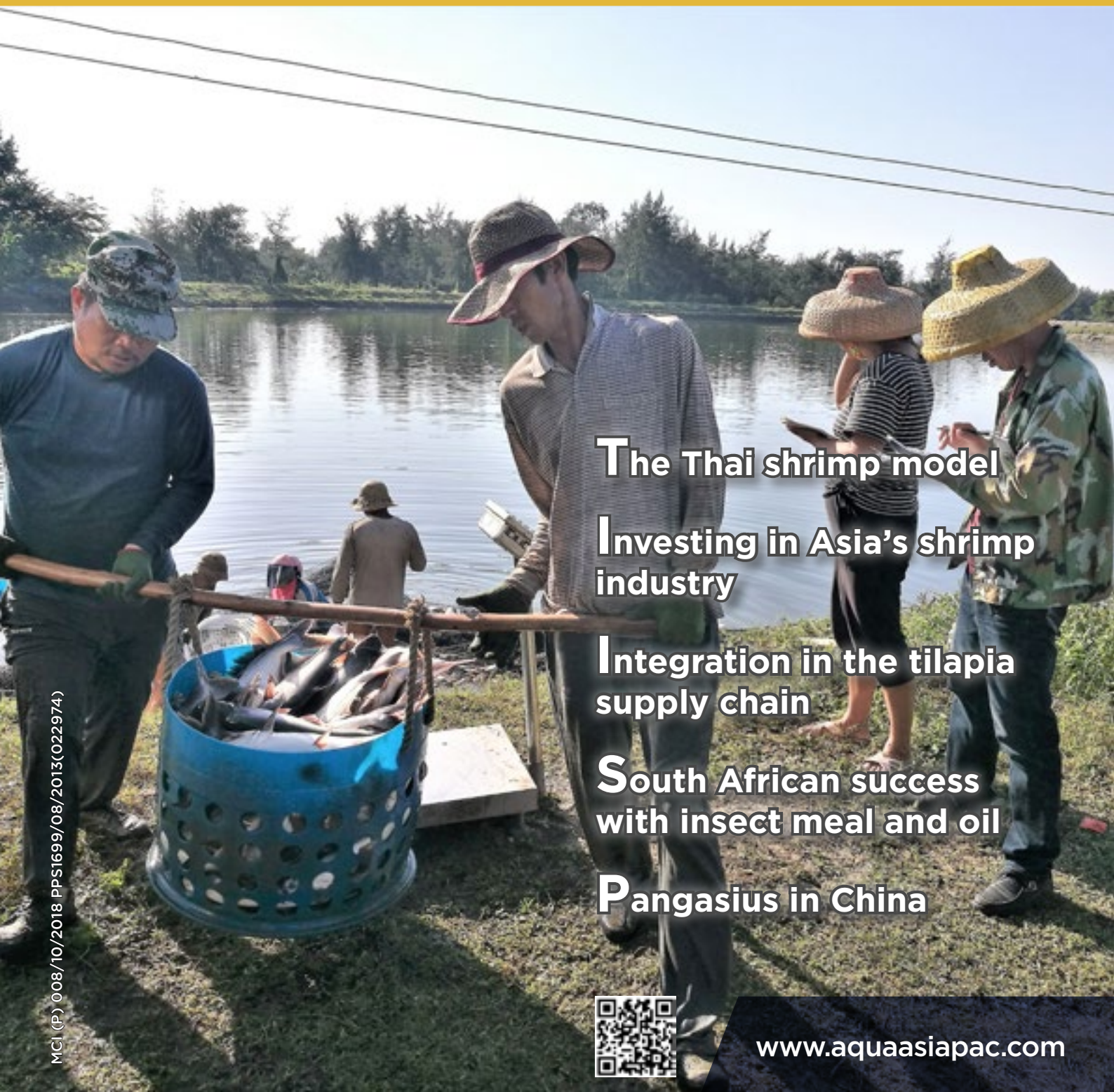

The Thai shrimp model

Investing in Asia's shrimp industry

Integration in the tilapia supply chain

South African success with insect meal and oil

Pangasius in China

MCI (P) 008/10/2018 PPS1699/08/2013(022974)

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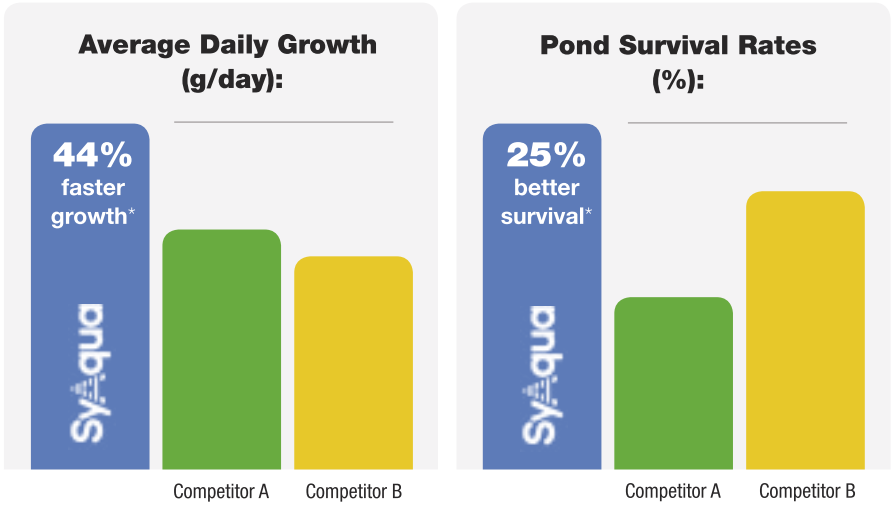

* Based on actual data from 2016 from 606 ponds in Southeast Asia.

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Tilapia in ponds at PTAN, Indonesia
Photo credit: Regal Springs Indonesia

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Zuridah Merican

The year that was – challenging times and start-ups

First the good news. The 22nd October 2018 issue of Bloomberg Businessweek highlighted an innovation article on "Facial Recognition for Fish." How often has good aquaculture news reached such a widely read publication? Hardly! It was reported that "The Ifarm, a 3D scanner developed by start-up BioSort AS, can tell salmon apart based on the distinct patterns of sorts around their eyes, mouth and gills. The objective is to identify, quarantine and treat sick fish before they spread disease and infestations such as sea lice which can cost the industry more than USD 1 billion a year." The age of start-ups for aquaculture has arrived.

This year has also seen start-ups go commercial in the protein meal and oil segments to replace fish meal and fish oil in aquaculture diets. For any of these replacements to be credible, they need economies of scale. There are four notable companies in insect meal production based on the black soldier fly. Agriprotein and Protix have secured USD 105 million and EUR45 million funding, respectively. Single cell proteins which boasts of a minimal footprint per output of protein has also been in the limelight. Calysta which has a 72% protein meal, is looking to Asia for a second plant. Veramaris' DHA and EPA from natural marine algae is expected to go to market in 2019. Cargill iQuatic and Skretting Innovations are investing in digitalisation. Nutreco took a share in Indian IoT company Eruvaka and has invested in Israeli start-up ViAqua, developing the first orally-administered treatment for viral shrimp diseases.

Shrimp has started to face a double-whammy. Disease is still a major challenge and yet production is beginning to outpace demand hence bringing prices down. International shrimp prices started to trend downwards from the 1st quarter of this year and have eased 10% by July. On the other hand, survival rates have been reduced to 50-60% compared to 80% in 2010 (for the same farms) due to diseases. This has increased the costs of production by at least 30%. So will there come a time when the selling price is below production costs? Industry in India, which reached a production record of 600,000 tonnes last year, shied away from stocking in the 2nd quarter this year fearing falling prices. Every producing country, including India, is relying on the China market. Ecuador, experiencing consistent organic growth has been targeting China with large quantities of shrimp. This year, it is estimated that 60% of Ecuador's exports are bound for China. Catherine Lee, while presenting at TARS 2018 said, "The buying mood has changed in China. Buyers have lost interest in the vannamei shrimp." With the disease challenge and poor prices affecting this shrimp, some farmers have reverted to the black tiger shrimp. Although production output per ha is lower, the current prices seem to allow better margins on the crop. A higher output may have a negative effect on prices in the future but Asia, with the black tiger as its indigenous species, should be a dual species producer.

Tilapia continues to face a situation of supply exceeding demand. The primary market of the US has not seen the growth experienced in 2012-2013 while Colombia and Brazil have increased their supply this year. Unfortunately, the escalating US-China trade tensions may affect 2019 trade as apparently most of China's frozen tilapia exports goes to the US. For pangasius farmers in Vietnam, 2018 saw an almost 20% increase in ex-farm prices, attributed to the high demand in China. The other positive is the lower anti-dumping duties (AD) during the last review in 2017.

With challenges come opportunities. Aquaculture in Asia continues to expand and innovate, such as the proposed marine fish farming project in Brunei by Singapore-based Barramundi Asia; a closed system farming model by Aquaculture Centre of Excellence also in Singapore; and the innovative Aquatec submersible offshore floating cage technology from Indonesia to combat our typhoons. Asian aquaculture remains resilient and our 2019 wish-list will appear in the next editorial.

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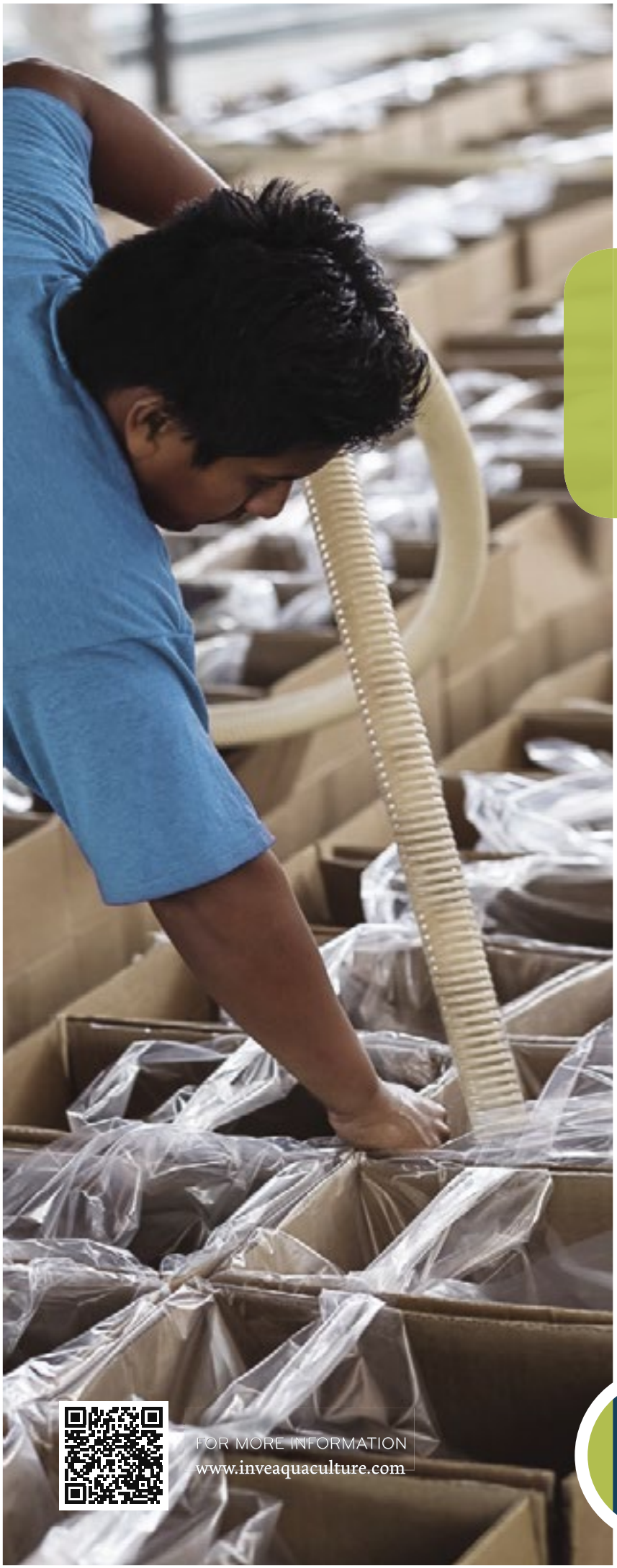

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In August, together with Aqua 2018 in Montpellier, France, the Food and Agriculture Organisation (FAO), the European Community (EC) and Aqua 2018 organisers convened a World Aquaculture press conference. This was aptly positioned with the conference slogan #WeRAquaculture; we are the producers and investors, the scientists and technical advisors, the legislators and educators, the students, the civil society organisations and the consumers of farmed aquatic products.

Speakers presented their views on the aquaculture situation and the future in China, Norway, Thailand and Africa, followed by a selection of degustation portions of local aquaculture products prepared by French chef Jacques Pourcel.

Dr Patrick Sorgeloos

Dr Árni Mathiesen

In his introduction to this media conference, Dr Patrick Sorgeloos, Aqua 2018 conference chair said that as aquaculture often faces bad publicity, industry stakeholders at this aqua event want the media to be updated. "Over the past few decades aquaculture, the controlled production of aquatic plants and animals, has become the fastest growing sector of food production, reaching 110 million tonnes and valued at USD 243 billion in 2016. Whereas aquaculture contributed less than 10% of our seafood consumption in the 1980s, present aquaculture outputs fulfill 50% of our seafood needs."

More from the oceans

Dr Árni Mathiesen, Assistant Director General, FAO Fisheries & Aquaculture Department, gave some highlights from the "The State of World Fisheries and Aquaculture 2018", an annual FAO report. He said that the industry cannot depend on land-based aquaculture anymore. The prediction by FAO is a demand for 150 million tonnes of fish by 2030 which falls on the global aquaculture industry to supply as production from fisheries has stagnated in the past years. There is a dire need to address issues such as the Fish-in Fish-out (FIFO) paradigm and scarcity of water. The appeal is for partners to work with FAO. In the short term to focus on freshwater aquaculture and onwards. In the long term to expand marine aquaculture offshore.

Karmenu Vella, EU Commissioner for Environment, Maritime Affairs and Fisheries said that Europe's approach in expanding sustainable aquaculture follows the recommendations of the "Food from the Ocean's report". Oceans can provide more as today, only 2% of the oceans have been utilised for aquaculture. This is on how more food biomass can be obtained from the oceans in a way that does not deprive future generations of their benefits. Furthermore, as 66% of the seafood supply comes from outside Europe, the need is to ensure that production is sustainable.

One selection of taste plates prepared by Jacques Pourcel (top, right) and sponsored by sturgeon producers and caviar marketeers, Caviar de France, Prunier, Sturia and Caviar Perlita; salmon and trout producer, Saumon de France; marine fish producer, Gloria Maris; fully integrated Groupe Aqualande and oyster producer, Tarbouriech.

Food safety and AMR

Specific to aquaculture, the EU Health and Food Safety Directorate General's policy on animal health displays concern on how diseases are controlled. There is a perception that the industry is not good in detecting emerging diseases and the call is for better ways to do this. Diseases should be controlled, and methodologies simplified and reviewed. Vella also raised the concern over the use of antibiotics in aquaculture, particularly with production outside of Europe.

Earlier, Mathiesen raised the global concern for the rise in antimicrobial resistance (AMR). There is a global action plan among FAO, WHO, OIE on AMR. Attention is on industry in Asia, as antimicrobials are commonly used in the prevention and control of aquatic animal diseases with intensive farming practices. The increasing movements of live aquatic animals have significantly increased the occurrence of diseases, particularly those caused by bacteria and other microorganisms in aquaculture. Asia is also weak due to lack of effective regulations and management in antimicrobial use (AMU), coupled with poor animal health

management practices. As the risk of developing AMR associated with aquaculture can pose a major threat to human health and the sustainability of its industry, FAO is collaborating with the Network of Aquaculture Centres in Asia-Pacific (NACA) to develop a proposed AMR surveillance guideline for bacterial pathogens in aquaculture.

Sustainable aquaculture models

While Dr Qingyin Wang, Chairman of the China Fisheries Society proposed 'green aquaculture' which is being used to tackle environmental challenges in China, Jon Arne Grottum, Director of Aquaculture at the Norwegian Seafood Federation, pointed to the salmon industry as an example of interdisciplinary approach in developing more sustainable farming.

Dr Qingyin Wang

In China, there has been a government -led push towards sustainable aquaculture. In 2018, China's aquaculture production was 69.1 million tonnes. Extensive farming methods requiring expansion of culture areas, climate change and habitat degradation challenge the sustainability of aquaculture in China. "Green development is a mode of economic growth and social progress which targets efficiency, harmony and sustainability. This focus is not only for yields but also quality, market demand, resource utilisation and balancing social and ecology," said Wang. The example of integrated multi-trophic aquaculture (IMTA) where wastes from one species are recycled to become inputs (fertilisers, food) for other species is carried out in Sungpo Bay, Yellow Sea in north China with kelp, sea cucumber, abalone and bivalve culture. In rice field aquaculture, polyculture of carps is being replaced by crayfish, loach, softshell turtles, frogs and mitten crab.

Jon Arne Grottum

Grottum said that as a young industry, salmon farming in Norway has been challenging. As production rose (it reached 1.3 million tonnes in 2017, 4 times more than meat production) in the 1980s, the issue was accumulation of organic loads and in 1990s it was bacterial diseases. The latter pushed for regulations on fallowing and research to develop vaccines to optimise production. Antibiotics usage was reduced to almost zero. Escapees were challenging in 2000s, which saw education of staff and cooperation in research. Since 2010, the issue is sea lice which pushed the search for new ways to manage infections, be it mechanical obstacles or biological robustness. In 2015, the intervention was 55% medication and only 9% mechanical but in 2017, this shifted to 44% mechanical.

Dr Chumnarn Pongri

Thailand's marine shrimp farming is a catalyser for developments in Asia. The outbreak of acute hepatopancreatic necrosis disease (AHPND) in 2012 led to 50% loss in production by 2014 and affected the whole supply chain, said Dr Chumnarn Pongri, Department of Fisheries, Thailand. High production costs led to better environmental management. Meeting standards is difficult for small-scale producers. The Asian Shrimp GAP standard was developed to assist this group. Sidiki Keita, Director General of the National Agency for Aquaculture in Guinea, Africa shared the experience of integrating family fish farming into commercial farms in this country.

Large disparity in production

In March 2018, FAO Fisheries and Aquaculture Department released an update on aquaculture production. In 2016 production was 80 million tonnes of food fish valued at USD 231.6 billion and 30.1 million tonnes of aquatic algae (USD11.7 billion). Farmed food fish include 54.1 million tonnes of finfish (USD138.5 billion), 17.1 million tonnes of molluscs (USD29.2 billion), 7.9 million tonnes of crustaceans (USD57.1 billion), and 938,500 tonnes of miscellaneous aquatic animals (USD 6.8 billion) such as turtles, sea cucumbers, frogs and edible jellyfish.

On the reliability of FAO's aquaculture production figures, author, Xiaowei Zhou noted that volume data is of considerably higher reliability and accuracy than value data. Since last year, special effort was made to improve the previously understated production value for several major producers including China. World aquaculture value in the new published data is considerably higher than in previous releases.

In 2016, grass carp and Atlantic salmon were the most produced species in terms of volume in inland fish farming and mariculture, respectively. Nile tilapia and common carp were among those most farmed species in terms of producing countries. The real production levels of a large number of species are greatly understated by the national data currently available to FAO.

One such species is the Australia freshwater fish, detailed as barcoo grunter *Scortum barcoo* in the FAO statistics but known as "jade perch" *Bidyanus bidyanus* by producing countries. For 2016, FAO recorded only 38 tonnes of aquaculture production of jade perch reported by Malaysia since 2012 and 1 tonne reported by Singapore. Jade perch is produced in Hong Kong through a government extension program several years ago and in the Guangdong province, China, there is significant production of jade perch. Zhou added that in Dongguan City, Guangdong, a farm with dozens of indoor tanks using recirculating aquaculture system (RAS) was built in 2012 for jade perch culture. This farm produces about 300 tonnes of jade perch annually.

Jade perch farmed in Malaysia. Photo credit; Khoo Eng Wah, Sepang Today Aquaculture Centre.

Shrimp aquaculture improvements in Vietnam

In October, Minh Phu Seafood Corporation, the Monterey Bay Aquarium, SGS and the Asian Seafood Improvement Collaborative announced a new commitment to bring 20,000 small-scale shrimp farms in the Mekong Delta, Vietnam, to a level equivalent to the Monterey Bay Aquarium Seafood Watch program's green Best Choice – the highest rating for environmental sustainability – by 2025. This will bring together the private sector and NGO collaborators to address challenges for small-scale shrimp farmers who make up much of the production in the Mekong Delta. The focus will be on key challenges for small-scale shrimp farmers by significantly scaling up improvement projects, training and tools needed for sustainable production. The collaborators will align sustainability standards, provide funding and technical support for infrastructure or improved farming methods, engage in government outreach, and build capacity through training and education. This commitment is expected to impact approximately 10% of Vietnam's production of black tiger shrimp by 2025.

Surge in pangasius exports

In the first nine months of 2018, Vietnam's pangasius fish exports was USD1.59 billion, an increase of 22.6% over the same period in 2017, according to the Vietnam Association of Seafood Exporters and Producers (VASEP). The forecast is USD 2.1 billion, up 22%, the highest level ever recorded by the sector. Pangasius exports to the US was USD 369 million for the first 9 months of 2018, up 43%. This surge was attributed to stable market demand and higher prices. The Food Safety and Inspection Service (FSIS) under the United States Department of Agriculture has proposed continuing Vietnam's eligibility to export catfish and other fish products to the US.

The US Department of Commerce (DOC) has announced the preliminary results of the 14th period of review (POR 14), between August 1, 2016 and July 31, 2017, and lowered anti-dumping tariffs on pangasius imports from Vietnam to between zero and USD 2.39 USD/kg from the average rate at USD 3.78/kg in POR 13. The DOC will announce the final POR 14 results in January 2019. Pangasius exports to China for the 9 months in 2018 reached USD 376.8 million, a rise of 30.8% against the same period in 2017. China is now Vietnam's biggest pangasius importer, accounting for almost 24% of its total exports. (vietnamplus.vn).

Blue shrimp

Aquaculture company Golden Corporation (GC), Brunei, wants to double production of its blue shrimp for the European Union and other new markets for 2018. In an interview with The Scoop, CEO Desmond Lim said that depending on the market demand, the company anticipates exporting around 500 to 1,000 tonnes to the EU. GC was given approval to export to the EU in 2017. The company earns USD30 million annually. GC already produces more than 1,000 tonnes of blue shrimp annually. The expansion is to accommodate new market demand.

"We have approximately 350 ha of shrimp farm. The biggest site which is a 200ha site is under construction and once all sites are fully operational, we can produce approximately 4,500 tonnes of blue shrimp annually." The blue shrimp, GC's flagship product, is exported mainly to Australia, China and Taiwan. (thescoop.co)

Feeding avocado oil to tilapia

In Mexico, experts led by Dr Hervey Rodríguez González are seeking to raise the nutritional quality and add value to Nile tilapia *Oreochromis niloticus* fillets. They are adding dietary oils from avocados from the Sinoloa region to improve content of fatty acids, alpha tocopherol and beta sitosterol. Currently, tilapia prices in international markets are very competitive, so Mexico should look for strategies to reduce farming costs and lift up quality of freshwater and saltwater species.

Avocado has a high content of fatty acids, fibre, antioxidants, vitamin C and potassium, among others, said Rodríguez González. It also has metabolites such as beta-sitosterol, which has nutraceutical attributes, since it can decrease the absorption of blood cholesterol in humans. Currently 50,000 tonnes of tilapia are imported from China to Mexico at low prices and giving the locally farmed tilapia added value with nutraceutical characteristics, makes it competitive.

The group uses avocado oil at inclusions of 3%, 6% and 9% in experimental treatments and compare against a commercial diet as the control. In previous experiments they found an effect of the inclusion of and linseed ingredients with a high content of omega 3 in higher concentration in the fillet; an omega-3/omega-6 ratio very similar to that found in fillets of marine fish such as salmon.

USD300 million aqua farm

China's aquaculture and feed giant Guangdong Evergreen Group is in discussions with Saudi Arabia to build a USD300 million aquaculture farm. In an interview with Undercurrent News, Frank Chen, vice president of Evergreen said it will be the contractor for the project to farm tilapia and shrimp. In November 2017, Evergreen completed a USD90 million integrated tilapia and shrimp farm in Egypt.

"It will be similar to the Egypt project; Saudi Arabia will be responsible for digging the ponds, we will be responsible for design, equipment, construction, operation and training," said Chen. Evergreen is conducting feasibility studies and site inspections as well investigating weather conditions, the variety of fish suitable for farming, and the salinity of water in proposed areas. The growing interest in the Middle East in Evergreen's role as designer and project manager for large-scale aquaculture projects follows the swift completion of the integrated tilapia and shrimp farm in Kafr el Sheikh, Egypt. The 2,200-acre (890 ha) site located at the mouth of the river Nile, is the largest of its kind in Africa and the Middle East and was built in collaboration with Egypt's Armed Forces National Services Projects Organisation (NSPO), an arm of the Egyptian military.

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The Thai shrimp model

By Suraphol Pratuangtum and Soraphat Panakorn

As it faces one crisis after another since 2011, the shrimp industry in Thailand has demonstrated a need to change at the farm and community level, to be more efficient, using fewer farming areas to reach 300,000 tonnes in 2018.

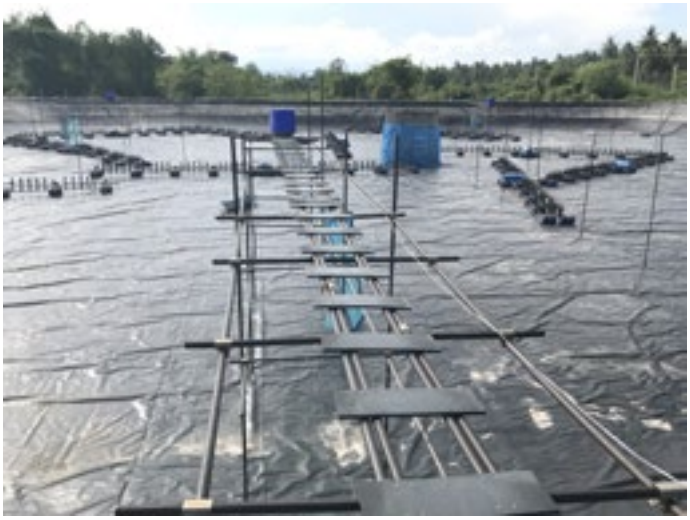
Thailand was the global leader of marine shrimp for 30 years until 2011 when the industry was devastated by the early mortality syndrome/acute hepatopancreatic necrosis disease (EMS/AHPND). Citing Robins McIntosh, Charoen Pokphand Foods, in his state of industry (SOI) presentation during TARS 2018, "Thailand's shrimp farming has not only recovered but changed by using less to produce more; a more efficient industry with profitability exceeding that in previous years. This is the correct way to expand instead of building more farms and more ponds. This production is from less than 10,000ha, almost half of that during the pre-EMS era. Thailand did not have the luxury of expanding into new areas such as Indonesia and India, thus industry focused on being efficient."

In this article, we will walk through the changes during the industry's important periods: before the EMS outbreak in 2012, facing EMS (2012 to 2016), post EMS, and the future for an investor friendly industry. However, these changes in production volumes and efficiency have been the result of hand-in-hand changes in farming technology and practices as well as through an exchange of knowledge as industry collaborated to seek solutions.

The first crisis faced by Thailand's farms as well as industry stakeholders came in 1993 with the white spot syndrome virus (WSSV). At that time, the main species was the black tiger shrimp *Penaeus monodon*. Production dropped slowly with a total collapse of farming this species in 2001. During this time, industry used wild brood stock infected with many unknown pathogens and there was little research on these pathogens. During the black tiger farming days, industry was faced with slow growth syndrome with low survival rates and large size variation, which could have been due to EHP (*Enterocytozoon hepatopenaei*) or probably white faeces disease (WFD). Thai shrimp farmers suffered huge losses and stopped farming the black tiger.

The introduction of domesticated specific pathogen free (SPF) stocks of the vannamei shrimp in 2003 saved the industry. Production went really high to a peak of 600,000 tonnes in 2010. An outbreak of EMS in Chantaburi quickly spread throughout the country in the last quarter of 2011. The identification of the pathogen causing EMS/AHPND in 2013 did little to recover production and farmers had to work hard at changing farming practices.

There is the perpetual question among stakeholders in Thailand as well as curiosity within the global shrimp farming community on whether Thailand's shrimp production could return to the good old days. With our experience in shrimp farming and our knowledge on the industry, we do not expect the production to return to the peak of 2010, in the future. Aside from changes in farming practices, we are also very limited in land. EMS hit the industry very badly, partly because we produced too high a volume in a very short time.



During the EMS crisis, many ponds were fully lined with polyethylene (PE) liners.

Moving from art to science

Looking back at the history of shrimp farming, around 30 years ago, when farmers needed only to pump in water, stocked the pond with post larvae, fed the shrimp and then harvested the crop It was relatively easy using one's art of farm management; there was little need for science and scientific support. However, 20 years later, this was no longer so, with diseases. Farmers needed PCRs to detect diseases. Then 10 years ago, with more diseases, more science was required in shrimp farming. In the future, it is crucial that science be alongside the art of management, to keep shrimp survival rates high.

"Stakeholders in Thailand argue on concepts; is EMS a result of the poor environment, weak post larvae or is it the result of poor management?"
- Suraphol Pratuangtum

There was also the dilemma with EMS. Industry often questioned why it took so long to manage EMS in Thailand. Aquaculturists and scientists differed in their hypothesis on the root cause of EMS. While aquaculturists emphasised on the art of managing the farm, scientists focussed on the disease and the pathogen. Stakeholders in Thailand argued on concepts; is EMS a result of the poor environment, weak post larvae or is it the result of poor management? If it is linked to a pathogen and if so, which pathogen? It took so long and too long a time to identify the pathogen. Even until today, industry still needs more time to understand the pathogen.

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In 2014, even though the EMS causing *Vibrio parahaemolyticus* was easily detected by PCR tests and Thai farmers learnt crucial lessons, hatchery operators still used fresh or live feed to raise brood stock in earthen ponds. This is very risky and an easy way to transmit the disease vertically.

Changing to adapt

In the shrimp farming business, we have often advocated a need to adapt and change proactively. The question will be how and when to change. Over time, Thailand's shrimp farms have been adapting; when farmers faced a serious problem, together industry (farmers and other stakeholders) handled one crisis after another. The adaptations in the Thai shrimp farming business is a role model for industry elsewhere to follow. In Table 1, we described the changes in farming practices during the three crises and the concurrent roles of the shrimp farming community to effect change nation-wide. Both played significant roles to raise production from the low of 180,000 tonnes post EMS to the current 300,000 tonnes.

Golden pre-EMS era

During this pre-EMS period which was before 2012, most farms were using earthen ponds and stocking at around 50-200 post larvae (PL)/m^2. This was the golden era: good feed conversion ratios (1.3 to 2.0), low production costs and enough dissolved oxygen in ponds just by using long-arm aerators at a ratio of 300-

Table 1. Shifts in production practices and farming community changes in Thailand over three periods

Periods	Pre EMS	During EMS	Post EMS	Today
Pond type	Earthen pond	Renovated earthen ponds with PE lining	PE lined ponds	PE lined ponds
Stocking density (PL/m^2)	50-200	100-300	100-500	50-400
Survival rate	>80%	50-70%	>70%	>70%
Feed conversion ratio (FCR)	1.3-2.0	1.5-2.5	1.3-1.5	1.1-1.5
Cost of production	USD 3/kg	USD 4/kg	USD 4/kg	USD 3.5/kg
Aeration	Long arm aerators;	Long arm aerators + aero tubes	Long arm aerators + aero tube	Long arm aerators + air diffusers
Aeration (kg/hp)	300-400	300-600	300-700	400-800
Pond size range (m^2)	5,000-8,000	3,000-8,000	3,000-4,000	1,000-4,000
Focus	Phytoplankton	Clean water+ recycle + nursing	Clean water + recycle	Clean water + probiotics
PL efficiency (tonnes/million PL)	8-10	3-6	6-7	>8
Priority	Post disease treatment	Healthy post larvae health	Organic matter	Production cost
Success rates	>90%	40-50%	60%	>90%
Systems	Closed system	Close-out/open system	Recycle systems	Environmentally friendly
Organic matter	Keep sludge in middle	Central drainage system	Systems depend on conditions	Organic matter control system
National production (tonnes/year)	400,00-600,000	230,000	280,000	300,000
Farming community networking, interactions and changes				
No of shrimp farmer clubs	7	>10	>15; rise of Thai shrimp federations with unique bargaining power	>70% farmers in strong shrimp clubs
Community structure	25,000 farms, majority small-scale	>10,000 farms; less small-scale	7,000 farms; majority medium-scale	6,000 farms; majority medium-scale
Farm management	Management led by semi-skilled technicians	Owner and team stay in farm to lead actions against EMS; use of only skilled labour	Owner and operations team in-farm; Start of marketing locally with price dropping; sense of ownership to farm staff	Owner and staff in-farm Shareholder workers All related parties become one

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A group photo of the committee members of the Thai Shrimp Federation. The federation has monthly meetings to get updates on the farming situation, to brainstorm solutions together and develop strategies to overcome adverse situations and launch new ideas.

400kg/hp and survival reached more than 80%. During this time, the focus was on phytoplankton for water colouration. Industry was happy with the production efficiency (tonnes/million PL) at 8 to 10 tonnes. Production success rate was more than 90%. Using a closed system and keeping sludge in the pond centre did not cause any problem. Using these practices, production rose from 400,000 tonnes in 2006 to around 600,000 tonnes by 2010.

During this period, most farmers had a shrimp club to relate to. For example, farmers in the south had the Surat Thani Shrimp Club and those in the east, the Chantaburi Shrimp Club. This gave some level of cooperation with other stakeholders and between the farmers themselves. However, they exchanged information only at shrimp conferences. There were no farm visits among farmers. Nearly every farmer had some secret farming techniques which they were not willing to share with others. Thailand had 25,000 farms, mostly small-scale. Farm operations were usually left to semi-skilled technicians.

Facing EMS

When faced with the EMS, Thai farmers knew that they needed to change their operating protocols to survive this crisis. At the peak of EMS, production dropped to 180,000 tonnes in 2013 and when farming protocols changed to manage the disease, production increased to 230,000 tonnes in 2016. It was during this time that farmers knew that to survive the crisis, they needed each other. The community became closer, and started to share information and farming techniques. About 10 shrimp conferences/year and farm visits were organised. The change was that farmers were more open. As some small-scale and large farms could not survive under the crisis, more medium-scale farms emerged.

Some farmers began to line ponds with polyethylene (PE) liners. As they faced EMS, survival rates declined to 50-70% and to compensate for the decline, some farmers increased the stocking density to 100-300 PL/m^2. Unfortunately, FCR rose to up to 2.5 and cost of production to USD4/kg. They supplemented long arm aerators with aero-tubes to increase the dissolved oxygen

Two photos showing the marketing efforts to sell shrimp locally and gain better prices. On the right, with the cooperation and support of the Department of Fisheries, and Ministry of Commerce, farmers sell shrimp in every province in Thailand as well as in government offices.

levels in pond water. Farms began to install central drainage systems for sludge removal and studied three phase farming to include nursery systems.

Production success rate declined to 40-50% and farmers found it risky if they continued with large pond sizes. Thus, they began to reduce pond sizes. The focus on phytoplankton shifted to closed systems: water recycling to avoid the introduction of bacteria pathogens from the environment into their farms, avoid discharging contaminated water into shared resources and avoid being blamed for any spread of diseases. Farms converted several culture ponds into reservoir and treatment ponds.

Post larvae production efficiency reduced to a low of 3 tonnes/million PL. During this time, the priority of most of the farmers in Thailand was selection for post larvae quality. One significant development was how owners and technicians began to live on site, working very closely with pond staff day and night. In addition, farms only retained only highly efficient, trusted and hard-working labour.

Post EMS

During this period of recovery, many new practises were adopted. FCR improved but production costs remained high with multiple types of aeration systems to increase dissolved oxygen. Size of shrimp harvested was small (80-100/kg). Industry as a whole looked at recycling water. Farms did not want to take any risks in sharing water with others. The focus was also on removing pond sludge quickly. Post larvae efficiency was low at only 6-7 tonnes/million PL.

"Shrimp farming may not be that easy, but it is also not that difficult either. To be successful, it just requires adequate effort with sufficient knowledge and techniques, and community networking and exchange."
- Soraphat Panakorn

Thai shrimp farmers modified culture practices, recognising pond carrying capacity, individual farm conditions and effects of farming practices on the environment and market forces. Production improved as each farmer quickly developed his own system of farming (i.e. in terms of stocking density, technical skills, pond capacity, conditions and location). Industry came together to start the Federation of Thai Shrimp Farmers which brought all clubs or organisations of farmers under one umbrella. Together, industry brainstormed at regular meetings held every 3-4 months. Whenever they faced a new problem, a brain storming process was initiated to find solutions. The number of farms dropped, and the number of farmers declined to 7,000; more medium scale farms survived, each usually with 10-20 ponds. Some farmers also started to do their own marketing and developed their own brands. Pond staff were given a sense of ownership. Farms also began to screen out daily paid labour and poor performers as they focused on high efficiency.

Investor friendly shrimp farming

Disease is the main obstacle in achieving production efficiency with stable production costs. Industry needs to overcome disease if it wants investments into the industry. For many years, Thai banks have been reluctant to provide loans as they associated shrimp as a high-risk business. Today, Thai farmers managed to have higher production efficiency, higher survival rates and lower cost of production. Industry realised that it could never revert to the days of high production. The new future is with investor friendly farming: efficiency in production by moving from an art to science, proactive nutrition and control of disease, research in shrimp nutrition and physiology, and R&D in innovations, farming and co-culture.

At present, within the industry we have variations in stocking density; some prefer to go for lower density such as 50 PL/m^2 to have consistent crops. An article on unconventional farming practices (Panakorn, 2015), showed that small pond size is better with clean water and probiotic management systems. Although post larvae efficiency rose to 8 tonnes/million PL, the priority is now on production costs.

In terms of production volumes, industry is now targeting at 300,000 tonnes per year. It is no longer seeking to reach 400,000 or 500,000 tonnes as the lesson learnt was that with high production, prices of shrimp will go down. For the industry, it is important that today 70% of the farmers have become friends and are sharing information. When there is a conference in Chantaburi, in the east of Thailand, farmers from the south also participate, sharing their ideas. The industry has a stable 6,000 farms which are mostly medium-scale farms. For an investor friendly industry, farm staff must be shareholders, not only with a sense of ownership but benefitting from farm success.

Conclusion

Today, the Thai shrimp farming industry has become more stable, more standardised than before and has a positive future. Over the years, Thai shrimp farmers have learnt that farming techniques cannot be copied but they need to learn from the success of others and modify the techniques to fit their own farming conditions. They now know that success comes with the open-sharing of knowledge and working together to find the right solutions. Shrimp farming may not be that easy, but it is also not that difficult either. To be successful, it just requires adequate effort with enough knowledge and techniques, and community networking and exchange.

There are lessons to be learnt from the experiences of the Thai shrimp community: how the Thai shrimp industry handled and survived under each crisis in the past. Looking at the future, our call is for cooperation from all stakeholders in the industry. Cooperation on disease and marketing among key players is most urgent today and must be initiated by the private sector. Without such cooperation, we foresee that many farmers might not be able to continue in this business soon.

However, no man is an island and the same can be said for the industry in Thailand. Shrimp farmers want to implement lessons learnt from the EMS days: proactive monitoring and control of potential diseases. However, farmers should know that when disease breaks out in one country, farmers in other countries should be alert to prevent the spread of any disease; otherwise production costs will escalate. Current intensification in farming, monoculture of shrimp and deterioration of the environment are three contributing factors for the outbreak of new diseases. As long we have these, disease will be there. Our message to all shrimp farmers around the world is that it is time for us to join hands and become one, as a shrimp farming community to work towards a better future for all.

Reference

Panakorn, S. 2015. Success story: Unconventional farming practices, Aqua Culture Asia Pacific, 11 (1) January/February 2015, pp 8-14.

Dr Suraphol Pratuangtum is a practicing dentist as well as a shrimp farmer for the past 30 years and is currently president of the Thai Marine Shrimp Farmers Association. Email:

Soraphat Panakorn is Technical Service Manager-Aquaculture with Novozymes Biologicals, Thailand & Vice President, Thailand Aquaculture Business Association (TABA). He has 21 years of working experience with farms in Thailand as well as in several other countries in Asia and Latin American.

This article was extracted from a joint presentation **"Towards Production Efficiency: The Thai Shrimp Model"** presented at TARS 2018 - Shrimp Aquaculture: Need for Change, 15-16 August 2018, Chiang Mai, Thailand.

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Investing for the future

Asia's shrimp aquaculture industry requires more investment in resources and R&D to improve production efficiency.

An investor's perspective

Tim Noonan spent 17 years in food industry-focused, private equity investment firms before recently joining Cargill Animal Nutrition as Enterprise Strategy Lead, based in the United States. At TARS 2018, Noonan shared, from an investor's perspective, why it has been so difficult to attract equity capital to Asia's shrimp aquaculture industry. He provided numerous insights into the characteristics that investors seek before they invest in such an industry.

Noonan's presentation began by outlining five key questions. "First, what is the level of investor interest in Asia's shrimp aquaculture industry today? Second, what must be true in this industry if investor interest is going to scale upwards in the future? Third, are there lessons that we can learn from Norway's salmon industry, or do other emerging markets (such as Chile's salmon industry) or other proteins (such as pork or poultry) provide better examples for how capital might be attracted to Asia's shrimp industry?" He added, "What historical risk or perceptions of risk could we mitigate differently today, perhaps through application of new technologies?" And lastly, "What principles might form the basis for a new paradigm that would increase investors' confidence in the shrimp aquaculture industry in Asia?"

Investor interest in shrimp aquaculture

Noonan then projected two bar charts showing year-over-year changes since 2001 in the global production of two un-named aqua species. The first chart showed consistent, mostly single-digit production growth, while the second chart showed much greater volatility, with several years of 20+% growth and several years of negative 6-10% growth. He asked the audience to put on their investor hats and decide which of these two aqua protein industries would they invest in? To his surprise, a significant majority of the audience chose the second chart – the one with much greater volatility. Noonan then revealed that this chart depicted global shrimp production, whereas the first chart had depicted global salmon production (historically, significantly more institutional investment has been directed toward the salmon industry).

However, during the last 24 months, there has been a notable increase in shrimp investment globally. Noonan highlighted several relevant transactions, including: salmon and seabass/bream producer Cooke Aquaculture's acquisition of Seajoy in Honduras; Charoen Pokphand's investment in Brazil's Camanor; and Toronto-listed High Liner's purchase of U.S.-based Rubicon. "We know that numerous challenges have constrained investment in shrimp aquaculture. But these recent transactions make me optimistic that investors are recognising new ways to mitigate many of those challenges."

Target of investors

Institutional investors focus on the six largest shrimp producing countries in the world (India, Ecuador, Vietnam, Indonesia, China and Thailand), but their perceptions of these emerging markets– beyond the widely-discussed disease risk – have limited their investment activities.

Norman Lim, Cargill Digital Insights, Singapore (left); Dr Chi Man, BASF East Asia Regional, Hong Kong and Stephen Crisp, BASF Animal Nutrition Asia Pacific, Singapore (right).

> **"Ignore the noise; instead, focus on your customers and the business fundamentals... Investors will come to the region..." Tim Noonan**

Historically, the shrimp industry in all of these countries has been highly fragmented with few examples where consolidation across countries or within segments of the value chain has produced financial synergies. These countries have also faced macroeconomic headwinds, with currency volatility, limited debt financing markets and high interest rates. Noonan explained, "Balance sheet efficiency can be an important contributing factor to investors' returns. Typically, a company is acquired using a prudent combination of debt and equity; the cost of that capital has been very high in most of the world's largest shrimp producing countries. As a result, it has been difficult for shrimp producers to consistently earn more than an investor's cost of capital, especially if that capital has been USD-denominated."

In addition, the shrimp investment targets in these markets are largely privately-held, often family-owned businesses with limited experience raising capital from institutional investors. "This requires a reciprocal, sometimes time-consuming, but critically important process where trust is developed between an owner and investor. When accomplished successfully, the owner and investor have a shared vision and business plan, agree up-front on the uses of invested capital, complement each other's capabilities, assume the good intentions of the other party, and understand each other's time horizon – meaning, does either the owner or the investor intend to exit its shareholding down the road and, if so, when?", said Noonan. "Investors won't be happy to hear that a disease is killing shrimp in your pond, but they can – and did – accept that risk when they invested in you. But they cannot accept a breach of trust."

The salmon industry as a role model?

Noonan does not necessarily believe that the Norwegian salmon industry should be a 'North Star' for Asia's shrimp aquaculture industry, given the substantial differences between Norway and Asia. Having said that, he did note the success with which salmon companies on the Oslo Stock Exchange (OSE) have attracted investment – as well as the significant gap between the depth of Norway's capital markets and Chile's capital markets, despite the fact that both are focused on the same aqua species (salmon).

Brothers, Christopher Adrian Domingo Anglo (right) and Ervin Anglo, Aderma Farm, Philippines

First row, from left, Malaysians: Benjamin Yeo, Behn Meyer Malaysia; Jeffrey Lee, Kembang Subur; Tee Hock Koon, THK Sales & Service (M); Chia Song Kooi, QL Resources; Anuar Sani Abdul Rahman, Blue Archipelago; Benny Ng, Kembang Subur; Zuridah Merican, Marilyn Sim, Diamond V; Zainah Zaid and Mohd Zaidy Abdul Rahman, Zaiyadal Aquaculture. Second row, from left, Ronnie Tan, Bryan Lee, QL Resources; Norman Lim, Cargill Digital Insights, Singapore, Fernando Castro Talero, Epicore BioNetworks, Vietnam; Fuci Guo, Fin & Shell Resources, Malaysia; Wan Nadhri Wan Fauzi, Blue Archipelago, Malaysia; and Serge Corneillie, Diamond V, Japan.

For example, five years ago, the combined market capitalisation of OSE-listed seafood companies was approximately USD 10 billion; today, it is approaching USD 30 billion (a 3-fold increase). By comparison, five years ago, the combined market capitalisation of Santiago Stock Exchange (SSE) listed seafood companies was less than USD 3 billion; today, the combined market capitalisation of SSE seafood companies is only about one-third of the market capitalisation of Marine Harvest, Norway's largest salmon producer. "Oslo remains unique amongst stock exchanges globally: it has sophisticated industry analysts and long-term investors who specialise in the seafood and aquaculture sector. This is the type of investor that Asian companies should try to attract when they raise private or public equity or debt."

Since Asia's shrimp aquaculture industry cannot control the pace at which regional financial markets develop, Noonan encouraged the audience to remain focussed on what is within their control. "Ignore the noise; instead, focus on your customers and the business fundamentals that drive profitable growth for them and you. Alibaba founder Jack Ma has said, 'Opportunity lies in the place where the complaints are.' Listen closely to the complaints of your customers and the end-consumers of your shrimp. First, address those spoken complaints. Then challenge yourself to meet your customers' un-spoken needs. If you can do that, you will find that you have also addressed potential investors' needs and they will come to the region."

New paradigm

"Innovation begins with understanding data. In our industry, sometimes claims about production volumes or growth rates or profitability are based on heuristics – biases of intuition – or even aspirations. From the perspective of the investor, those companies that are able to aggregate, analyse and interpret real-time data will be best-placed to accurately and quickly diagnose a problem, intervene to limit the consequences, and re-engineer the processes or systems that created the problem in the first place." Noonan expects that digital tools – like Cargill's iQuatic™, which delivers real-time decision support through artificial intelligence (AI), machine learning, and Internet of Things (IoT) integration – will play an increasingly important role in helping Asia's shrimp participants make their most important decisions - predicting customers' needs, optimising business fundamentals and benchmarking performance.

Noonan concluded, "If we think first about the needs of our customers, and if we utilise the many new tools that are available to us, there is no reason that Asia's shrimp industry cannot provide what seafood investors seek – a product that is healthy, that is farmed and processed responsibly, and that is economically viable. This is the new paradigm."

Anne Lo, Pebble Labs, USA

Dr Anuphap Prachumwat, BIOTEC, Thailand.

A roundtable on feed, health and environment (FHE) during the breakout session

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A shrimp eye view: nutrition modulation

In the future, industry will be looking at modulating nutrition to fit into handling stress and immunity for the shrimp. **Dr M A Kabir Chowdhury**, Global Program Manager – Aquaculture, Jefo Nutrition, Canada gave this title to his presentation, "A shrimp eye view: nutritional modulation to immune function." In his opinion, in the future, disease prevention will be achieved through nutritional modulation to match changing shrimp farming practices. "As we continue to put more pressure on our farming systems, we need to understand more on the mechanisms of immunity."

In Asia, there is intensification and accompanying these, disease outbreaks occur every few years. "Low-intensity traditional systems of farming such as those in Latin America induce less pressure and consequently, has lower risks. Despite high margins, overall profit per unit area in these systems is low compared to the intensive systems. Because of low gross-profit, in Asia, it is difficult to roll-back to traditional farming systems. Therefore, the important question for Asia remains: how do we manage the intensive production systems with high gross-profit per unit area that is associated with high risks? Inability to minimise these risks puts a lot of stress on the animals, and at the end, on the farmers."

> **"Only recently, has there been studies to show that invertebrates can have adaptive immunity. This needs to be further explored." - M A Kabir Chowdhury**

Shrimp immunity is a black box

In dealing with stress and anxiety in animals, "We can only modulate in a better way if we understand how it works. If we just copy and use solutions blindly, there is a cost element and the solutions are not cheap," noted Chowdhury.

There is a general understanding that shrimp has natural or innate immunity, where the cells not only engulf and destroy any invading microbes but also release proteins that activate other parts of the immune system. "We long believed that they do not have adaptive immunity; immunity that develop only upon exposure to antigens and can be carried over from generation to generation. Only recently, have there been studies to show that invertebrates can have adaptive immunity. This needs to be further explored."

Chowdhury described the two innate immunity pathways and selective responses. The toll pathway is stimulated mostly by viruses, fungi, gram-positive bacteria, lysine-type peptidoglycans and some gram-negative bacteria with lipopolysaccharide cell walls. The immune deficiency pathway is mainly modulated by gram-negative bacteria and creates the intracellular immune signalling.

Melanisation is the principal innate immune response. Recognising foreign materials, there is a proteolytic cascade where some metalloproteases are involved and activation of pro-phenol oxidase (PRO-PO) enzymes to create melanisation. "A recent, very interesting finding is anti-lipopolysaccharide factors or ALFs, which have been well studied in the black tiger shrimp. These are very active against filamentous fungi as well as gram-positive and gram-negative bacteria. But to date, this information is still at the research level."

Palanisamy Ravi, The Waterbase Limited, India

Cellular responses

There are three types of cellular immune responses against viral pathogens in shrimp: phagocytosis, apoptosis and RNAi. In phagocytosis, macrophages engulf and then, digest cellular debris and pathogens. "Apoptosis is the programmed cell death, a natural response to viral-replication and to eliminate virus infected cells. This is where when farmers see shrimp dying. RNAi destroys viral RNA."

Lastly, reverting to adaptive immunity, there is hope for industry. Chowdhury referred to some recent research which showed some situations of adaptive immunity with shrimp and crustaceans. "One on them was on teaching shrimp self-defence to fight infections and the other showed three generations in *Artemia* with some immune characteristics."

Feed based solutions

There is a range of nutritional solutions available including beta glucans, mannan oligosaccharides, nucleotides and lipopolysaccharides. Acting on gram positive or gram negative bacteria are antimicrobial peptides (AMPs) and beta glucans binding proteins. "Antimicrobial peptides come from different sources and identifying those with bioactive properties is important. Protease is also in the immune system and all these including organic acids and probiotics act to modulate the gut microbiota which can produce antimicrobial peptides in the gut."

Chowdhury underlined that there is no one magic solution and understanding the whole system (farming practices, existing environmental conditions etc) can help industry to find solutions.

Finally, "The focus for all stakeholders is growth. We have already gone through genetics selection for fast growth, but the modern farming system is very stressful for the shrimp. So, we need to better manage stress in shrimp and shrimp welfare to secure better survival and better economic outputs."

Suraphol Pratuangtum, Thai Marine Shrimp Farmers Association (middle) with Dr Preecha Ekatumasuit, TRF Feed Mill Co., Ltd (left) and Apirum Wanaputh, ERBER Biotech (Thailand) Co.,Ltd.

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Productivity in the supply chain

By Zuridah Merican and Yvonne Nathan

Any weak links along the supply chain will disrupt the final output. Below we report on two presentations at TARS 2018, covering genetics as a tool to develop a more targeted shrimp, adapted to its production environment and approaches for sustainable nursery culture in Asia.

"While Latin America is adapting the shrimp to the environment, Asia is trying to manage the environment to suit the shrimp."
- Morten Rye

Different horses for different courses

Dr Morten Rye has worked on applied genetic improvement programs for fish and crustaceans for more than 30 years, with extensive experience from Europe, Asia and the Americas. Rye in his presentation with the above title, focussed on genetics as a tool to develop a more targeted shrimp, adapted to its production environment.

"Using the salmon as a reference, we know that all commercial production globally comes from well-designed breeding program, and that will be the direction for all key aquaculture species," said Rye, while highlighting trends from development of genetic resources for the vannamei shrimp. Shrimp production is characterised by highly diverse production systems-super intensive farming in Asia and very extensive systems in other parts of the world. One critical component to consider is biosecurity, as most farms are located close to each other; water discharged from one farm could well end up entering another. "In shrimp genetics, we have to consider genotype by environment interactions. A specific stock which is well adapted to one environment may not be the best suited to another."

Today, vannamei is produced in vastly different systems, from freshwater to full strength seawater. They are cultured in a wide range of temperature zones and there are huge variations in the oxygen levels in the systems.

SPF and pathogen exclusion

"Stock introduced to Asia is generally healthy and specific pathogen free (SPF), and there is currently a major focus on pathogen exclusion and a fight to get rid of major diseases. Considering the cycle of repeat disease outbreaks in the region, however, one could argue if this approach has been successful. Today we realise we also have to modify the shrimp to suit its production environment."

Rye said, that in Latin America, the shrimp have generally been selected for robustness to face the challenges in the less intensive systems. There has been less focus on selection for fast growth rate, but the evolved stock is being developed gradually. The overall approach is trying to live with local pathogens first.

"Because the prevalence of pathogens is high, it has become almost impossible to eradicate. Furthermore, in extensive production systems it is very difficult to modify and control the production systems. While Latin America is adapting the shrimp to the environment, Asia is trying to manage the environment to suit the shrimp. There are significant genetic resources coming to Asia, but since vannamei is a non-native species, most of these are not developed for an Asian situation."

Thailand vs Ecuador

Referring to trends in these two typical countries, Rye said, "In comparison to Thailand where both industry growth and collapse have been spectacular, Ecuadorian production has shown lower productivity but a steadier development. Ecuador's last major disease was white spot seen in 1999 and since then Ecuador has had a gradual and steady increase in production."

Fit for the environment

Rye believes that Asia under the current strategy is likely to continue to face significant outbreaks of new diseases on a regular basis. "This is because whatever strategy farms have for eradication, there is no way to eradicate all the pathogens affecting shrimp. This has to be considered when developing a sustainable strategy for the genetics work."

The goal must be to develop robust animals that can resist the new challenges. "The way to do this is to face the challenges that is coming down the road, to develop shrimp that can survive and grow well under specific conditions of a location, season or production system. There are tools now from the genetic side to tailor-make products to differentiate for the environments needed."

The key point for Asia is that in some countries, industry is already developing genetic materials that is considering the local adaptation to sustain the shrimp industry.

"The objective of genetics should be to produce animals that are better adapted to local conditions and Asia has to come up with a system to secure long term sustainability. Is it possible to balance the extensive and intensive experiences so that we can avoid this rollercoaster situation typically seen in Asia to arrive at a more stable growth?" The answer is to develop robust shrimp that can resist new challenges, such as use of specific pathogen resistant (SPR) shrimp while ensuring that animals entering are clean, e.g. not bringing new pathogens.

Morten reminded industry on the difference between SPF and SPR status, and that, under any circumstances, there must be a strict quarantine on introduction of new genetic stocks. The system which supplies post larvae must not carry diseases that are not at the facility or in the region and it must start with robust stocks, so that they can face the local pathogens without leading to major problems of diseases. In addition, there should be a

more advanced certification system in place, which considers the current situation in the specific region where these animals are used, allowing tailor-made products to better suit the new environment rather than have a very general SPF requirement.

"There is new knowledge on the immune system which is of great interest for genetics. It was believed that shrimp has an innate immune system with no memory, but new results show that there is a highly adaptive system which is open for immune priming. Likewise, is the implementation of genomic selection currently underway in leading shrimp programs expected to further boost the selection response for disease resistance."

> **"you have to be very balanced on the selection process in order to develop robust stock that combines high growth performance with high resistance to pathogens."**

Trade-offs

Rye summarised, "Asian production, currently relying on use of SPF animals selected for fast growth, may invite use of stock that eventually over time, is becoming more susceptible to new diseases. We should think of new strategies to obtain clean animals from populations that either have been exposed to the pathogen stressor because this is actually building a resilience and resistance to these pathogens."

He added that there is a trade-off between the traits of growth and resistance and it is easy to lose the trait of resistance from the stock. "We have seen this when we started in Colombia 20 years ago - as soon as selection pressure was solely placed on growth, we were losing resistance." Rye emphasised, "To take this into account, you have to be very balanced on the selection process in order to develop robust stock that combines high growth performance with high resistance to pathogens. This is critical for maintaining a sustainable production sector in the longer term".

Rye's message was, "For an advanced and sustainable breeding program in shrimp, start with a pro-genetic material that is building on the most important traits into the nucleus selection. Then add on the adaptation with these animals to tailor them for a specific market. This approach is done on a regular basis in livestock, as well as in advanced salmon program for the last decade or more.

"The result is producing an animal that is more specifically adapted and tailored for the challenges faced in shrimp aquaculture. We are maintaining a sustainable nucleus operation, maintaining genetic variability, but we are also taking the newest tools to develop this tailored product for the specific environments as well as customers preferences."

Chiow Yen Liew, DSM, Asia Pacific, Singapore (right) and Thiago Soligo, DSM, Costa Rica.

Sustainable culture for shrimp nurseries

Stressing the importance of microbial control in the environmental management of shrimp nurseries, **Manuel Poulain**, Key Account and Project Manager at Thailand's INVE Aquaculture, brought attention to the balancing act of a multi-trophic ecosystem approach.

In his presentation, 'Sustainable Approaches for Vannamei Shrimp Nursery Culture in Asia', Poulain advocates for low or zero water exchange and covered facilities in the fight against diseases as a way forward in sustainability, both environmentally and economically. "Like many different businesses, the success of a farm is mainly based on risk management," he said covering topics from biosecurity and nutrition to microbial and nitrogen control.

Biosecurity

This is the control of contamination factors which Poulain explained as chiefly water, shrimp as well as other considerations such as crabs, birds, aerosols and people. "Limiting water exchange will help you minimise your risks." He added that the future will require ensuring quality control of post larvae and covering facilities to reduce environmental influences as well as a measure of minimising phytoplankton dynamics. He recommended covered facilities only for super intensive farming, as it may incur considerable capital investment. "The use of a nursery will basically minimise the investment due to smaller pond sizes and a lower risk," added Poulain and expanded on this with comparisons between high water exchange facilities, biofloc systems-based nurseries and use of multi-trophic environment.

"In a high-water exchange system, especially nurseries, there is 100% to 600% water exchange a day, depending on the type of system." The main strategy is managing the environment through solids removal and bio-filtration. "So, it's ecology control by suppression." A limitation observed is the difficulty in exchanging water with small animals involved, because of mass clogging. Others include high-energy consumption used for pumping water and nutritional limitations in systems with poor natural productivity. "Basically, the shrimp is relying mainly on feed."

"The ecological control is based on competition with opportunistic and pathogenic bacteria." - Manuel Poulain

With biofloc system, activated sludge is a supplementary food source for shrimp. It works by managing carbon-to-nitrogen (C:N) ratio with zero or reduced water exchange and the removal of nitrogen via the heterotrophic population. "The ecological control is based on competition with opportunistic and pathogenic bacteria." A drawback is the tendency to accumulate nitrite within new environments and the biofloc system becoming semi-biofloc as farmers panic with rising nitrite levels and take reactionary measures by initiating water exchange.

A multi-trophic approach on the other hand uses autotrophic nitrification that does not require a carbon source. Employing zero-water turnover, it is similar to the biofloc system in that it is based on competition. "Limitations we observed is oxygen – we have seen that when you have more than 3kg/m^3 of biomass, it's very difficult to maintain oxygen levels of 3.5ppm or 4ppm. So, we have basically identified feed loading and shrimp biomass as KPI for sustainable nurseries or sustainable farming."

Constraints that crop up with zero or reduced water exchanges range from high *Vibrio* dynamics, organics and solids accumulation, leading to pathogens to high nitrogen build-up, with a likelihood of experiencing phytoplankton crash. "All these are linked so the approach is holistic as it considers all these clusters in our management.

"In limited water exchange nurseries, in terms of risk, the higher the density, the shorter is the nursery (under 20 days). Usually we like to transfer animals over 0.3g, otherwise catching with a net is very stressful to the juveniles." Poulain showed a design of a high-density nursery, up to 40 PL/L with 6 x 45m^3 tanks to sustain this system, aeration is by blower of 3.5hp and 65 diffusers as in the case of a nursery in Vietnam. There is shading to lower phytoplankton dynamics.

Nutrition

"Feed digestibility is important and so is managing feed amounts and frequency, as unconsumed feed accumulates at the bottom as waste alongside faeces and moult, creating toxic areas."

In feed management, Poulain advises using air blowers to create convection currents that are more efficient as aerators. "Circulation currents are not so good because when you put feed in the tank, shrimp does not grab the feed right away. If you have a current that is too strong, the feed accumulates in some areas and creates a lot of competition for feed between animals – basically this stimulates size variations and drops survival rates.

"Then we talk about high-density nurseries; we have high productivity, so we are diluting production costs, so you can afford to use higher nutrition and quality feeds," he said, recommending a minimum of 15% replacement of daily feed by quality feed. "The idea is feed less, feed better. This limits nitrogen build-up and creates more strength with health boosters for the animals." On the down side, high-density nurseries induce stress, demanding quality immunostimulants as feed coating to boost shrimp immunology.

Microbial and nitrogen control

A hygienic environment is key as a start to microbial control. Poulain explained that the primary tool in the arsenal is a high

Manuel Poulain leading a roundtable on culture, technology and innovation (CTE) during the breakout session.

Some of the table leaders in the feeds, health & environment (FHE) breakout group, from right, Stephane Ralite, Lallemand Animal Nutrition, France; S Santhana Krishnan, Marine Technologies, India and John Tinsley BioMar A/S, Ecuador.

Fiona Tansil, PT Suri Tani Pemuka, Indonesia

Jeffrey Lee Kat Choy, Kembang Subur, Malaysia.

concentration of probiotic bacteria for water conditioning and top coating, using competitive exclusion on two fronts. Firstly, is covering the space with good bacteria. Secondly is limiting food, starving *Vibrio* out. Nevertheless, problems arise because of different multiplication rates as it takes an average *Bacillus* six hours to multiply, compared to the *Vibrio*'s 20 minutes.

Minimising nitrogen accumulation comes with feed management, quality diets, biofloc and the holistic approach of reduced water exchange. "It's risk management," he said revealing that over his 20-year experience, the vannamei shrimp can handle up to 5ppm of nitrogen for a time. "Would you prefer 1 to 3ppm of nitrogen, or exchanging water and taking the risk of bringing in white spot disease, early mortality syndrome or *Enterocytozoon hepatopenaei* (EHP)? Before you exchange water, look at alternatives – lower feeding, bottom syphoning or shrimp toilets."

In summary, expenses can be redistributed to cover important purchases such as additional cost of superior quality diets by reducing costs associated with high water exchanges as it reduces contamination risk, water treatment costs and power usage while halving labour costs. "In my opinion, sustainability is biosecurity, plus consistency. I think that is what the industry needs."

(For more details, refer to Poulain, M. 2018. Nursery operations at the farm site: A sustainable approach for Asia's vannamei shrimp industry. Aqua Culture Asia Pacific, 14 (4), July/August 2018, pp 16-21.)

Integration in the tilapia supply chain

As PTAN approaches 30 years as the leading responsible tilapia aquaculture producer, adapting to changing environments and market conditions are inevitable.

Regal Springs, the world's largest integrated responsible tilapia aquaculture enterprise with its own natural genetic selection, hatcheries, cage culture, processing facilities, marketing and distribution has its origin and roots in Indonesia. In this article, we trace its beginnings to the current and now wider Regal Springs group, with aquaculture spread over three countries (Indonesia, Honduras and Mexico) and sales and marketing in the US, Asia, Latin America, South Africa and the European Union. Today, under new ownership, the business is developing consumer sales in Indonesia and Asia where it sees demand for high quality protein food such as the Regal Springs Tilapia it produces.

The company responsibly farms tilapia in lakes. Its products, meet local and national regulations- fully traceable and independently certified by the Aquaculture Stewardship Council (ASC) and Global Aquaculture Alliance, Best Aquaculture Practice standards and certified to the British Retail Consortium (BRC) for food safety and good manufacturing practice.

The Indonesian operation of Regal Springs group is PT Aquafarm Nusantara (PTAN) which has a hatchery and grow-out in Central Java, a hatchery in North Sumatra and grow-out operations in three man-made lakes in Central Java and the volcanic crater Lake Toba in Sumatra.

At his office in Klaten, I Wayan Mudana, Head of Farming recounted the early start-up days of PTAN in Klaten which was selected for its relatively cool spring waters.

"Around Klaten, we have numerous springs popping up all the time. Back in 1988, the founder of Regal Springs, who was an ex UN aid worker, was looking for a site to farm the *Clarias* catfish and help alleviate the poverty of the surrounding communities. But as the water temperature was 24°C, his efforts to breed the catfish were not successful. He then took up the suggestion of breeding the tilapia but was very hesitant due to the marketing challenges of such a species at the time. The catfish had a ready market, but the tilapia was relatively unknown among the locals."

In Klaten, the water in the reservoir is as clear as 30 years ago. Photo credit: Regal Springs Indonesia

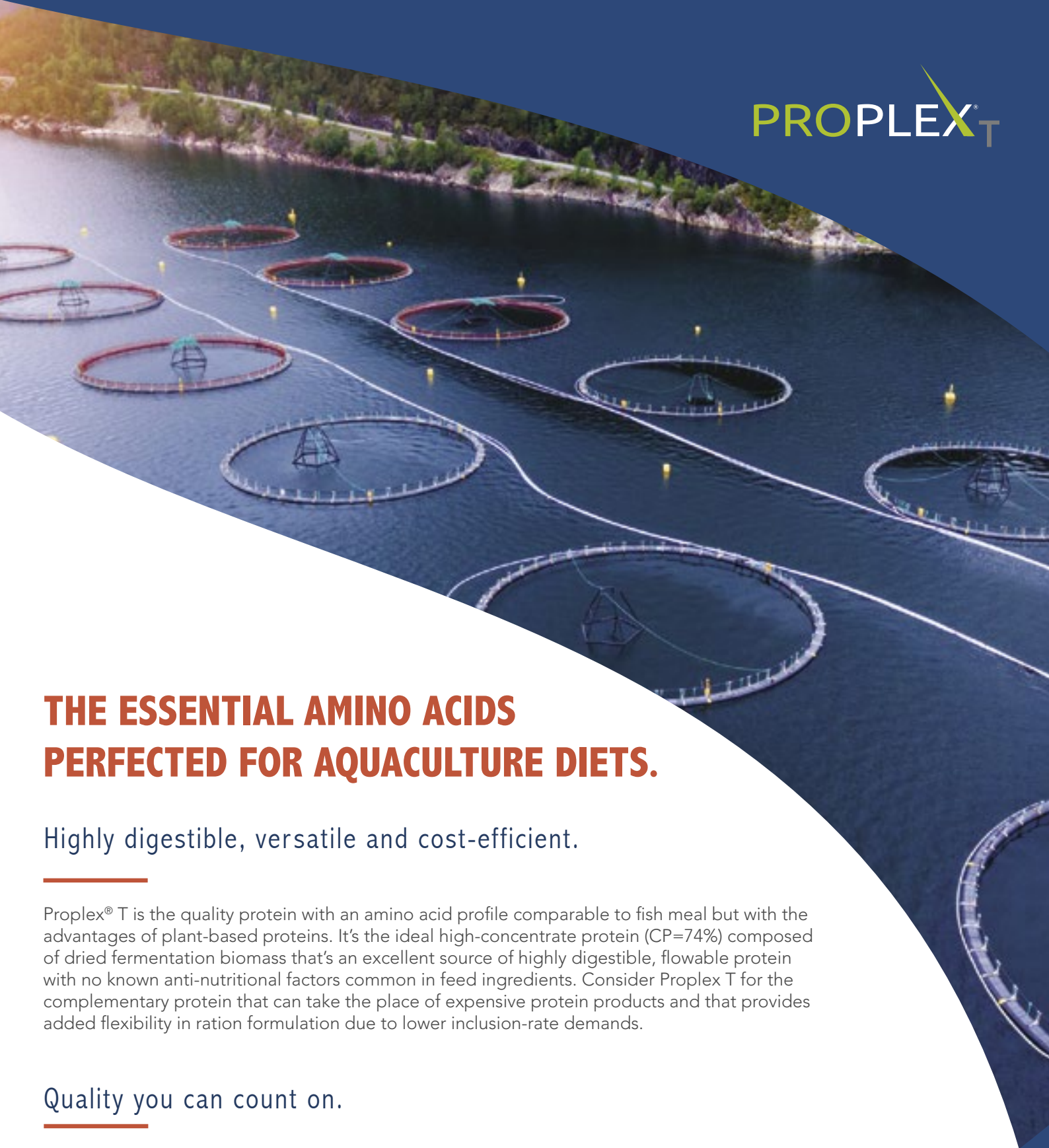
Nevertheless, with good advice from experts, the very successful breeding of tilapia and its farming evolved. The next step was developing a market. The US market with a diverse consumer base led to good demand and pushed PTAN to increase production very quickly. Farming in three lakes in Central Java was started in the early 1990's and operations around Lake Toba began in 1998.

The beginning in Klaten

Today, the 4.1ha stony area with hatchery culture for the tilapia enjoys the clean spring water. Regal Spring practices natural spawning at its hatcheries. In Klaten, 2-day old swim-up fry are collected and rearing continues in cement tanks. "As we have limited space, we started by sending the 0.5g fry, to 100 third party nursery farms around Slemang regency in Jogjakarta which grew them to 15-20g fingerlings. In 2015, we forged a partnership with a 15ha nursery near Semarang, which only works to our specifications for the on-growing to juveniles," said I Wayan.

"We found it too difficult to manage to our responsible aquaculture standards by handling hundreds of small nursery farmers and so moved part of the capacity to one nursery farm which is very efficient and helps us maintain our standards. We have an agreement to source the juveniles depending on our specification. The larger the fingerlings, the less we pay."

PTAN's cage farm in Lake Toba. Photo credit: Regal Springs Indonesia



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Cement lined spawning and culture ponds in Klaten. Photo credit: Regal Springs Indonesia

The breeding operations

Both the male and female brood stock of the red and black varieties of *Oreochromis niloticus* male and female brood stock are kept in rectangular ponds at a 1:3 ratio (red males: black females) and left to spawn naturally. "Depending on water temperature, the swim-up fry will appear within 7-8 days after egg fertilisation and kept by the female brooders in their mouth. In the past, we used to collect the eggs and incubate them but today we allow mouth brooding. We collect them two days after release for transfer into fry rearing tanks.

"In fry rearing, we use crumbled shrimp feed as no feed miller is producing fry or early stage feeds for the tilapia," said Budi Santoso, Site Manager. "The shrimp feed also has a high level of protein (46%). Feeding is *ad libitum*, 4-8 times/day." The fry stay in the tanks for 21 days before being harvested and sent out to the nursery farm. However, this will also change with demand from its farming operations within Central Java.

Water quality

The location in Klaten benefits from the good quality spring water at a 7ppm dissolved oxygen. As it passes through the hatchery and grow-out ponds, dissolved oxygen will go down to 4 ppm. The reservoir pond is continuously replenished with clean and clear spring water. "The condition of the water has remained the same over the past 30 years and we do not need to treat the incoming water," said Totok Yunionto, Farming Officer.

Despite this, PTAN invests more in water quality monitoring than any other fish farming business across its operations as it recognises that the main requirement of high-quality fish is water quality.

Budi Santoso and Totok Yunionto (right)

"We only use brood stock from our own natural genetics program," – I Wayan.

Genetics and brood stock development

Over at PTAN's hatchery at Serdang Berdegai, North Sumatra there is an ongoing PTAN proprietary natural genetics program. Here the average weight of a female is 800-1,000g and average weight of male brood stock is 1,000g-1,200g.

"We only use brood stock from our own natural genetics program," said I Wayan. "Fry from our genetics program are brought over to Klaten for rearing into brood stock." Around the Klaten hatchery are cement ponds to culture brood stock. After 7-8 months of culture, tilapia can be selected for our brood stock. "These are exclusive for the use of PTAN's hatchery," said I Wayan.

Farming operations and employment

The once humble tilapia in Indonesia is now a major source of employment for many. Across just its operations, PTAN employs 4,200 people. There are however, many more upstream on the supplier side.

PTAN's annual total production is 30,000 tonnes with around 8,500 tonnes from operations in Central Java from 3 lakes; Wonogiri, Kedung Ombo and Wadaslintang and the rest from North Sumatra in the Lake Toba region. Across North Sumatra alone the company has 3,360 employees which also supports over 1,250 families. Farming and feed operations in the Lake Toba region supports 780 jobs.

Burnawan Yasum (right) said "At Wonogiri, we run aerators and sometimes, diffusers when there is no wind."

Changing environments

So far this year, conditions were very dry and thus were challenging for the farm especially in Wonogiri. Usually October is the rainy season. "Water depth was lower than normal when we have a wet season. But in July, we had upwelling with the cold winds from the south and the air temperature around was 20°C and water temperature was good at 24-25°C at night and 27°C in the day time," said Burnawan Yasum, Manager of the Wonogiri farm. The Wonogiri farm has cages that are 6mx12m and 2-2.5m deep. Lake water temperatures range from 27-30°C.

FCRs *vs* ADG

PTAN has a small (900 tonnes per month) feed factory in Medan producing crumble starter feeds (36% crude protein) for 10 to 150g fish. It is the single largest user of tilapia feeds in Indonesia, buying 32% crude protein extruded floating feed from leading feed millers in Indonesia.

Usually, feed conversion ratios (FCRs) depend on the months of the year; FCR is also linked to fish mortality and the stage of fish when mortality is highest. "When mortality is at the smaller size, FCR is not affected. We chase after FCR rather than ADG (average daily gain)," said I Wayan. At the cages in Wonogiri, the use of auto feeders was tried but with windy conditions, the preference is feeding by hand.

Harvest and marketing

Harvest size of tilapia vary; 950g to 1 kg from cages in Central Java for fillet production and 1-1.2kg fish from Lake Toba, mostly for loins production. PTAN is self-reliant with two processing plants; production in Java is sent to the plant in Semarang and that from Lake Toba to a much larger plant close to Kualanamu airport. The newer plant in Semarang, completed in 2014 has 45 tonnes/day capacity in one shift.

Photo credit: Regal Springs Indonesia

Growing micro nutrition in Asian aquaculture

DSM invests more resources into its aquaculture portfolio to sharpen its competitive edge.

Historically a strong European company, DSM Nutritional Products has diversified geographically and across species. Globally, within the animal nutrition and health segment, DSM is synonymous with micro nutrition in the widest portfolios across animal production. Whichever product, whether vitamins, carotenoids, premix or enzymes it is recognised for, is built from a solid history with its customers. Today, DSM also has a growing position in eubiotics.

In October, DSM enlarged its premix footprint in India with a second plant, this time in Jadcherla, Telagana State. Largely focussed on the burgeoning poultry sector which is growing at 2-3% annually, the new premix plant is ideally located to also serve aquaculture. (see page 60).

David Blakemore, President Animal Nutrition and Health, was in India for the inauguration of this premix plant. In this interview in Hyderabad, Blakemore gave his views on how DSM is growing as it supports a rapidly expanding aquaculture industry in India and in the rest of Asia. Also present and providing inputs were: Fidelis Fru, Senior Director Marketing, Nutritional Solutions and Innovations Sales, DSM, Singapore; Captain Ravindra Vyawahare, Business Unit Director for South Asia; and Vilas Autade, Business Manager - Aquaculture India.

The commitment

Blakemore began the interview with DSM's raison d'être. "We are a purpose-led and performance-driven company and we do believe we can do good and by doing so, it matters well for the planet. So, the good business results will also come. At the heart of DSM is science and innovation. Science and knowledge are applied to our different market domains; health, nutrition and sustainable living.

"Today, we show not only our commitment to the growth of the Indian market, but we also continue to strategise to grow around the world. Furthermore, we do not regard this plant as an asset but very strongly as a channel to the market. We have our team supporting the premix plant but more importantly, we connect with our local customers in bringing the global innovation of DSM here to India."

On aquaculture, Blakemore added, "When we think of some of the challenges, obviously, sustainability is important as is the focus on productivity, environment and discharge issues. This fits very well with DSM's culture."

Long history in aquaculture

DSM is committed to aquaculture since the 1960s through innovation and global supply of key vitamins and carotenoids. It continued with nutritional solutions for growth performance, health and disease management, and environmental sustainability through a portfolio of products for aquaculture–vitamins and mineral premixes, functional feed additives and enzymes. These help fish and shrimp farmers to boost survival rates and immunity while promoting environmentally friendly farming.

"Aquaculture has the potential to grow," said Blakemore. "In our last strategy meeting, we talked about aquaculture as an

David Blakemore, President Animal Nutrition & Health, DSM since May 2016, is a business leader with over 31 years of experience in driving a strong focus on customers and markets with a disciplined approach to business and innovation.

'under penetrated species'. The market, growth for aquaculture is moving at a fast pace, possibly at 4-7% per annum, twice that for poultry. With this kind of growth rates, we are putting additional focus and additional resources. Going forward, we expect aquaculture to be an increasingly important part of our portfolio."

Within the Asia Pacific region, the drive is with warm water aquaculture and predominantly, shrimp in India. "In the last couple of years, Asia Pacific has been our fastest growing region, and it has been changing the geographical diversity of our business and the species focus of our portfolio. We will, today, however, continue to focus on the premix products for aquafeeds but this does not mean that we will be just limiting ourselves to premixes," said Blakemore.

> **"Going forward, we expect aquaculture to be an increasingly important part of our portfolio."**

"We pull together global researchers to reach a strong focus in warm water aquaculture. The Brazilian and the Latin American team learn a lot from the Asia Pacific team and vice versa. Of course, traditionally, we have a stronger presence in the salmonid feed market, but I would say the growth rates in tilapia and warm water aquaculture are much higher. I am elated as the demand for healthy fish does create unique opportunities for DSM."

Strengths with feed additives

"In aquafeeds, we have made our mark in carotenoids, micronutrients etc. Now our technical team is looking at our enzyme's portfolio for aquaculture. Enzymes are getting a lot of attention across all species, not only in aquaculture. Higher digestibility of feeds will lower discharge into the environment.

"Our astaxanthin product available since the mid-80s has been a very important part of aquaculture. The functional feed area with vitamins, other micro nutrients and enzymes is getting a lot more attention today for improving health of the animal, feed digestibility and on the environmental side, reducing phosphorus discharge."

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David Blakemore (second left) at lighting the lamp ceremony to mark the opening of the premix plant together with Dr Fidelis Fru (third from right) and Captain Ravindra Vyawahare (fourth from left).

In aquaculture, DSM is putting big investments and stepping up resources to be close to customers, developing more insights on the challenges they are facing and driving our innovation pipeline.

Back in the 1994, DSM started its Aquaculture Conference: Asia Pacific in Bangkok and in 2018, the 24th conference will be held in November in Bangkok and Jakarta. This annual conference updates the industry in Asia with the latest information for their aquafeed business. It also links key researchers with industry in Asia. A more recent activity are webinars to guide industry on nutritional matters, akin to classroom lectures. The most recent webinar focussed on the environmental Impact and sustainability in aquafeed, whilst the first for 2018 dealt with aquafeed optimisation: key for improving quality fish and shrimp feed.

Premix footprint in Asia

DSM already has a large footprint in premix plants globally, with a total of 48 plants. In India, DSM expanded the first premix plant and embarked upon a second one. "We put in the first plant and then saw the growth and development of the market. We expanded and identified growth in this south-eastern region – an expanding poultry industry and growing aquaculture. Today, Captain Ravindra is already talking about where a third plant in India would be. This is an important part of our premix strategy. It also serves as a technology outreach."

Back to basics

"Whether chicken, fish or shrimp, it is back to basics; a rejuvenation of our OVN (Optimum Vitamin Nutrition) concept and micro nutrition is getting more attention. We believe that the industry is not using the optimum level of vitamins for optimising growth and achieving the healthiest possible fish or shrimp. to survive the different disease challenges. We are also seeing this concept getting new traction and attention with antimicrobial resistance in the poultry sector," said Blakemore.

Support for aquaculture in India

Blakemore noted that shrimp aquaculture in India is fast growing as well as the focus on exports markets. Thus, there is a high expectation on quality which presents the opportunity to work with industry.

Ravindra who was responsible for the site selection of the second premix plant added, "This region of India has 90% of aquaculture activity. This is why we are here."

An increase in market share would be a target but Fru commented, "It is just not about market share but also about growing a base which currently is small. We want to grow together with the industry in India. We also hear that our customers are using carotenoids to combat the white spot syndrome virus although we have not yet done our own in-house research to confirm this. We know that carotenoids have strong anti-oxidative properties. We, on the other hand, are promoting a health premix to help animals activate their immune systems. At DSM, we do not have a cure for diseases, but aim to feed the animals to become resilient. This is one of our biggest innovation focus in aquaculture, both for fish and shrimp."

DSM is using all the necessary tools to impart knowledge to the aquaculture industry in India. In 2018, the DSM aquaculture team in India conducted an "aqua school" for around 100 participants comprising farmers and aquafeed producers. The aim is to share DSM's technology, update them on new trends and refresh their knowledge on aquaculture nutrition and the role of vitamins in fish and shrimp farming.

In the pipeline and algae oil

There is a constant innovation pipeline of products for aquaculture. Probiotics is being developed for aquaculture as well as a new phytase product. By mid-2019, the latest product for the aquafeed market will be algae based omega-3 oil with EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) from Veramaris, a joint venture between DSM and Evonik.

"This is a great sustainability story for DSM. Part of the sustainability in aquaculture challenges is FIFO (Fish-In Fish-Out) ratios with the dependence on marine oils. Now we have a natural yet sustainable source to grow healthy fish and in the case of the salmon, be able to get back to the traditional levels of EPA and DHA in the fish for human nutrition. This fits into our action for healthy hearts, healthy minds."

Blakemore explained, "We do not expect to position this as a commodity fish oil product because of the advantages it brings to the market and the unique attributes. We feel we have the best product for the industry with the right levels of EPA and DHA required for both fish and shrimp. This is our competitive edge even though there are other replacements for fish oils coming to market."

Lastly, on new markets for the premix business, Blakemore said that there is clearly a demand in Myanmar. It is on top of the DSM list for the region and top of the global team's list in its premix footprint investment.

Lessons from soccer – applied to microbiology

By Benedict Standen

Taking the cue from using best strikers in soccer, multi-genus rather than one single genus could be more effective in probiotic formulations.

As football fever spreads across the world, nearly half the world's population watched the World Cup in 2018. The competition equalled a record, with the joint highest number of penalty shootouts, with a total of four (also in 1990, 2006 and 2014). Penalties can be a very anxious time, especially when your native country is involved. Many factors can influence the outcome of a penalty shootout. Most importantly though, you need to use your best strikers to score, and your best goalkeeper to save. It is extremely unlikely that a world-class goal scorer, can also be a world-class goalkeeper. This is obvious, since each player has strengths and weaknesses and possesses a different set of skills, which allows them to successfully accomplish a task.

The same is true for beneficial bacteria, or probiotics. Different species have different characteristics, which affect their efficacy, and ultimately their probiotic functionality. With this in mind, why are the majority of commercial probiotic formulations focussed on a single genus, the *Bacillus* sp.?

There are a few reasons for this. Firstly, most common *Bacillus* spp. are generally not too difficult to grow at moderate cost. Secondly, they can form bacterial spores, which allow for a longer shelf life and have greater (but not limitless) heat stability. Thirdly, they have an extensive safety record with only a couple of species known to be pathogenic, or toxic to animals (*Bacillus anthracis* and *Bacillus cereus*). This safety record makes it relatively easy to register *Bacillus* spp. products, since they appear on many positive lists: for example, GRAS - Generally Recognized as Safe in USA; QPS – Qualified Presumption of Safety in EU. However, these benefits are more useful for the probiotic producers, as opposed to the animals.

Although there is scientific evidence to support the use of *Bacillus* based probiotics in aquaculture, it is unlikely that a single genus of bacteria can do everything. The intestine is an extremely complex ecosystem, and therefore specific microbial drivers are needed, in the right concentration, for specific tasks within the gut. Consequently, the probiotic should be chosen based on the benefits one wants to achieve i.e. growth performance, immunity, disease resistance, survival etc.

Probiotic colonisation

It is controversial whether 'true' probiotic colonisation is possible. A number of studies have reported that once probiotic feeding has stopped, the probiotic can persist in the intestine for a certain period of time, therefore demonstrating temporal colonisation. In aquatic species, the current literature suggests this period can be <3 days to >3 weeks and is dependent on the probiotic species, host species, environmental factors, dosage and duration of probiotic supplementation. The intestinal microbiota can be split into two distinct groups, those that are transient (allochthonous) and those associated with the static mucosa (autochthonous). Here, cell turnover rates need to be taken into account. Once colonisation happens, a "release" is not further happening, and the colonists are sluffed off with usual intestinal epithelium cell turnover rates. The best probiotic colonists are the autochthonous bacteria. By attaching to the intestinal epithelia, they compete with pathogens for adhesion sites, preventing their attachment and subsequent translocation leading to immune response/sub-acute stage of energy loss, or even acute infection. Furthermore, through a complex system of molecular receptors, they can also interact with the host immune system, improving immunity and increasing disease resistance.

Different probiotic species possess different adhesion properties, and this can ultimately affect their ability to colonise the intestine and exert their benefits. As important mucosal surfaces, two aquatic epithelial cell lines from rainbow trout, *Oncorhynchus mykiss*, were chosen to evaluate probiotic adhesion; commercial gill cell lines (RTgill-W1, ATCC, Virginia, US) and intestinal cell lines were isolated fresh by scientists at the BIOMIN Research Centre (BRC), Austria (Figure 1). The probiotic species (*Lactobacillus* sp., *Pediococcus* sp., *Enterococcus* sp. and *Bacillus* sp.) were chosen based on their well-documented benefits in aquatic animals, and their combination makes up the commercially available probiotics, AquaStar® Growout and AquaStar® Hatchery (Biomin, Austria).

In general, lactic acid bacteria (LAB; e.g. *Lactobacillus* spp., *Pediococcus* spp. and *Enterococcus* spp.) can be the colonising bacteria in the gut. As this is one crucial criterion for an efficacious probiotic, all LAB strains selected for AquaStar® are able to attach to the gill and gut epithelial cells, with stronger adhesion observed in the intestinal cell lines (Figure 2). AquaStar® *Lactobacillus* sp. was extremely good at attaching to epithelial cells, with an average of >100 and >300 probiotic cells attaching to an individual gill and gut epithelial cell, respectively. AquaStar® *Pediococcus* sp. exhibited the second strongest adhesion properties, with >30 probiotic cells attaching to a single enterocyte (gut epithelial cell). *Enterococcus* sp. also displayed adhesion abilities, albeit at a lower level than *Lactobacillus* and *Pediococcus*.

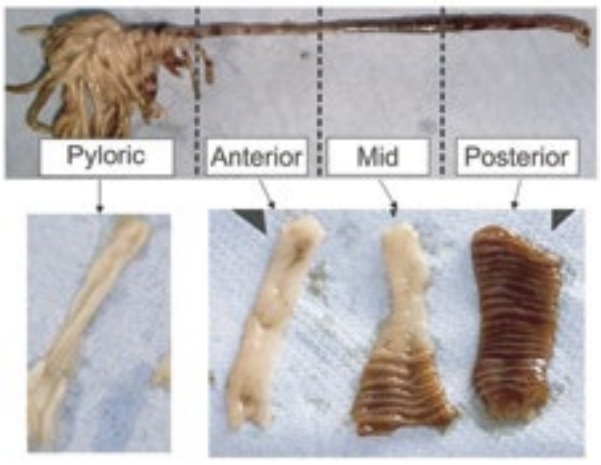

Figure 1. Schematic diagram of where intestinal cells were isolated from the digestive system of rainbow trout, *Oncorynchus mykiss*. The intestine was split by region, opened up longitudinally and epithelial cells isolated for further *in vitro* culture. Source: Langan et al. 2018

In addition, there was the complete inability of AquaStar® *Bacillus* sp. to attach to either epithelial cell type (<1 *Bacillus* cell per epithelial cell). In the intestinal environment, this suggests that their main function is in the lumen of the gut. The hypothesis is that, due to their proteolytic nature (discussed below), it would actually be negative, and potentially harmful, for the animal if a *Bacillus* probiotic were to attach to epithelial cells. These data suggest that for a better colonisation of the intestine, an in-feed probiotic should favour LAB, instead of *Bacillus* spp.

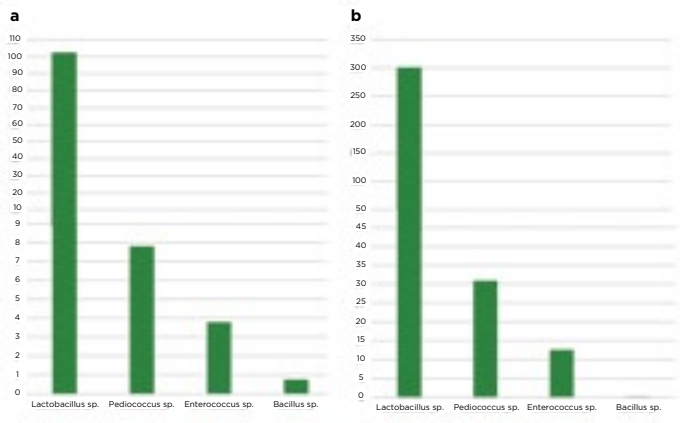

Figure 2. Adhesion properties of selected probiotic bacteria to gill (a) and gut (b) epithelial cell lines. The data indicate the number of probiotic cells attached to a single epithelial cell. Source: BIOMIN

Enzyme production by *Bacillus* spp.

Although numerous benefits are reported, *Bacillus* spp. are well known for their ability to produce enzymes. In the intestine, these enzymes can improve the digestibility of feeds, contributing to better feed conversion and growth performance, whilst in the environment they can help break down organic matter in the water and sediments. Using *in vitro* techniques, our scientists documented the ability of numerous *Bacillus* probiotic candidates, to produce proteolytic, amylolytic and cellulytic enzymes. It was clear from the variation, that the ability to produce enzymes is not universal within the genus *Bacillus* (Figure 3) and therefore caution must be applied when choosing a commercial probiotic. Most interesting is the variability within a single species. For example, when looking at protease production, the inhibition zone from *B. subtilis* #1 was approximately half that of *B. subtilis* #5, indicating considerably lower protease production.

Similarly, amylase production differed between *Bacillus* spp. tested. Certain *Bacillus* candidates were not able to produce amylase at all (e.g. *B. licheniformis* #1), whereas others (e.g. *B. subtilis* #5) could produce more. Whilst carbohydrates are not fully utilised in aquatic animals, starches help with pellet binding and expansion in extruded aquafeeds, affecting pellet density. For example, sinking feeds will typically have 6-8% starch, whilst floating feeds will have more, at >20%.

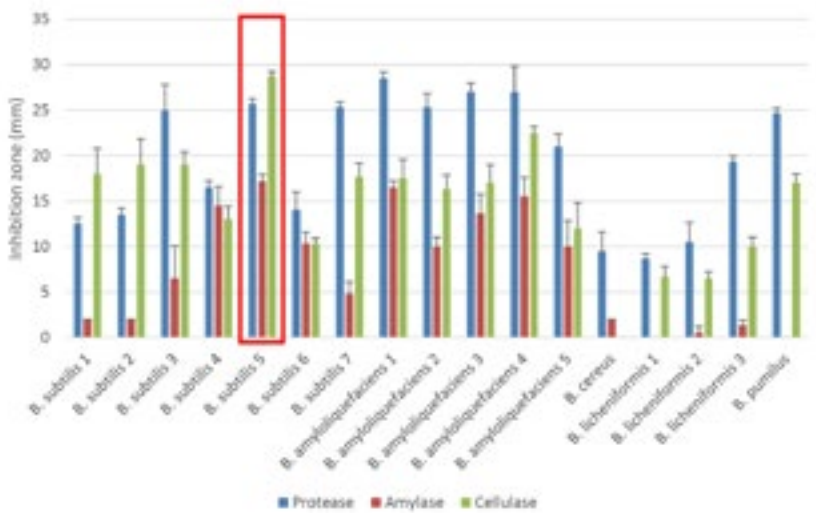

Figure 3. Ability of *Bacillus* spp. to produce extracellular proteolytic, amylolytic and cellulytic enzymes. Higher bars indicate greater production, or activity, of the respective enzyme. The red box indicates the *Bacillus subtilis* strain in AquaStar® products. Source: BIOMIN

Conclusion

The intestinal microbiota is infinitely complex, with different groups of bacteria having different roles and bringing different benefits to the host. Therefore, it is extremely unlikely that a single probiotic species, or even genus, can offer a silver bullet solution to the diverse challenges in aquaculture. Producers and feed millers can fully address these complexities by choosing formulations that utilise a multi-genus and multi-benefit concept, such as AquaStar®. *Bacillus* sp. can produce high volumes/activity of enzymes contributing to digestibility and feed conversion, whilst AquaStar® containing LAB can colonise the intestine, reducing pathogen load, improving immunity and increasing disease resistance. Clearly, there is a place for simple *Bacillus* probiotics, but to use another football analogy, perhaps it is time that that they were substituted, in replacement of alternative and maybe more promising, systematic probiotic products.

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Era of disease, adapt or die!

By Alexandre Veille

Increases in disease burden from a dynamic aquaculture require industry to catch up fast with pathogen evolution.

The world population is projected to grow from 7.3 billion in 2015 to 9.7 billion by 2050 (United Nations Department of Economic and Social Affairs). The fact is that we need to produce more food to support this growing population. While cereals and roots account for 82% of the global food supply, meat products only account for 4.64% with pork as the most-consumed meat followed by chicken and beef.

However, with a 1.69% share of global food supply, seafood, where aquaculture represents more than 50%, is the fastest growing sector with 7.4% compound annual growth rate (CAGR). Seafood may become the third most consumed meat product by 2020. Given the rapid growth and dynamic nature of aquaculture, it seems likely that even without evolution, epidemiological changes will lead to increases in the disease burden of aquaculture. There is strong evidence to indicate pathogen evolution, including evolution of virulence, is also playing a role in the emergence of some diseases in aquaculture (Walker and Winton, 2010).

Potential disease driver

In an attempt to raise awareness, David A. Kennedy et al. (2015) surveyed various aquaculture practices that can create conditions favouring the development of highly virulent pathogens which can lead to increased disease severity. It is however unrealistic to expect all evolutionary changes to be explained by the evolution of virulence theory alone.

Highly virulent strains tend to truncate infectious periods by killing their hosts; they thus have to have a higher transmission rate to survive and spread while their hosts are still alive. Strains with low virulence that do not kill their host can thus have lower transmission rates. Thus, high host densities in recirculation aquaculture systems (RAS), raceways or shrimp nursery systems can allow for the maintenance of pathogens that would otherwise kill hosts too quickly to persist and evolve toward higher virulence (Anderson and May, 1982).

Moreover, shortening the effective host lifespan, for example by compressing the rearing cycle through genetic improvement or farming practices, may thus favour evolution of increased pathogen virulence (May and Anderson, 1983; Choo et al., 2003; Nidelet et al., 2009). The pathogens are said to evolve towards higher virulence due to generational compression if they can induce chronic, persistent, infections with lifelong potential for pathogen transmission, such as the koi herpesvirus (KHV), cyprinid herpesvirus 3 in koi and carp (Ilouze et al., 2011), infectious pancreatic necrosis virus in salmonids (IPN, Yamamoto, 1975), and white spot syndrome virus in shrimp (WSSV, Tsai et al., 1999).

It is commonly accepted that the more the genetic variation in the host population, the less specialised the pathogen will be (Lenski and Levin, 1985; Ladle, 1992; Ebert and Hamilton, 1996; Jokela et al., 2009; Morran et al., 2011). However, reduced genetic diversity, due to selection of beneficial traits, has been observed in mass production systems, such as agriculture and

High host densities in recirculation aquaculture systems as above can allow for the maintenance of pathogens that would otherwise kill hosts too quickly to persist.

livestock. Aquaculture is also trending towards hosts with high specialisation and thus pathogens with higher virulence. Direct evidence of it has also been observed between host species for infectious hematopoietic necrosis virus (IHNV) (Garver et al., 2006) and *Gyrodactylus salaris* (Bakke et al., 1990; Bakke, 1991) in salmonids, and for viral haemorrhagic septicemia virus (VHSV) across five finfish species (yellow perch *Perca flavescens*, rainbow trout *Oncorhynchus mykiss*, Chinook salmon O. *tshawytscha*, koi *Cyprinus carpio koi*, and Pacific herring *Clupea pallasii*) according to Emmenegger et al. (2013).

Pathogens can also adapt and specialise according to the environment and become endemic when their eradication is impossible. Thus, the chance of possible host species jumping increases, and this often leads to higher virulence in new host species. This was the case for the fish rhabdoviruses, IHNV and VHSV that jumped from sockeye salmon and pelagic fish (herring) to rainbow trout, with heavy economic losses (Kurath et al., 2003; Einer-Jensen et al., 2004). Moreover, in the context of mixed infections, pathogens will adapt to be more competitive either by a faster reproduction rate or by developing toxins such as antibacterial toxins, with overall higher hosts mortality rate. Evolution will favour the more virulent strain (Bremermann and Pickering, 1983; Nowak and May, 1994).

> **“We need to be fast to catch up with pathogen evolution. As pathogens can evolve, so can the host’s immune mechanisms.”**

Mitigating infectious diseases is one of the many challenges in aquaculture. From the perspective of virulence evolution, the economic consideration for high productivity by increasing density, shortening rearing time, reducing genetic diversity by breed selection and misuse of antibiotics, could lead to the evolution of increased virulence as described above. Altering rearing practices or enhancing host natural immune defenses in the interest of preventing pathogen evolution could potentially give a long-term benefit with short-term costs.

The key for aquaculture immunity

We need to be fast to catch up with pathogen evolution. As pathogens can evolve, so can the host’s immune mechanisms.

However, immunity comes with a price (metabolic and maintenance) that should be balanced by the protection it confers. Therefore, depending on the pathogen occurrence and virulence, different strategies to identify and target the pathogen have been adopted. Innate and adaptive immune systems can be a first set of strategies, the first one being the most efficient to deal with persistent and frequent pathogens while the second one is more suitable for rare and transient pathogens (Andreas Mayer et al., 2016). An important characteristic inherent to fish, is that the immune system tends to rely more on its innate response for the clearance of an invading microorganism (Magnadottir, 2006).

The natural immune defence seems to be a good candidate against pathogen evolution as the immune system can evolve alongside the evolution and can be enhanced at a reasonable cost. However, a good understanding of the immune system is a prerequisite to its enhancement. The immune reaction is initiated by the recognition of pathogen associated molecular patterns (PAMPs) by cellular or humoral pattern recognition receptors/proteins (PRRs) (Abbas et al., 2012; Tort et al., 2003). It will then trigger a cascade of messenger molecule (cytokine, chemokines) secretion (Roher et al., 2011) which aims to activate a general immune response, including recruiting phagocytes and lymphocytes via chemo-taxis, and the activation or secretion of cellular and humoral antimicrobial defense mechanisms, such as the complement system, lysozyme, antimicrobial peptides, etc. (Abbas et al., 2012; Bayne and Gerwick, 2001; Reyes-Cerpa et al., 2012). Other molecules also have the ability to induce messenger production.

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Alexandre Veille is Asia Aquaculture Manager for Olmix. He is based in Jakarta, Indonesia. Email: aveille@olmix.com

SHRIMP AQUACULTURE: NEED FOR CHANGE

Nutritional and health interventions

By Yvonne T Nathan and Zuridah Merican

Insights, knowledge and updates for farmers and feed producers as they face challenges with health issues, robustness of shrimp and nutritional gaps with fish meal and fish oil replacements.

Gut health to mitigate disease

A healthy digestive system is essential for animals to maximise nutrient absorption and to minimise the intrusion or interference of pathogens, including bacteria such *Vibrio* species in shrimp.

"It is especially important to reduce these pathogens in the shrimp gut because they cause huge losses during production," said **Dr Serge Corneillie**, Business Development and Technical Director for Diamond V based in Asia, specialising in aquaculture. "In shrimp farming, several *Vibrio* strains – like *Vibrio parahaemolyticus*, *V. alginolyticus*, *V. harveyi*, and *V. vulnificus* – can cause up to 100% mortality."

> "There are no silver bullets to replace antibiotics; it is not so easy to find an alternative to antibiotics."
> - Serge Corneillie

However, Corneillie noted, today the use of antibiotics in animal production is under much greater regulatory control. In many countries, it is no longer possible to use antibiotics to prevent disease or promote growth, even though they are cost efficient. He cited an example from pig production where AGP's (antimicrobial growth promoters, including antibiotics) in the feed could show an average 8% improvement in growth and 3% improvement in feed conversion over production without AGP's.

"There are no silver bullets to replace antibiotics," Corneillie said. "It is proving very difficult to discover or develop a comparable alternative. So nowadays, we try to influence the microbial community in the gut, by reducing pathogens without using antibiotics while promoting more beneficial bacteria.

Options to improve gut health

The modes of action and recent findings for options in shrimp feed such as use of organic acids, probiotics, immune stimulants, essential oils, and fermentation-based immune support products, were described.

The mode of action for the organic acids is to lower gastric acidity (pH), Corneillie pointed out, and the shrimp intestine has pH 7.

"Organic acids reduce the intestinal pH, which favours the non-dissociated form of lactic acid produced by the *Lactobacillus* bacteria. Only the non-dissociated lactic acid can penetrate the cell wall of gram-negative bacteria and destroy them. Studies show that propionic acid and butyrate (the salt form of butyric acid) added at relatively high concentrations of 1% or 2% are most effective for shrimp."

The mode of action of butyrate is to increase the lower intestinal cell proliferation, reduce inflammation, increase intestinal epithelial integrity, and promote enzyme production, amongst others.

But so far, Corneillie said, there are only five recent studies on butyrate in shrimp: "Butyrate improved the growth and survival of shrimp. It reduced *Vibrio* species. However, the inclusion required was 2% to be effective. I think we will hear a lot about butyrate in the future, but the application will still be an issue. Butyrate is not 100% stable and requires encapsulation."

There are attempts to use specialised butyrate-producing bacteria as probiotics or 'direct-fed microbials' in feed: "Unfortunately, these specialised bacteria are unstable and difficult to grow, even in the laboratory. The transfer from lab to commercial application is still to come."

Nonetheless, other probiotics are widely used in shrimp farms. In general, Coreillie said, the mainly gram-positive bacteria show growth promotion, the reduction of pathogens, improvement in digestibility, and improvement in water quality.

"It is mainly the gram-positive bacteria that are used," Corneillie said. "*Bacillus* and *Lactobacillus* species seem to be the best organisms. The potential benefits of probiotics are very clear, especially by adding to the feeds, but for feed companies, this is still a challenge as many species are non-heat stable and not easy to use in feed pelleting or extrusion applications.

"Also, while probiotics in poultry and swine production is limited to about five different species, in fish some 50 to 60 species of bacteria have been used. It's important to note that the positive probiotic effects tend to be species-specific and even strain-specific."

Corneillie commented on the debate on whether it is effective to add probiotics to the water: "My take is that if you have an extensive system in a 1 ha pond and the *Vibrio* population is 10^4 CFU/mL, then a lot of probiotics is required to counter-balance the pathogens. Especially as the turnover of *Vibrio* is 20 times faster than *Bacillus*, for example, so it would not be easy for this relatively durable probiotic bacteria to out-grow the pathogens. It is much easier to dose the water in hatcheries and nurseries and the most intensive farming operations."

In terms of immune stimulants or 'boosters', Corneillie said that oligosaccharides and beta-glucans are the most widely known types.

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"Beta-glucans appeared in the market about 25 years ago in Europe. This type of immune stimulant has a very fast overload immune reaction, which means it requires carefully timed feeding."

Corneillie described an experiment that demonstrated one of the challenges of 'boosting' the immune system. In the trial, pangasius were fed two beta-glucans products, a yeast with glucans in the cell wall and a mannan oligosaccharide (MOS). The control group had a 40% survival rate, whereas the beta-glucans group had a 60-65% survival rate. However, following 2 weeks of feeding, there was no longer any improvement in survival."

"This immune overload with beta-glucans," Corneillie said, "occurs not only in fish but also in pigs, poultry, and humans."

By contrast, MOS are more likely to function as an immune modulator and not an immune stimulant: "MOS promote mucous production in fish. The increased mucous layer prevents parasite larvae attaching to fish. MOS also improve the gut structure and gut integrity."

"Phytogenic feed additives comprising essential oils refined from rosemary, oregano, thyme, sage, thymol, carvacrol, fenugreek, mustard, cumin etc. can have a number of effects," Corneillie said. Effects include reducing heat stress, inhibiting bacterial growth, and inhibiting 'quorum sensing' among pathogenic bacteria. Corneillie offered MIC (minimum inhibitory concentration) values for the pathogen mitigation effect of some essential oils and added, "There are about 30 essential oils in the market, which may have the potential to reduce certain bacteria. Many of them are still in the screening process to identify the target species and disease."

Which one?

Taking an example from the European Union poultry industry, Corneillie described the search for a product to target *Campylobacter jejuni*, a gram-negative bacterium, which is not recognised by the phagocytic cells of the immune system but very harmful to humans. In a 42-day study, three types of products were efficacious — coated butyrate, probiotics, and a natural, microbial fermentation-based, immune support product. The latter type has had success in poultry and livestock production in the United States over the last five years. Researchers found It could reduce prevalence and concentration of several foodborne pathogenic bacteria, including *Campylobacter, Salmonella, Escherichia coli*, and *Klebsiella*.

"When those researching *Salmonella* load in US poultry used the immune support product on top of their existing program," Corneillie said, "the prevalence of *Salmonella* was reduced by 56% and *Salmonella* numbers were reduced by 88%. Subsequent university research showed that not only did the immune support product strongly reduce pathogen prevalence and concentration, it also reduced virulence of the pathogens."

Cherry Anne Silva, Novus International (left) with John Capellan Nealega, Luningning Febelitas Ubasa Pascual and Diomede Cubal Bucog Jr, Santeh Feeds Corporation, Philippines.

However, Corneillie added, there was an even more surprising discovery. The university researchers found that the immune support product restored sensitivity to antibiotics in the pathogenic bacteria: "For example, the antibiotic resistance decreased from 18% to 1.4% in Salmonella resistant to florfenicol.

"In challenge trials with shrimp using the immune support product, we showed that the product reduced *Vibrio* in the intestinal tract. There was an associated strong increase in immune response, with an increase in phagocytic activity.

"Unlike immune stimulants or boosters, the immune support product appeared to increase the capability of the innate immune system to respond quickly to the channel, then return to a normal level of preparedness. By contrast, keeping the immune system in a constant state of stimulation — which is a risk using an immune stimulant — unnecessarily wastes energy and other nutrients and may cause other unintended consequences."

In conclusion, Corneillie said, "Encapsulated or otherwise protected butyrate and possibly essential oils and probiotics may be valuable in the shrimp industry in the future." These are options for good gut health but we still must do some work in finding the right applications and how to apply them. Presently, microbial fermentation-based immune support technology has great potential in shrimp production, not only for gut health benefits, but because the products of such technology have proven effects in the innate immune system. Again, however, we still must learn more about how such products work in shrimp and other aquaculture species.

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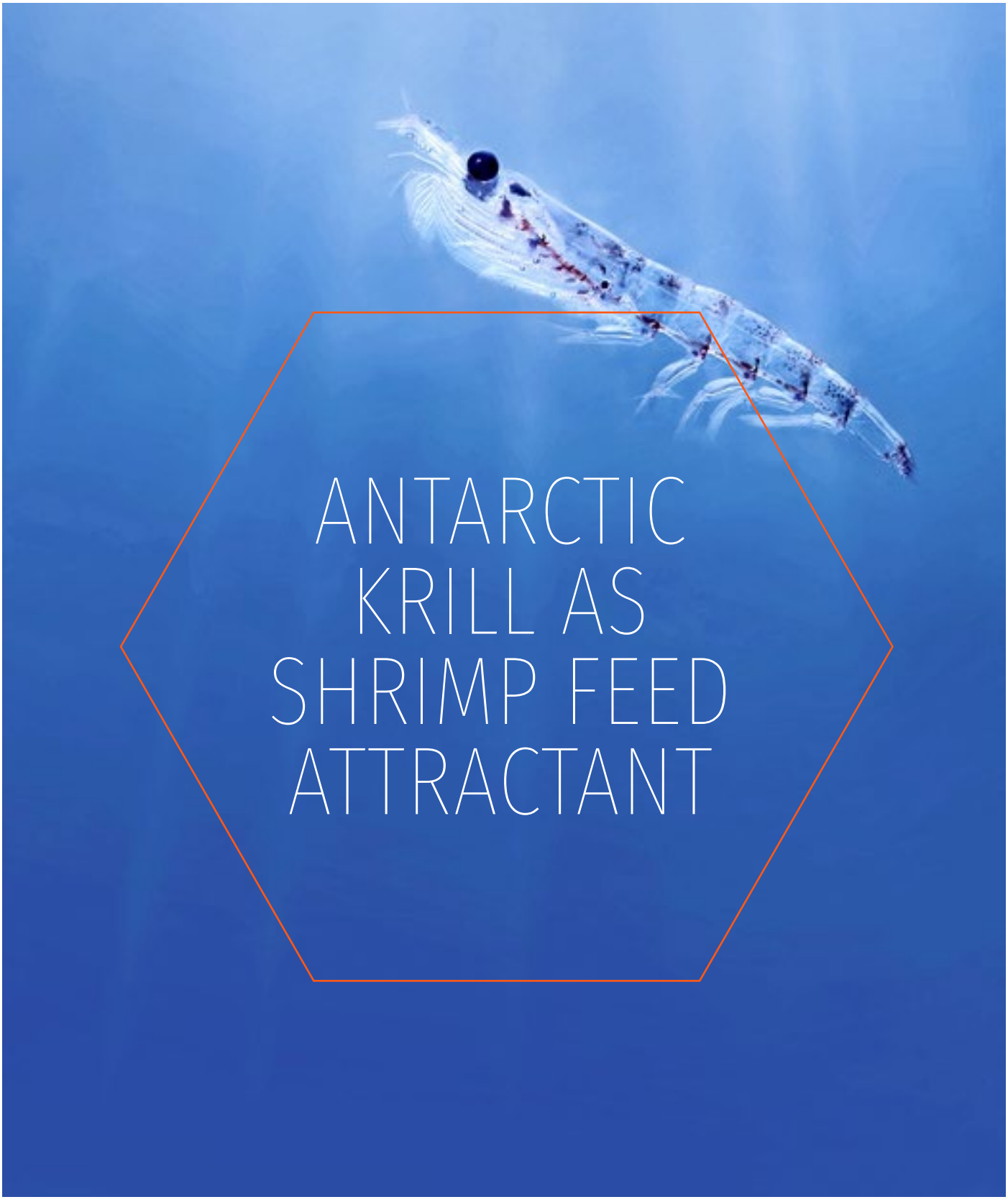

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Preventing disease with nutrition as the key

A trial organised in Ecuador offers proof that nutrition may be the healthiest option to controlling the white spot syndrome virus (WSSV) through prevention rather than cure. DSM Nutritional Products Latin America's Regional Aquaculture Manager **Thiago Soligo** discussed the results of some trials at his TARS 2018 presentation, 'A Nutritional Solution against White Spot Syndrome Virus on Pacific White Shrimp *Litopenaeus vannamei* tested in Ecuador.

Outbreaks of WSSV have shrimp producing countries hitting a wall in efforts at expansion. Its far-reaching consequences have affected Asia Pacific all the way to Central and Latin America, almost wiping out entire populations of shrimp farms. Soligo described the disease as the most pathogenic, hitting Latin America at a crucial time during the region's early development of shrimp culture in 1999 and spreading to nine Pacific coast countries. Outbreaks are common during the change in season or rainy season with sharp decrease in temperatures. Chronic mortality can lead to survival rates from 70% to 40%.

Farming and hatchery activity almost disappeared in the southern part of Brazil, due to WSSV. The severity of disease outbreaks caused Brazil to cease almost 100% of export and forced a shift in production for the domestic market only. "When the disease arrived, it generated a sharp drop in production, and a time of change. It introduced a whole new way to culture shrimp."

Evolving practices

Fresh perspectives and processes began to dominate shrimp production in efforts to counteract the growing epidemic. Soligo expanded on these improvements that revolved around adopting new technological innovation.

In Ecuador, improved shrimp genetics by generating strains with enhanced growth and disease resistance allowed the industry to recover in 2006 back to pre-WSSV levels. Profit and production levels were increased by optimising resources such as the use of water and aquafeed. To produce shrimp again, some producers in Brazil shifted to intensive culture in small ponds (0.1-0.4 ha) and stocking 170-250 PL/m^2, covering ponds, HDPE liners, water recirculation, zero water exchange and biofloc systems.

> "Switching to more technology-driven and efficient intensive farming technologies enabled shrimp farmers to increase production in the last few years," - Thiago Soligo

In Guatemala, producers began to implement hyper-intensive culture using fast growing and disease resistance strains, shorter cycles to avoid low temperature months (November to February) and clean pond bottoms with siphoning. In Costa Rica, the industry aimed at a higher market price by adding value to their products through certification, to compensate high production cost conditions in the country.

"Switching to more technology-driven and efficient intensive farming technologies enabled shrimp farmers to increase production in the last few years," said Soligo, adding that farm management and biosecurity to prevent and coexist with shrimp diseases became more important. These best management practices were then adopted throughout Latin America.

Upping immunity

Shrimp have an extremely basic immune system that relies on non-specific or innate mechanisms, as specific or adaptive immune response and related immune memory do not exist. With only this first line of defence in play, Soligo advocated reducing conditions that can suppress immunity for example stress and environmental factors. "This could be possible with an increase in control of environmental factors such as temperature, oxygen, and salinity or pH levels."

> "Our proposal on a health solution is prophylaxis as a way to improve the immunology of shrimp, and resistance to stress and disease."

In addition to these, he emphasised the importance of proper nutrition to promote health conditions. "Our proposal for a health solution is prophylaxis to improve the immunology of shrimp, and resistance to stress and disease. Controlling the disease is better achieved by prevention than cure." He suggested a balanced supply of micro ingredients and immunostimulants as an adequate defence line in support of innate immune system development. It functions optimally and reduces risk of secondary infection.

Soligo explained that the key element to assist in immune stimulant development is by achieving synergy between substances to modulate different immune functions. These involve phagocytosis, lymphocyte proliferation and natural cytotoxicity.

Synergy between substances

"To mention a few examples one important immune stimulating ingredients, is nucleotides. It helps cellular proliferation, improving the non-specific immunological response, disease resistance and reduction of stress effects. Research in Thailand showed that nucleotide-rich products supported the resistance of the vannamei shrimp to pathogens, the bacterial *Vibrio harveyi* and viral WSSV. Nucleotide levels used in the trial were 75ppm, 150ppm and 225ppm.

Following results from the trial, a premix boost with increased levels of vitamins and additives was proposed, then tested in the National Marine Aquaculture Research Centre (CENAIM) in Ecuador. Using the premix boost, the two-phase trial was conducted in July 2017. "The first phase was an experimental culture with 3.8g shrimp in tanks at a density of 16 shrimp/m^2 since the usual final density for Ecuadorian farms is 12-16 shrimp/m^2. The second phase was a challenge test using WSSV infected tissues. Information from the trial supported the positive synergetic effects of ingredients used," said Soligo.

"Our concept says the nucleotides enhanced proliferation of the immune cells, which are not able to synthesise nucleotides. The beta-glucans activate the phagocyte response by binding to a membrane receptor or prophenoloxidase system." He added that vitamin C, an important cellular antioxidant, then protects the cells from oxidation, while vitamin E helps the membrane antioxidant to improve cell communication by enhancing membrane fluidity and overall status of the cell.

Soligo reiterated that best managing practices should be adopted to help biosecurity measures to increase shrimp resistance. Among them is the use of a health premix. "We propose the use of a premix boost as a routine throughout the production cycle to achieve disease prevention and stress reduction that can result in better survival. The premix boost can better prepare shrimp to perform during disease events, improving overall health to mitigate the fate of stress with a better immunological start." He ended with a recommendation to introduce the feed for two to three continuous weeks prior to any critical or stressful event.

Meeting farming expectations

Dr Fabio Soller, Technical Director for Asia Pacific, Diana Aqua, Thailand said, "Most of the time, what shrimp feed producers and what the farmers are looking for do not really match. It is normal that expectations are different as we have one group concerned with feed ingredients and another worried about their cost of production and selling the shrimp for a profit." His presentation covered, "Meeting farming expectations: Functional ingredients for modern shrimp feed and robust animals"

Soller added that fish meal price is always on the upward trend, albeit today it is not at its highest level but what is hurting feed mills as well as shrimp farmers is the exchange rate. "Based on interviews with some farmers, low-cost feeds can contain protein from 31-42%. Thailand seems to have the cheapest feed with Vietnam the highest at USD1.32/kg. Premium feed contains protein ranging from 34- 45% and again price variability is large, the cheapest being in Thailand, followed by India and Indonesia."

Feed producers vs shrimp farmers

Feed producers want stability: ingredients with the same profiles so they do not have to reformulate their diets every time. As for the shrimp farmers, they want excellent shrimp growth performance, i.e. shrimp to grow fast at low feed conversion ratios. Feeding behaviour must be visible. Feeds should not pollute water; they should reduce stress and disease, while producing better shrimp quality and robustness. Feed prices must be stable. Overall, they want a sustainable and standardised feed.

"In comparison, sustainability is high on top of demands by feed producers. The reduced use of fish meal is not about price any more but revolving around sustainability. For farmers, sustainability is low in their list of priority. Farmers are more worried about their shrimp surviving so that they have something to sell at the end of each production cycle," said Soller.

In the 1980s, marine ingredients comprised 36-60% fish meal, but now only 5-25% is used, depending on the species cultured. Soller said that the transition from high levels of marine ingredients to low levels in feed comes with the removal of soluble nutrients (vitamins, antioxidants and water-soluble peptides). Filling the gap is starch, and plant ingredients with anti-nutritional factors. At the same time, ingredient quality has increased as producers focus on studies on digestibility. The attention now is on better formulations.

Focus is also on functional ingredients such as vitamins, antioxidants, minerals, botanicals and enzymes, all of which promote health, boost energy and prevent diseases.

Functional protein hydrolysates

These are very important in shrimp feed when the desired attributes are attractability and palatability. There are also nutritional (growth) and health attributes. "Protein hydrolysates consist of soluble protein and peptides. Small peptides below 1,000 Daltons (Da) should be considered as bioactive and play important roles in the organs of fish and shrimp," said Soller. The production process and specifications have been described in Soller et al., 2018 (Aqua Culture Asia Pacific, July/August 2018, p36-40).

> **"Bioactive peptides in the diet of shrimp will activate the innate immune response with the production of lysozyme and antimicrobial peptides to challenge bacteria."**
> **- Fabio Soller**

Different processes will yield different ingredients. Two hydrolysate products, tuna liquid hydrolysate (24% protein; 20% is 90% soluble with 14% peptides below 1,000 Da) and shrimp powder hydrolysate (64% protein; 70% is soluble protein and 57% small peptides) are the targets of the research at Diana Aqua.

Comparing with other meals, Soller said, "Fish meal has about 70% of soluble protein and 9% of the total protein are small peptides. These are the most bioactive fractions of fish meal which are not found in alternative raw materials. Blood meal for example, has about 72% of soluble protein but only 3% are small peptides. Plant proteins which include soy protein concentrate, wheat gluten and wheat meal, are not very water soluble and contain very small percentages of <1000 Da soluble peptides."

Health interventions

Bioactive peptides in the diet of shrimp will activate the innate immune response with the production of lysozyme and antimicrobial peptides to challenge bacteria. These include catalase (CAD) and superoxide dismutase which are antioxidant enzymes. Soller described some growth trials in Thailand and Colombia with the marine shrimp.

Daniel F Fegan, SyAqua, Thailand (left) with Thomas Popp, NK Ingredients, Singapore

Sirirat Chatvijitkul, PT DSM Nutritional Products Manufacturing, Indonesia

Henrik Aarestrup, BioMar Group A/S, Denmark

The aim of an acute hepatopancreatic necrosis disease (AHPND) challenge trial conducted in Thailand was to see how shrimp responded to stress and bacterial infection. Shrimp fed with the treatment diets were challenged with immersions of *Vibrio parahaemolyticus* bacteria twice. "The treatment diet had 3% tuna hydrolysate. In another treatment diet, we top coated commercial feed containing 56% plant protein with a high dosage of vitamin C (1.5%). This was to compare if the vitamin works to fight stress or fight off disease with the animal's antioxidant capability," explained Soller.

In this 4-week trial, there was no significant difference in growth between the control and vitamin C diets. "But shrimp fed the hydrolysates grew 8.6% faster. It could be due to attractability and high feed intake."

However, in the AHPND challenge, there was higher survival of shrimp (70%) fed the tuna hydrolysate. There was no difference compared to shrimp fed diets with vitamin C, but shrimp fed the control diet showed lower survival at 60%. "By just stimulating the immune system, you can get them to survive better to those diseases," said Soller.

"In Colombia, we top coated liquid fish hydrolysate at 2% to a feed with 40% crude protein and 9% fat. There was about 10% marine protein in the diet. After 118 days of culture in large ponds, there was 14% increase in production with a 48% increase in profitability."

Investing in feeds

Soller explained that for the farmer, the barrier to the use of functional ingredients is price of feed. "With addition of a functional hydrolysate, the feed price will increase marginally. But we showed that survival was better at 67% and compared to the control diet, the increase in profit reached 52%."

In another trial conducted at Jeju University, South Korea, the growth performance of shrimp fed diets where the squid liver powder (SLP) was replaced with hydrolysates, was compared to the control feed with 5% SLP. Two treatment diets had inclusion of shrimp and tuna hydrolysates at 1% and 1.5%, respectively.

"There was no difference in survival rates between the hydrolysate treatments (82-83%) but weekly growth was 0.89g in SLP diet and 1g to 1.04g with the hydrolysate diets. In these trials in clear water systems, the biological FCR improved to 1.36 and 1.40 with hydrolysate diets compared to 1.57 in the SLP diet. Both feed and protein efficiency improved with the inclusion of shrimp and tuna hydrolysates, even if the total marine protein content of these treatments remains less than for the SLP diet."

Finally, Soller said, "Histological studies showed that dietary inclusion of hydrolysates had a positive effect on hepatopancreas development with a higher height of villi which allows for a higher capacity to absorb nutrients."

William R Kramer, CCM Agri Aqua Ventures Corporation (left) and Ong Si Mon, GS Biotech, Malaysia

Investing in alternatives for shrimp feed

While soybean meal may substitute marine protein meals in shrimp feed formulations, it creates nutritional gaps. At TARS 2018, Aqua Lead Scientist for Nutriad, Spain, **Dr Waldo Nuez-Ortin** looked at what it takes to upgrade the nutritional value of shrimp feeds in his presentation "Sustainable Shrimp Feed: In Search of Novel Ingredients and Functional Additives to Power the Shrimp Feed of the Future".

He covered novel ingredients with more nutritional value than conventional vegetable-based ingredients, as well as functional feed additives that can be combined with them or with traditional plant-based protein meals to enhance the nutritional value of shrimp feed.

As a prelude, Nuez-Ortin gave results of a survey on trends in commercial shrimp feeds in India in 2016 versus that in 2014. Major changes were in omega-3 long-chain polyunsaturated fatty acids (n-3 LCPUFAs) and cholesterol, decreasing by 16% and 24%, respectively. He also noted that feed samples contained 10-15% fish meal, lower levels than in the past.

> "However, a major drawback is still a lack of cholesterol, which shrimp cannot synthesise, that needs to be sourced elsewhere."

Novel ingredients

"Plant-based feeds require supplementation with essential nutrients such as cholesterol, amino acids, and trace elements to compensate for the nutritional gaps introduced by the replacement of marine ingredients," said Nuez-Ortin.

There are transgenic oil seeds high in n-3 LCPUFAs with relatively low production cost. Camelina and canola oils with the introduction of genes from microalgae and yeast can produce high levels of DHA and EPA. Most microalgae oils will have high DHA levels (17-28%). "To date, there is no information on their use in shrimp feeds but by 2020, a few of these novel oils will be available." However, a major drawback is still a lack of cholesterol, which shrimp cannot synthesise, that needs to be sourced elsewhere. Soon to be available is a microalgae oil produced by a multinational with 32% DHA and 16% EPA but with low cholesterol content relative to fish meal.

As a protein source, soybean meal still seems to be at the top of the list due to supply, pricing and nutritional characteristics. Hydrolysates can work with soybean meal. "Free amino acids, protein and small peptides in hydrolysates have the ability to provide a nutritional balance between protein solubility, attractability, palatability and additional functional properties, while attenuating oxidative stress with possible immune-related properties," said Nuez-Ortin.

Insect meal is another promising alternative, focusing on species with fast growth, reproduce easily and efficiently convert low-grade organic matter into high-value protein and fat. "Protein content can range from 30% to 80% in some species with a generally well-balanced amino acid profile." Limitations however are with total sulphur amino acids. Although, high in lipid content, there is no trace of n-3 LCPUFAs unless insects are grown on a substance high in these essential lipids. Similarly, single cell proteins such as bacterial biomass is receiving considerable attention due to rapid growth, high protein content and immunity to climate influence. He observed that, "Most research so far has been conducted with *Methylobacterium extorquens* that grow rapidly on methane with an essential amino acid profile similar to soybean, without some of its anti-nutritional factors."

Adding value to shrimp feeds

Once nutritional inputs for growth and health are optimised, the next step is finding solutions to maximise the absorption and utilisation of nutrients from new ingredients, such as digestibility enhancers. This is where functional feed additives come in.

"Bile salts are important in the digestion of fat in vertebrates, however they are absent in shrimp, so why bile salts for shrimp? First as digestibility enhancers because of their emulsification properties," said Nuez-Ortin. "This improves digestion and utilisation of lipids." Secondly, as a nutritional supplement, because the steroidal structure in bile salts in the form of bile acids can to some extent replace cholesterol as precursor of the moulting or ecdysteroid hormones.

Feed enzymes upgrade the value of shrimp feed. Some are standalone products and some cocktails with different forms and application methods.

To address anti-nutritional factors such as phytate and non-starch polysaccharide (NSP), Nuez-Ortin proposed the use of microbial phytates in shrimp feeds to improve the availability of phytate-bound phosphorous and nitrogen. Carbohydrases are seen as alternatives to gain access to fat, protein and starch as well as improve protein and energy digestibility. That the combination of two types of carbohydrases, namely xylanases (XYL) and arabinofuranosidase (ABF), has been found to improve overall carbohydrase activity by more than 35%. A study showed 50% soybean meal and 26% whole-wheat supplemented with the addition of 200mg/kg of the enzyme cocktail improved protein, energy digestibility, and generally positive weight gain and feed conversion ratio (FCR).

Nuez-Ortin concluded, "More work is needed to scale up the production of novel ingredients. Novel oils are rich in n-3 LCPUFAs but low in cholesterol so we still need other sources of cholesterol. With bile salts we can improve digestion and utilisation of essential lipids and supply a replacement for cholesterol or an alternative precursor for ecdysteroid hormones.

TARS 2019 will be on ***Aquafeeds: Fit for Future***. It will be held in Bali, Indonesia, from 14 to 15 August.
Email: conference@tarsaquaculture.com;
www.tarsaquaculture.com

Yvonne T Nathan is a contributing writer based in Selangor, Malaysia.

ß-glucans: Innate immune system response in shrimp and fish

By Melina Bonato and Liliana Borges

The strategy is to combat contamination, reduce mortality and improve productivity.

For a long time, the most common method for dealing with the occurrence of bacterial infections in aquaculture was the administration of antibiotics. However, aquaculture faces serious problems due to various adverse effects of antibiotic residues which have accumulated in the tissues of the cultured animals and in the microbial flora in the culture environment. Moreover, the use of antibiotics or vaccines for fish is expensive and in many farms, these medications are not available (Yousefian and Amiri, 2009). The alternative substances or additives incorporated into the feed to improve survival rates, disease resistance and growth of fish and shrimp have been more frequent as well as more successful.

Adaptive and innate immunity

Fish, similar to mammals, have innate and adaptive immune systems. Innate immunity is responsible for primary responses which are fast but not specific, and with no memory against recontamination. The adaptive immunity is responsible for specific responses. In other words, it is an intense response with specific antibodies for each pathogen. However, shrimp are apparently entirely dependent on a non-specific immune mechanism to resist infections (Hertrampf and Mishra, 2006).

The most widely known cells of the innate immune system are the macrophages, neutrophils, dendritic cells and natural killer cells (Sharma, 2003). Toll-like receptors, located on the surface of immunological cells, recognise microbial patterns and induce an immediate innate immune response. After this activation and phagocytosis, the phagocyte presents a processed fragment of the pathogen to the adaptive immune system and stimulates an anti-pathogen response. Therefore, the phagocytes are called antigen-presenting cells. The recognition of pathogens by the innate immune system triggers immediate innate defenses and activation of the adaptive immune response (Lee & Iwasaki, 2007).

ß-glucans supplementation

ImmunoWall® from ICC Brazil, is a product produced by the cell wall of the *Saccharomyces cerevisiae* yeast; it originates from the sugarcane fermentation process for ethanol production, which produces around 35% ß-glucans and 20% mannan oligosaccharides (MOS). ß-glucans are known as immune system modulators or stimulants, because when they come in contact with the phagocytes, which recognise the ß-1,3 and 1,6 bindings (Petravic-Tominac et al., 2010), they are stimulated and will produce some cytokines, which will start a chain reaction inducing an immunomodulation and improving the response capacity of the innate immune system (Figure 1).

This type of response is especially important in the animal's initial growth, reproductive phases, stress periods and environmental challenges; it acts as a prophylactic agent and increases the animal's resistance, thus minimizing further damages, such as a drop-in performance or increase in mortality rates. Intensive

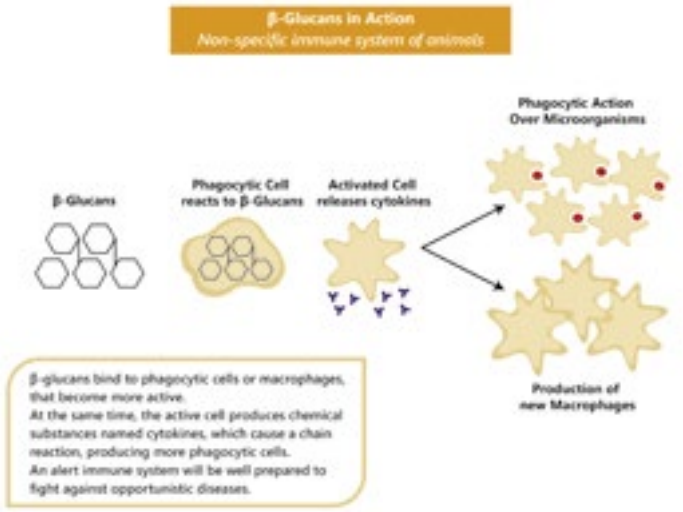

Figure 1. Macrophages inhabit the intestinal mucosa. When they come into contact with the 1-3 and 1-6 ß-Glucans found in yeast cell walls, the interaction triggers activation of the immune system.

animal production is always associated with a highly challenging environment and therefore the strengthening of the immunological system can be one of the keys toward greater productivity.

MOS for pathogen agglutination

ImmunoWall® also contains MOS, that are known for their pathogen agglutination capacity (mainly those with type 1 fimbria), as well as, diverse gram-negative strains. MOS offers a binding site for pathogens, thus preventing the colonisation of the intestinal epithelium. The agglutinated bacteria will be excreted together with the indigestible part of the fibre (Figure 2).

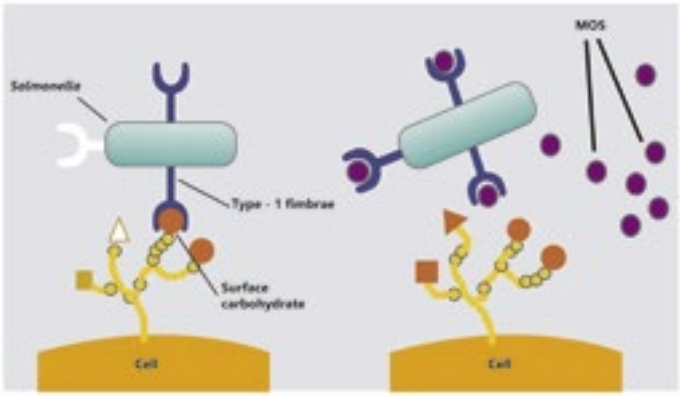

Figure 2. Scheme of pathogens with type I fimbriae adhering to the cells of the intestine (left side), and in the presence of MOS (right side)

Several studies have been published on ImmunoWall® supplementation in aquaculture. Jintasataporn et al. (2016) showed an improvement in the survival rates of *Litopeneaus vannamei* infected with *Vibrio harveyi* and some immunity

parameters under disease challenge conditions by *V. harveyi* or *Vibrio parahaemolyticus* (pathogen causing early mortality syndrome) fed with 1% of ImmunoWall (Figure 3). Another trial conducted by Jintasataporn (2014, unpublished data) also studied the effects of ImmunoWall on the response of *L. vannamei* challenged with *V. parahaemolyticus*. The results showed an improvement in disease resistance against virulent bacteria (immunity parameters and survival rates), mainly under high salinity conditions.

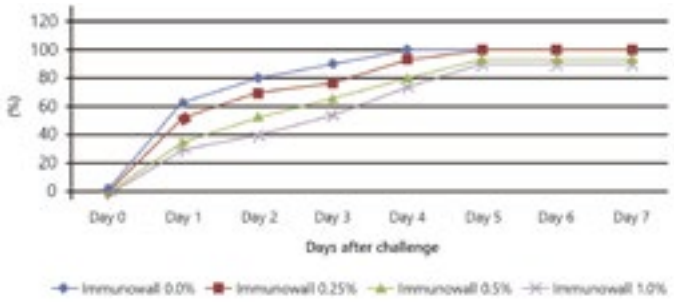

Figure 3. Mortality rates from shrimp groups treated with different levels of ImmunoWall® supplementation (Control; 0.25%; 0.5% and 1%) after challenge with *Vibrio harveyi* (Jintasataporn et al., 2016).

Enhancing and modulating the innate immune system may be one of the strategies to combat contamination, reduce mortality and improve productivity. If dietary yeast cell walls are supplied early to the animals, the immune system will be modulated as well as alerted to many infections or contaminations. The action of the ß-glucans occurs at the innate immune system, where the first immune response to a pathogen contamination happens. This action avoids a greater expenditure of energy to mobilise the adaptive immune system (fish), and it also mitigates decreases in production and high rates of mortality (fish and shrimp).

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A South African success story: Insect meal and oil for global markets

By Zuridah Merican

A pioneer in waste to nutrient upcycling, AgriProtein is expanding laterally and vertically, producing insect meal to replace fish meal in animal diets and pet food.

During World Aquaculture 2017 held in Cape Town and for the first time on the African continent, AgriProtein's co-founder and CEO, Jason Drew introduced AgriProtein Technologies to the delegates as the "world's biggest farm-a fly farm with 8.5 billion flies" converting organic wastes into high protein feed ingredients for the global livestock and aquafeed industry as well as for pet foods. This is the South African success story.

In October 2018 AgriProtein made headlines in TIME magazine as a Top 50 Genius Company in a new league table of businesses TIME believes are inventing the future. In June 2018, AgriProtein also raised USD105 million, the largest investment in the insect protein production domain. Today, AgriProtein has chalked up success in insect meal production, with many companies in all continents, some in the initial experimental or start up stages.

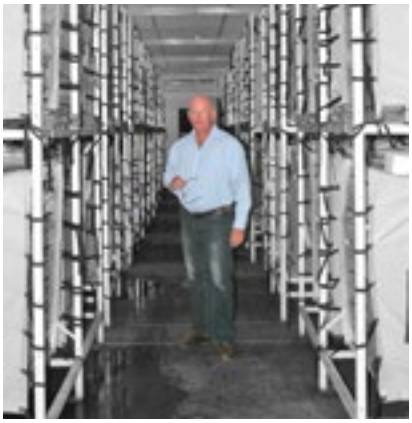
Industrial production

Waste to nutrient cycling is the new economy—fulfilling the sustainability challenge producing insect meal as replacement for fish meal and fish oil in animal diets and solving the waste crisis. AgriProtein is a pioneer in this industry as Jason Drew started the R&D into insect meal production in 2009. The real beginning was in 2016 with the first industrial scale production of insect meal and oil in Cape Town. A future factory will be in Johannesburg and in the long run, there will be many factories. In the works are factories in North Asia, the Netherlands, and California.

"AgriProtein is among four companies that have managed to reach industrial scale. The core objective of the company is to achieve the circular economy, converting waste into value. We have advanced expertise at an industrial scale with the black soldier fly (BSF)," said John Diener, COO of AgriProtein during the visit to the factory in Philippi, Cape Town.

"Our uniqueness is the dual sustainability story. We assist to reduce the amount of organic material going to landfill and upcycling to a sustainable high value protein which can offset fish meal. In the case of California, the state has mandated that by 2025 there should be a 75% reduction of organics to landfill."

"Each factory costs around USD40 million and with our Generation 1 technology, can convert annually 90,000 tonnes of organic wastes to 5,000 tonnes of meal and 3,000 tonnes of oil. The revenue expected is USD13-15 million/year."



Where it all begins. CEO Jason Drew in the adult colony room where BSF breed and lay eggs to be bred for future colonies and harvested for insect meal and oil production. Photo credit: AgriProtein

AgriProtein has three products, the insect based complete protein – MagMeal™, an extracted fat – MagOil™ and a rich residual soil conditioner – frass. The meal has 55% protein on a dry matter basis. Currently, the insect meal as well as the oil are sold to a specialist pet food company and several aquaculture feed companies. "We have preliminary studies indicating the oil and meal are attractants for dogs, although we need more studies to confirm this," added Diener.

Innovating production technology

The production of insect meal starts with the BSF, *Hermetia illucens*, as breeding stock and a conducive environment (in terms of light, temperature and humidity) to lay eggs. Eggs hatch to larvae, which feed voraciously on a substrate of organic waste, and within 72 hours, 1kg of eggs turns into 380kg of larvae (Drew, 2017). In Cape Town, the substrates are fruit and vegetable wastes from industrial and commercial sources such as food manufacturers and supermarkets. The 22-25% moist larvae are collected before the prepupae stage, then oil is decanted and the remaining solids are dried and ground into MagMeal at <10% moisture.

"We have to be very discerning on the source of waste to use. We need to ensure there is no contamination. Thus, we cannot use household waste. However, where separation rules exist, it may be possible to use post-consumer waste such as is done in Japan and Korea," said Diener.

"The substrate needs to meet our minimum specifications. It is then pasteurised and blended. The conversion is 15 tonnes of dry meal from 250 tonnes of wet substrate. This means a feed conversion ratio of 4 in dry matter terms.

The production process; -from organic waste being dropped into a skip which is later scooped out with a scoop forklift and placed on a conveyor in the feed plant to feeding of larvae, harvesting and the final products. Photos credit: AgriProtein

Biology operators stack and clean cages on cyclical basis to ascertain high levels of production and egg laying. Photos credit: AgriProtein

AgriProtein staff checking the quality of the breeding larvae. Photos credit: AgriProtein

"Different markets demand different types of substrates. For example, insect meals and oils for the EU market cannot currently be made from insects reared on catering waste or former food containing meat or fish," added Diener.

Technology leader

Along the production chain, there is a need to refine the production process to constantly improve efficiency and to be a technology leader. "We have been building up our core capabilities in BSF breeding and genetics, and in technology and engineering. We need to be able to optimise the life cycle of BSF in terms of high egg productivity. In breeding and genetics, the goal with selective breeding is to increase growth rate and fecundity. Then there is nutrition and also the need to ensure an ideal environment for bioconversion."

During production, there is a need to ensure traceability of substrate and reduce variability. Diener explained that waste is mixed batch by batch, kept in silos and then fed to larvae within 24 hours. "At the larval stage, we continue to reduce variability by ensuring that the larvae are of the same age and maintained at a constant temperature and humidity.

Each cycle takes 2 weeks and harvesting is before the larvae develop into prepupae. "The result of the work of our 30-person R&D team in entomology and other disciplines is the reduction of the rearing cycle from 20 days to 10 days."

The technology department has been working on innovation in process engineering. "In our Generation 1 processing factory we can convert 90,000 tonnes of waste into 5,000 tonnes of final 55% protein meal with <10% moisture, <10% ash and via a decanting process produce <10% fat. We can increase the lipid level if required. We are constantly upgrading the process and we will achieve our Generation 3 production prototype by the end of 2019. Among the innovations at AgriProtein is a patented method of breeding BSF under artificial conditions. In terms of species, most insect meal producers focus on BSF but Diener said that the R&D team is also looking at several other species for insect meal production.

"AgriProtein is helping to handle the waste crisis by pioneering technology to up-cycle organic waste into high protein animal feed." – John Diener

A dual sided sustainability story

"We are playing a large role in the circular economy. Organic wastes are created around the world and looking at the food material hierarchy, there are large volumes of waste created at the production, handling and storage stages which cannot be redistributed. These are the waste for us to recycle." Diener discussed the global challenge with waste management; according to the World Bank, the global organic waste will reach one billion tonnes by 2025.

"AgriProtein is helping to handle the waste crisis by pioneering technology to up-cycle organic waste into high-protein animal feed, reducing the volume, pollution and cost of landfill. Disposal of organic waste in landfill is a costly and unpleasant environmental hazard and many authorities have banned it or are setting reduction targets."

The livestock production and aquaculture industries are constantly on the lookout for a sustainable protein meal, most often to replace marine fish meals to meet the sustainability agenda, such as the FIFO (Fish-in-Fish-out) ratio. Insect meal production has a small footprint and is CO_2 neutral.

Production area where larvae are left to grow for future harvesting. Photo credit: AgriProtein

Boilers used to keep factory warm and at the right temperatures for larvae growth. Photo credit: AgriProtein

AgriProtein Technologies factory Philippi, Cape Town, the first commercial facility which grows BSF on a large scale and manufactures MagMeal, MagOil and frass. (Photo credit: AgriProtein)

Formulating into aquafeeds

AgriProtein's insect meal is positioned as an alternative to fish meal. Diener, who previously was Managing Director at Aqua Division, Gold Coin Group, Singapore, is well versed with the challenges with replacement of fish meal and fish oil in fish and shrimp feeds. "MagMeal's composition of amino acids (such as the levels of histidine, lysine, arginine) is comparable to the levels in fish meal.

"We are looking at this meal only as a partial replacement of fish meal. Similar to soybean meal (SBM), it is deficient in methionine." In terms of EAA:NEAA ratios, the meal is 1.33 as compared to 0.95 for fish meal and 0.86 for dehulled SBM. Pepsin digestibility is high at 94% and it could be sold at equivalent prices as fish meal," said Diener.

MagOil has a wide range of fatty acids, from short to long chain. There is a high level of medium chain lauric acid. "It also has some antimicrobial properties, is absorbed directly and highly available as an energy source. In piglets, MagOil has immune boosting properties which means there are advantages of this oil during the early growth stages." The oil is being benchmarked against palm oil and price-wise ranges between that of palm oil and crude kernel oil.

There are numerous peer reviewed research articles on BSF insect meals and insect oils. Some show that species such as salmon, shrimp, and tilapia can grow well on diets with insect meals but other fish such as the turbot cannot digest the ingredient. The target for AgriProtein is for salmon and shrimp feeds where the inclusion rate of BSF meal can reach 25% as higher levels have resulted in negative impacts on growth.

"An interesting possibility is the use of insect meal as a functional ingredient. The presence of antimicrobial compounds could promote gut health. In shrimp, these could work against *Vibrio parahaemolyticus*, the pathogen causing acute hepatopancreatic necrosis disease (AHPND)," added Diener.

The approval by the European Food Safety Authority (EFSA) in 2017 to allow insect meal into aquafeed production in Europe has opened the insect meals market in Europe. This has also opened markets for insect meals in other regions for the imports of final products into EU markets.

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Push for pangasius farming in China

By Dong Qiu-Fen, Wu Tian-Pei, Peng Zhi-Dong, Zhang Tai-Zhuo and Wang Yao-Hua

The high demand for white fillet is driving its farming using high quality feeds but industry expects to only resolve the shortage of fingerlings by 2020.

China is the world's largest aquaculture producer with more than 66.81 million tonnes of fish production in 2016 and a projected production of 79.13 million tonnes by 2030. It is also the world's leading fish consuming country, consuming 38% of the global fish production in 2015. The per capita consumption reached around 41kg in 2015, fuelled by growing domestic income and wealth (FAO, 2018). Today, Chinese aquaculture is diverse with over 100 aquatic species cultured commercially from approximately 25 species in the 1980s (Jian-Fang Gui, 2018). With the good foundations and conditions, a new aquatic species is easy to be introduced and farmed in China.

The pangasius fish was first introduced to China in 1997 when 100 pieces of basa catfish (*Pangasius bocourti*, Sauvage, 1880), 3 cm long were sent to Hubei Province from An Giang Province in south Vietnam, in appreciation for a cooperation on pangasius fish hatchery between these two provinces since 1994. Although these basa fish were reared as brood stock and later produced basa fingerlings in Hubei in 2008, commercial farming activity was not popular and basa fish were initially regarded as an ornamental fish, due partly to the cold winter in central China.

However, since 2015, basa fish has become popular in China with a sharp increase of imports of processed pangasius products from Vietnam. It is also called Cá tra (*Pangasianodon hypophthalmus*, Sauvage, 1878) in Vietnamese, and tra catfish, patin catfish, striped catfish and sutchi catfish elsewhere. The imports from Vietnam since 2015 were mainly the striped catfish (*P. hypopthalmus*) and not the basa catfish (*P. bocourti*).

Since 2000, *P. hypopthalmus* replaced basa catfish as the major farmed pangasius species in Vietnam, but the name "basa" is still used for the export of catfish products. The Chinese continued to use the name "basa" by habit, but the farmed pangasius in China is *P. hypopthalmus* catfish, not basa catfish.

With higher income and increased consumption of fish, Vietnamese pangasius products started to appear in menus of Chinese restaurants and in the home some 3 years ago. With thick flesh, little bones, delicate texture and low prices, pangasius products are easily accepted in Chinese kitchens in various cuisines. The easily processed butterfly product is very suitable for several famous Chinese dishes: barbecue fish, boiled fish, sauerkraut fish and hotpot dishes.

A Chinese restaurant chain "Yinizaiyiqi (鱼你在一起, the fish is together with you) takes pangasius as the main material for its sauerkraut fish dishes and has expanded to 1,800 restaurants since January 2017.

Main importer of Vietnam's pangasius products

In 2017, China became the largest buyer of Vietnamese pangasius with a value of USD410 million and a share of 23% of total exports (VASEP, 2018). With some border transactions of the pangasius between these two countries not included in this volume of imports, the import volume will be larger in 2018. According to the latest statistics from VASEP, during the first 8 months of 2018, China imported USD332 million pangasius from Vietnam, an increase of 34.4% compared to 2017.

This rising demand and low supply for the pangasius raised prices. Ex-farm prices have increased by 60%, from VND20,000/kg in 2016 (USD0.86/kg) to VND32,000/kg (USD1.37/kg) in 2018. The profitability and high prices also created an interest in farming of the pangasius in China itself.

Consequently, some Chinese farmers in South China took the opportunity and started this fish culture in Hainan, Guangdong and Guangxi provinces since the end of 2017.

Exotic in China

As a new exotic species, there are many issues regarding seedstock, farming, diseases, feeds, transportation, processing and future development. Seed supply, temperature adaptability, cost competitiveness and fillet colour are the four most pressing concerns of farmers. There is a looming need for knowledge and information on pangasius aquaculture. Guangdong Nutriera

Using autofeeders in a pangasius pond.

A sauerkraut fish dish with pangasius.

Professor Hung (fourth from left) with other experts at the Chinese First Pangasius Fish Symposium on Nutrition and Feed Technology.

Group organised the "Chinese First Pangasius Fish Symposium on Nutrition and Feed Technology" in Zhanjiang City in Guangdong Province in April 2018, to share its knowledge and experiences on this fish with other experts.

Professor Le Thanh Hung, Nong Lam University, Vietnam, was invited to give a keynote presentation titled "History and key success to pangasius catfish farming in Vietnam." More than 400 attendees benefited from the successful pangasius story from Vietnam. Another seven speakers were from Guangdong Nutriera Group, Guangdong Fishery Germplasm Conservation Center, Beijing Dongdao Union Brand, Zhanjiang Guolian Aquatic Group, Vinh Hoan Corporation (Vietnam) and Guangdong Evergreen Group. They gave presentations on pangasius hatchery technology, farming and disease issues, special feed, processing, import and pangasius consumption in China. This symposium delivered important technical information and raised confidence on the Chinese pangasius industry.

Juvenile supply shortage in China and Vietnam

There are around 15 pangasius hatcheries in Hainan, Guangdong and Guangxi provinces, but with limited brood stock, hatcheries can only supply around 60 million fingerlings in 2018. The demand for fingerlings was supplemented by supply from Vietnam via several channels. Vietnam also has a shortage of brood stock and fingerlings; with low fish prices before 2017, farmers reduced operations leading to a lower production of juveniles. The fingerling supply cannot meet market demand, leading to price increases. It is estimated that the fingerling shortage may only be solved by 2020. The hatcheries are stocking good quality pangasius as potential brood stock. They are even importing live large size pangasius from Vietnam and Myanmar.

Pangasius fingerling

Farming conditions

The pangasius is a facultative air breather which can tolerate low dissolved oxygen (0.05 mg/L) and can be stocked at densities as high as 120 fish/m^2. The conditions for farming the fish in China are very different from that of the Mekong Delta in Vietnam and Chinese farmers cannot farm the pangasius the way it is done by Vietnamese farmers: with high density and high-water exchange. In China, farmers must use different farming conditions with the most suitable farming models, to achieve profit.

From a farming perspective, the pangasius performs better than tilapia with faster growth, less disease problems and lower cost of farming cost. It has replaced tilapia in many farming areas. Similar to tilapia farming, pangasius is farmed in several different ways: monoculture, polyculture with swine, duck and other species of fish. There are also some new farming ways for pangasius: culture in rice fields and IPA (intensive pond aquaculture) system. Without too much water exchange, auto-feeders, aerators and probiotics are used for farming to ensure better performance and white fish fillet. As algae is rich in pigments and will invoke a yellow fillet problem, it is very important to control water quality, algae species and quantity using probiotics and other farm-care products.

Since April, more than 30 million pangasius fingerlings (body length 2-3cm) have been stocked in three provinces of China. About 3 million fingerlings were stocked in Hainan, 10 million in Guangxi and the rest in Guangdong. The stocking density is about 15 fish/m^2; after 5 months of culture, some farmers harvest their pangasius on reaching commercial sizes of 1kg/fish. The farmers can get a good profit, about USD 0.3/kg with USD 0.91~1.02/kg farming cost and USD 1.23/kg farm gate price. Only high-quality special feeds are used for pangasius, the FCR is 1.1~1.3 at 70~98% survival rate.

More profitable than the tilapia

The first crop farming result shows that farmers can earn more from pangasius than with tilapia. About 150,000 tonnes pangasius will be harvested in October. More farm gate data will prove the farming practicability, resulting in more farmers joining this farming business. In winter temperatures can be as low as 10°C which is not suitable for pangasius culture and only a few farmers may try to stock the pangasius for the over-winter season. Both pangasius and tilapia are tropical species; the farmers can take the lessons from the successful tilapia hatchery and farm systems to develop pangasius fingerlings tolerant to low temperatures to ensure farming for the whole year.

Packing fingerlings

Feeding for white flesh

The Chinese consumers associate white colour fillet as higher flesh quality which also fetches higher prices. Subsequently, Chinese farmers also need to produce pangasius with white fillet, the production of which is linked to feed quality. The aquafeed ingredients for pangasius in China are different from Vietnam. Fishmeal, soybean, rice bran and cassava are the 4 main raw materials in pangasius feeds in Vietnam, but the Chinese feed mills cannot buy these 4 raw materials at the same or lower prices and with a stable supply. Feed mills should use different sources of ingredients to produce high quality feed, and Guangzhou Nutriera Group shares nutrition knowledge with the feed mills and supplies additive solutions to help the feed mills produce feeds for white fillet production.

34% CP, 1.0mm, USD 0.77 /kg

32% CP, 2.0mm, USD 0.74 /kg

30% CP, 3.0mm, USD 0.72 /kg

28% CP, 4.0 to 5.0mm, USD 0.70 /kg

Figure 1. Extruded floating feeds for the pangasius. CP= crude protein; Exchange rate: CNY6.85 to one USD.

Special floating feed for pangasius

In 2018, there are more than 15 feed mills in China producing around 60,000 tonnes pangasius feeds in China. As these feeds are exclusive for pangasius with different feed formulations, the feed prices are higher than for tilapia feeds. The pangasius feed conversion ratio (FCR) in China is much lower than that of the pangasius feeds sold in Vietnam with higher feed nutrition level, lower pangasius stocking density and less water exchange. Most of the feed mills provide technical services and financial support to the farmers, and even buy back fish from farmers.

Processing

Tilapia processing factories can be used for pangasius processing, as tilapia production remains stagnant. Apart from pangasius, some factories are also processing some other aquatic species to utilise their extra processing capacity. The quick-developing e-commerce is helping to promote seafood marketing in China, and customers are happy to buy pangasius online or offline. Pangasius from South China can be processed for the domestic market. Besides the popular processed butterfly products, some other types of pangasius products are also acceptable in China.

However, pangasius production in China this year only reached around 40,000 tonnes, which cannot meet the strong market demand. China still has to continuously import pangasius from Vietnam and some other countries.

Prospects

The pangasius from Vietnam continues to meet some marketing problems, such as anti-dumping duties and "whitefish wars" in the American and European markets, but it has become very popular and attractive to Chinese consumers. Since 2017, the Chinese government has taken strong actions on the smuggling of "grey-trade" seafood across borders and reformed VAT (value added tax) regulations and restaurant taxes. All this will push for the legal imports of the pangasius and ensure the food quality and safety of products. Now the Chinese are more willing to pay higher prices for food with good quality, guaranteed safe and convenience. As Vietnam cannot supply enough pangasius to China, fish importers are seeking pangasius from other countries. Some pangasius products from Myanmar are already available in some Chinese supermarkets since August 2018.

The Chinese pangasius farming industry will attempt to address the poor supply situation quickly. but it will need around 2 years to solve the fingerling shortage. Once the fingerlings are available, pangasius farming will scale up rapidly if the market price is lucrative. A combination of improved farming models, together with the appropriate feed formulation and processing technology can ensure the production of white fillet. Soon, Chinese consumers may be more concerned on quality and safety rather than the fish fillet colour.

Reference: http://www.nutriera.cn/en/News/Show_242.html.

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8th World Nutrition Forum

An exploration on latest market trends, and scientific developments in meat production, particularly in mycotoxins and -omics technology.

The theme of BIOMIN's 8th World Nutrition Forum (WNF) was S.C.O.P.E. or "Scientific Challenges and Opportunities in the Protein Economy." The innovative animal nutrition company hosted 800 delegates from 76 countries in Cape Town, South Africa from 3 to 5 October 2018. There were 40 expert speakers from industry and academia, in the plenary and in four breakout sessions: aquaculture, poultry, ruminant and swine. Formed in 1983, Biomin celebrates its 35th year in 2018.

Accelerating towards the future

The conference covered a range of topics to give insights on market outlooks, consumption patterns and technology advances. Focussing on antibiotics use in farming, invited speakers discussed antibiotics use in livestock production (including aqua), specialty feed ingredients to minimise use of antibiotics and antibiotics resistance. There was also a presentation on the use of transcriptomics to unravel the mode of action of antibiotics and in developing alternatives.

Erich Erber
(Picture credit: Biomin)

In his keynote presentation, Dr Erich Erber, Founder of Biomin referred to science, speed and service. "In a nutshell, with science we make sure that our products are always the top of its class. With speed we make sure that we are there when needed and our response time to customer requests is as fast as possible. With service we make sure that our long-standing customers are served well.

"Fourteen years have passed since we inaugurated the WNF in Salzburg. Since then, we have seen many challenges as well as changes, mainly in science but as well as in industrial structures, markets, and process breakthroughs. These have brought about a whole set of factors that influence how we shape the future of our industry."

"Growing global incomes provide opportunities for the entire animal protein industry, but the added production must be safe, affordable, sustainable and environmentally friendly," reminded Dr Vanbrabant, Managing Director of Biomin and CEO of ERBER Group.

Global feed to meat outlook

Growth projections are optimistic. "You are definitely in an industry with big opportunities," Nan-Dirk Mulder, Senior Global Animal Protein Analyst at Rabobank told delegates. Global meat markets will grow by 35% in the next 20 years. "The main drivers are population growth, income growth and changing preferences. The importance of the Asian region will rise significantly but will be a big challenge. Asia has limited resources for feed grain production.

"Social concerns are opportunities to differentiate markets. We see consumer demand changing due to social concerns on food safety, environmentally friendly, animal welfare friendly, buy-local and health issues. This major industry factor is leading to rising

(Picture credit: Biomin)

standards throughout the world in terms of production standards. Food safety, antibiotics use and also higher appreciation of local products," added Mulder.

Industry 4.0

This is the new buzzword Erber said that without education and know-how we are lost in the new world of knowledge. Chris De Lavigne, Deloitte, Singapore said, "The global farming and feed sector face unprecedented challenges: surging produce demand, resources pressure, evolving (and high) customers demand amidst glaring environmental pressures. Industry 4.0 has the potential to usher in an agricultural renaissance and supports the growing 'sustainability revolution' force. Agribusiness in the feed sector must embrace this force or face becoming irrelevant."

The fast pace of technological advancement in the fields of next-generation gene sequencing (so-called –omics technologies), mycotoxin detection and mitigation, and the adoption of Farm 4.0 methods was cited as a trend that promises to reshape the protein economy. "The future is for the innovators," said Vanbrabant.

Responsible use of antibiotics

The move to reduce the application of antibiotics and the removal of antibiotic growth promoters (AGPs) from production systems in particular was seen as having an impact on the meat, egg and dairy markets. "Today we can raise high-performing, healthy farm animals and reserve antibiotics for treatment - thanks to science," observed Franz Waxenecker, Director of Development and Innovation at Biomin.

Mycotoxins

The understanding of fungal metabolites and how they affect agriculture and the living organisms that consume them has expanded significantly over the years. The mycotoxin session discussed topics such as climate change, tools to predict mycotoxin occurrence patterns and novel mitigation strategies relying upon enzymatic biotransformation (the MYCOzyme concept). "Biomin is the global leader in mycotoxin risk management and we will continue to invest in new solutions for the industry in the future," announced Dr Gerd Schatmayr, Global Head of Research at the Biomin Research Center.

The aquaculture breakout session covered a range of topics from predictive modelling in aquafeeds, alternatives to protein meals, production without antibiotics, disease interventions to aquaculture in Africa. (The report on this session will be published in issue January/February 2019).

Jan Vanbrabant (right) and Albert van Rensburg .(Picture credit: Biomin)

Supporting sustainable production

During a press conference held before the official opening of WNF, Dr Jan Vanbrabant, gave an update on developments at Biomin during the two years since WNF 2016.

"Our goal has always been to support sustainable agriculture, now and in the future," noting that "our main contribution to sustainability is the application of our solutions in livestock production and aquaculture."

Highlighting some successes, Vanbrabant identified these as PoultryStar®, the only multispecies probiotics registered in the EU and the encapsulated phytogenics Digestarom® DC with a pending EU review. "In mycotoxin deactivation, there are more products in the pipeline under MYCOzymes concept. We want to offer the whole portfolio of enzymes."

Another development is the innovative mycotoxin detection service for clients. This involves the detection of 50 different mycotoxins and metabolites simultaneously using a LC-MS/MS method developed by Romer Labs. The custom report is enhanced with the largest data set on mycotoxin occurrence, procured during the annual Biomin mycotoxin survey. "In the future, there will be Farm 4.0 and -Omics technologies. Omics is the future, it will allow us to see, at the genetics levels, what our products are doing and see the genes that are being triggered."

On expanding capacity, Biomin will continue to invest. Biomin opened its Wuxi plant in 2017 to serve the markets in China. There are new projects in the pipeline such as a new plant in Austria. Vanbrabant said that the aqua business is growing and fast in India and Ecuador.

Biomin in South Africa

The venue of the 8th WNF in 2018 highlighted Biomin's strategy in giving importance to Africa. "By 2050, Africa will have one quarter of the global population," said Albert van Rensburg, Regional Director Africa, Biomin since 2011. Africa has its own business unit based in South Africa. The aim is to offer a comprehensive product, service and technical support in the South African market and to serve as a base for operations in other countries including Mozambique, Zambia, Zimbabwe, Namibia and Malawi.

"Africa's protein economy is important for us; in this continent production will not keep pace with consumption. The challenge is to produce enough food for its population," said van Ramsberg as he displayed the trends in meat, poultry and milk production in Africa.

"With around 280 customers, including feed millers, premix manufacturers, large poultry integrators in Africa, Biomin will continue to bring innovative animal nutrition solutions to support sustainable feed and food production in terms of feed quality, animal health and aquaculture products," said Vanbrabant.

The global trend towards the reduction or complete removal of antimicrobials from livestock production has also garnered attention in South Africa. "Biomin has a long history of offering high performance antibiotic-free feeding solutions to the livestock industry. Locally, our aim is to educate the market on antibiotics free feeding and share our global experience and expertise in this regard," added Vanbrabant.

R&D under the microS.C.O.P.E.

At the cornerstone of various innovations is Biomin's in-house R&D program, conducted by 100 scientific researchers at the Centre for Applied Animal Nutrition (CAN) and supported by 8 units located globally. There are five in Europe, and the rest in Thailand, Vietnam and Brazil. In addition, it has R&D collaboration with 200 universities and research institutes during the past 5 years.

"Biomin's R&D is from basic to applied to product development, new technologies, formulations and application to performance and biomarkers," said Dr Gerd Schatzmayr and Franz Waxenecker, to media representatives at WNF2018.

"It ranges from formulation and product stability in the intestinal tract to biomarkers development. It is a challenge in working with mycotoxins because of the great diversity in structures, with different biochemical and physical properties," said Schatzmayr.

The team explained the ground-breaking research in developing novel, innovative mycotoxin deactivating enzymes (MYCOzymes). This involved going down to the ground to seek wild type enzymes and engineer the enzymes for feed use, as well as developing fermentation processes for the enzymes, and carrying out economic evaluations, formulations and *in vivo* feeding trials.

At the core of the research is the -omics technologies. For example, in the gastrointestinal tract of the chicken; expression of all genes (transcriptomics); identify the genome of all microbes (metagenomics) and study the metabolome (all metabolites) present and also in the blood and organs (metabolomics).

The practical application of sequencing technology is on- farm sampling and analysis of raw data based on algorithms. Information available is then provided to the farm for intervention.

Gerd Schatzmayr (left) and Franz Waxenecker

New study shows potential future of aquafeed

With both fish meal and fish oil suffering from price issues, along with concerns over sustainability, the search for suitable aquaculture feed ingredients to replace them is constant. A new study shows that the amount of fish meal can be reduced, if krill meal is added to feed, with growth performance actually improving.

Conducted at the Institute of Sustainable Aquaculture and Marine Ecosystems (ECOAQUA), Universidad de Las Palmas de Gran Canaria, Spain, and focusing on gilthead seabream juveniles, the 12-week trial evaluated the growth of fish, when split into groups and fed a diet including 3%, 6% or 9% krill meal. Directed by researchers from the Aquaculture Research Group (GIA) and Aker BioMarine, triplicate groups of fingerlings were randomly distributed in six experimental tanks, at a density of 55 fish per tank.

Fed manually one of the diets, three times a day, for 12 weeks, feed intake was calculated by recording uptake every day, as well as the number of uneaten pellets at each feeding point. There were no significant differences in feed intake between the control group and those fed krill meal during the trial, and survival was high in all groups, at around 97%.

Results showed that the juveniles fed the 9% krill meal diet had significantly higher body weight (32.76 g), compared with fish fed the control diet (30.30 g). This is due to krill meal's unique profile. Protein rich with strong palatability effect and naturally containing astaxanthin and chitin, it also has an excellent lipid and mineral profile.

In addition, the fish fed 9% krill meal also displayed a reduction in the accumulation of lipid droplets in the hepatocytes and around the pancreatic islets, showing a better feed utilisation and therefore, promoting fish growth.

Commenting on the results, Tibiabin Benitez-Santana, Director R&D Fish Nutrition, Aker BioMarine said, "Good nutrition is one of the four pillars for sustainable aquaculture. However, there is a raw material challenge in aquaculture, where we need to be more independent from fish meal. This seabream study is allied with industry-wide efforts to find alternative sources to fish meal and fish oil, using krill meal in aquafeeds. The findings suggest that krill meal enhances seabream juveniles' growth, and reduces lipid accumulation in the liver, when fish meal is reduced."

Tibiabin Benitez-Santana

She added, "The aquaculture industry's goal should not be only about finding less-costly alternative sources, it should also strive to ensure that resources are used more efficiently, improving the productivity and environmental performance of aquaculture. Krill meal could be the solution as it is a sustainable, nutritional solution for the aquaculture industry." www.akerbiomarine.com

New ASC-VietGAP benchmark to guide Vietnamese farmers

A new collaborative project has been launched by the Aquaculture Stewardship Council (ASC), the Vietnamese Directorate of Fisheries (D-Fish) and WWF Vietnam. This will provide guidance for Vietnamese farmers to achieve ASC certification.

The ASC-VietGAP benchmark compared the Vietnamese aquaculture standard, VietGAP, and the ASC standards for shrimp, pangasius and tilapia, to allow farms that have achieved VietGAP certification to transition to ASC certification as efficiently as possible. The guidance documents for farmers were released in September, following an initial presentation and plenary discussion at Vietfish 2018, in August in Ho Chi Minh City.

The project is the result of collaboration between the three organisations and identified areas of overlap between the standards. Farmers that have achieved VietGAP certification and wish to pursue ASC certification previously lacked easy access to information outlining what they needed to meet the requirements. With the commonalities identified, farmers can now focus on the areas of difference between the certifications, thereby streamlining the ASC certification process for Vietnamese farmers.

D-Fish, the government department responsible for fisheries and aquaculture in Vietnam, and manages the VietGAP standard, which currently certifies 390 shrimp, pangasius and tilapia producers has endorsed the benchmark and will be using its links with Vietnam's fish farmers to promote the guidance. Roy van

Presentation and plenary discussion at Vietfish 2018, in August.

Daatselaar, Producer Support Manager at ASC, in presenting the new program at Vietfish said, "The ASC is a global certification program which brings many advantages to producers, but we also recognise that every region has different opportunities and challenges. This collaboration allows us to work with local partners to put things into a regional context, to extend the reach and benefits of ASC certification."

"WWF Vietnam supports sustainable aquaculture, benchmarking VietGAP and ASC will support to mobilise resources and increase opportunities of good aquaculture practice products to access the global market," said Huynh Quoc Tinh from WWF Vietnam. The guidance documents can be found on the ASC website. www.asc-aqua.org

Launch of new shrimp hatchery product

INVE Aquaculture believes that post larval quality and robustness lie at the core of successful shrimp hatcheries worldwide. With support of Benchmark, Inve Aquaculture continuously strives towards development of effective products that tackle the daily challenges encountered in shrimp culture.

In October, Inve Aquaculture presented the latest development, a plant-based water conditioner that protects shrimp larvae and post-larvae against stress and health threats. The new product, Sanocare® FIT, is a phytochemical mixture that has been engineered to enhance the robustness of post larvae during culture, and to suppress *Vibrio* levels during transportation of post larvae from the hatchery to the nursery or farm.

As health booster during the hatchery cycle, Sanocare® FIT stimulates the production of heat shock proteins in *Litopenaeus vannamei* post larvae. These proteins act as a first line of defense mechanism and constitute one of the most important survival strategies of cold-blooded animals when they are exposed to abiotic stress and pathogenic micro-organisms. Proof of increased robustness comes from extensive stress tests where considerable higher survival of *L. vannamei* post larvae was observed when using it during the culture.

The product can be used directly in the culture water during the hatchery cycle of shrimp, thereby increasing the robustness of the animals. Furthermore, Sanocare® FIT can be added directly to the transportation water to suppress the *Vibrio* levels during transfer of post larvae from the hatchery to the nursery or farm.

"The application of Sanocare® FIT during hatchery trials at Fitmar resulted in remarkable higher survival and growth at the end of the grow-out cycle. This first experience convinces

me to incorporate Sanocare® FIT in Fitmar's standard hatchery protocol," said Fernando Marino Pinzón Miranda, Proveedora de Larvas, S.A. De C.V, Mexico.

As *Vibrio* suppressor during transportation, application in the transportation water notably controls the *Vibrio* load in the water and in *L. vannamei* post larvae. The use of Sanocare® FIT during transport results in a 100-time lower *V. parahaemolyticus* count in shrimp post larvae as compared to transport without it. Eddy Naessens Product Manager Shrimp Hatcheries, said, "The application of Sanocare® FIT during transport prevents *Vibrio*-induced stress in shrimp post larvae and thus, gives them the best start upon stocking in the ponds for further growth."

Product availability will depend on the product registrations. Currently, it is available in Mexico and Thailand. www.inveaquaculture.com

Acquisition to enter Indonesian feed market

Royal De Heus Group ("De Heus") has signed a share purchase agreement to acquire 100% of the shares in Universal Agri Bisnisindo ("Universal"), a private Indonesian animal feed company held by a consortium of several private shareholders. The acquisition in October represents De Heus' entry into the Indonesian animal feed market and is in line with De Heus' strategy to further strengthen its position in the animal feed in Asia. We expect to close the acquisition during the fourth quarter of 2018.

"With a total annual sales volume of 300,000 tonnes of poultry, fish and shrimp feed, Universal provides De Heus with an ideal platform to build and further expand our activities in Indonesia," said Koen De Heus, CEO of Royal De Heus. He added, "De Heus is a family owned company with a long-term vision for the animal feed industry. Four generations of our family have shown their leadership, commitment and involvement with our clients and partners. I am sure that our knowledge, experience and international presence will help us to strengthen and grow Universal's feed activities in Indonesia by optimising the technical performances of its customers and the independent Indonesian farmers. We welcome the Universal employees to the De Heus family."

Octo Rachnalim, one of Universal's main shareholder said, "First of all, we would like to sincerely thank our loyal employees and loyal customers for their commitment to Universal that we have built together since 2000. Secondly, we would like to inform them that we are confident that De Heus will further strengthen and grow Universal."

In 2009, De Heus entered the Southeast Asian market through the acquisition of an animal feed company in Vietnam. Nine years later, De Heus Vietnam has become a top three player, with eight factories strategically spread throughout the country. "The success of De Heus in Vietnam – where since last year our regional Asian head office is located - has boosted our confidence to develop our activities in the region. Besides Vietnam, we are now successfully operating two feed mills in Myanmar, constructing a feed mill in Cambodia and through this acquisition, we can enter the promising Indonesian animal feed market," said Gabor Fluit, Regional Director De Heus Asia.

De Heus will appoint Kay De Vreese - who has more than 15 years of experience in key management positions in the industry in both Europe and Asia, as President Director of Universal. He will be supported by Ton Hovers, an experienced professional in the Indonesian animal nutrition industry, who will become a member of Universal's Board of Directors and who will focus on the further development and growth of the aquaculture business. www.deheus.com

Expansion of India operations with second premix plant

Cutting the ribbon for the new premix plant, David Blakemore (second right) with the Dutch Ambassador, Marten van den Berg (second left) and the team, from left: Balasubramanyam Rajagopal, President, DSM India; Dr Vijay Makhija, Regional Marketing and Communication APAC - ANH and Uma Sankar Padhi, Site Manager-ANH, Hyderabad.

In early October, **Royal DSM**, a global science-based company active in nutrition, health and sustainable living, officially opened its second Animal Nutrition & Health premix plant in Jadcherla, India. With the aim of deepening DSM's connection to its Indian consumers, the new plant serves as a catalyst for growth in India, reinforcing DSM's strong ambitions for the country. The opening followed years of detailed research and analysis of the Indian market, with the objective of serving the market with solutions that are tailor-made for local needs.

India's economic growth is accelerating rapidly and is pegged to be one of world's fastest growing economies. According to DSM's Animal Nutrition and Health, Business Unit Director for South Asia, Vyawahare, the dynamism of the market was key to continued investment in India. With over 20 years in the region, the plant also marks an important milestone for in the development of DSM's presence in India.

"India is one of the world's largest and fastest growing economies. We see strong potential for growth in the animal premix industry. The Jadcherla plant shows our willingness to support further development as it gives us far greater geographic reach and increases our production capacity to meet the growing industry demands," said Ravindra. "This premix plant, located in south India, where 90% of aquaculture activity is located will bring us closer to our aquafeed customers and the aquaculture industry as a whole."

The opening of the new premix facility signals DSM's commitment to develop operations in the country. As a purpose-led and performance driven company, DSM seeks to extend its presence in India with sustainable solutions that respect the environment and meet the specific needs of the Indian customers, thus creating greater value for the Indian market.

Commenting on the opening, David Blakemore, President, Animal Nutrition & Health for DSM said, "The opening of this premix facility in India underlines our commitment to meeting the global feed industry's need for innovative and sustainable solutions through continuing investments in our production footprint to support the growing markets. The plant is an example of DSM's growing global presence, and its commitment to drive innovation building on its wealth of resources and capabilities and extensive understanding of customers' needs both in India and globally."

DSM draws on the latest science to provide flexibility to develop tailor-made solutions for the Indian market, leveraging its product portfolio and innovation capabilities to ensure customers extract maximum value from the solutions developed and produced locally. The plant is fully equipped with best-in-class safety, health and environment compliance systems and its design allows for additional capacity for growth in demand. www.dsm.com

Appointment

Nutriad invests in aquaculture team in India

Multinational feed additives producer, a pioneer in species specific health and nutrition solutions for aquaculture producers, Nutriad has announced the appointment of **Goud Dhanunjaya** as Regional Sales Manager Aquaculture for the Indian sub-continent (ISC). The move is part of the continuous strategic expansion of Nutriad into the rapidly developing aquaculture market, aiming to have experienced local staff in key markets.

Goud has a Master of Fisheries Science (Aquaculture) from the College of Fisheries, Ratnagiri, India and 15 years of hands-on experience in aquaculture sales and technical support to shrimp farms, shrimp hatcheries, aqua feed manufacturers and fish growers in Asia.

Aquaculture in the ISC has shown tremendous growth during the past decade and has potential in terms of water and coastal resources for future growth. In 2018, shrimp production in India is forecasted to reach 800,000 tonnes and is expected to surpass China as the leading producer in 2019. Bangladesh has dramatically increased production of farmed freshwater fish such as catfish, carp and tilapia.

Erik Visser, CEO Nutriad commented, "The fast expansion of aquaculture is driving the need to solve a number of limiting factors for the industry, including the reduced availability of local fish oil and fish meal and the increasing impact of diseases on productivity. Now that the integration of Nutriad and Adisseo is well advanced, we can offer the combined product portfolio of both our companies as well as the service of local support teams, to build value adding species specific solutions for our customers. This is a very exciting development, that will bring us accelerated growth into the aquaculture market in the coming years."

Expanding R&D capabilities at BioMar

Shrimp research in Ecuador

In October, BioMar announced the opening of its Aquaculture Technology Centre (ATC) in Ecuador to expand its shrimp research capabilities. The ATC is state-of-the-art trial facility dedicated to the full lifecycle of shrimp, with the most advanced technology for shrimp research in Ecuador.

ATC Ecuador was officially opened with participation of the Danish Ambassador and the Ecuadorian Minister of Foreign Commerce and Investments. The new trial facility, ATC Ecuador, will be dedicated to the test of shrimp feed and it will service the development of shrimp diets and farming practises globally, being a part of the global ATC network in BioMar Group.

"Just one year after Alimentsa joined the BioMar Group, I am happy to see another tangible evidence of the commitment towards shrimp. The new trial centre is ready to go-live and we have created a strong collaboration with the global R&D network of scientists," said Danny Velez, Managing Director in BioMar Ecuador.

The opening of the new shrimp research and development facilities is a significant step in BioMar's strategic plans for the shrimp segment. In addition, the company is in the process of expanding production capacity in Ecuador. The country has for many years been acknowledged for the quality of the shrimp products and is taking lead participating in the development of efficient and sustainable shrimp farming. BioMar stated that this is one of the core reasons for intensifying the investments:

From left to right: Danny Velez, Managing Director, BioMar Ecuador; Håvard Jørgensen, Global R&D Director BioMar Group; Pablo Campana, Ecuadorian Minister of Foreign Commerce and Investments; Carlos Diaz, CEO BioMar Group; Jens Godtfredsen, Danish Ambassador to Ecuador; Laurence Massaut, R&D Director BioMar Ecuador

"We see a significant growth potential in the shrimp feed segment. Our new research facilities will help us continue to evolve our shrimp feed range while allowing us to respond faster to market and customer needs. In BioMar, we have for many years been contributing to minimising the environmental foot print of the industry, enhancing efficiency and strengthening the health of the fish. Now, we are ready to conduct local product test supporting our global research within raw materials, process technology, health and nutrition", said Carlos Diaz, CEO, BioMar Group.

Hatchery feed sector

BioMar increases its research capabilities in hatchery with an expansion of its Aquaculture Technology Centre, ATC Hirtshals facility in Denmark with a state-of-the-art marine fish larval trial unit that not only allows for larval rearing but also the production of live feed.

As it celebrates 15 years of excellence in hatchery feeds and invest in business growth in new geographical markets and new species, BioMar has recently streamlined the product portfolio and adopted new innovations and functional raw materials in their LARVIVA hatchery range to maximise health and performance. The new research facilities will enable it to continue to drive breakthrough innovation in the hatchery feed segment.

This opening of the new hatchery research and development facilities is the second of a three-phase strategic plan for the segment. In 2017, BioMar announced heavy investment in the area including the establishment of a business unit in Nersac, France headed by Chris Dinneweth and the expansion of the fry feed production line in Brande, Denmark expected later in 2019.

The ATC Hirtshals now houses 24 RAS larval rearing trial units ranging from 50 to 100L all operating under strict controlled conditions. The new system allows for fine-tuning protocols for larval rearing as well as the production of live feed including rotifers and artemia. BioMar have complete control within the trial units including temperature, salinity, photoperiod and light-intensity allowing for strongly replicated trials and the ability to work on a range of marine species.

The hatchery trial unit at ATC Hirtshals

"We see significant growth potential in the hatchery feed segment. Our new research facilities will help us continue to evolve our larval feed range while allowing us to respond faster to market and customer needs. This hatchery trial facility is a significant boost to the hatchery business unit which will allow us to undertake in-house marine fish larvae feed trials. We look forward to developing and bringing to the market new and exciting innovations in hatchery feeds", said Ole Christensen, Vice President, EMEA, BioMar. www.biomar.com

Acquisition strengthens presence in shrimp market in Ecuador

Neovia announced in September, the acquisition of the Ecuadorian company Balnova, a feed manufacturer for the shrimp market. Through this acquisition, Neovia will consolidate its strong international expertise in aquaculture and its presence in one of the largest shrimp producing markets (ranked 4th worldwide). In 2017, Neovia acquired the US larval feed and probiotics manufacturer Epicore, who also operates a major branch in Ecuador.

This operation is part of the divestment plan in non-strategic assets planned by the Nueva Pescanova Group until 2020, with the aim of obtaining maximum profitability for the vertical group integration, increasing the level of occupation of its factories and optimising the planning of raw material supply.

Hector Marriot, CEO of Balnova said, "We are thrilled to share our know-how with a major international group like Neovia. The collaboration between our R&D teams will allow us to expand research and develop new innovative products. This opens wonderful opportunities for our teams to develop new innovative solutions for Ecuadorian farmers."

Ignacio Gonzalez, CEO of Nueva Pescanova Group, added: "We believe Balnova is set to continue growing as part of a specialised international group. Moreover, it will continue to be one of Nueva Pescanova Group's main suppliers of prawn feed for a minimum of 5 years. Neovia has shared its intention to keep the entire workforce, as well as the current management team".

Eric de Seguins Pazzis, Marketing and Business Development Director at Neovia added, "In keeping with its resilient strategy, Neovia is balancing its business lines, having made aquaculture one of its 7 activities in its own right in 2016. Neovia wishes to thus develop and reinforce its product offer and aquaculture solutions in a sector witnessing strong growth (+450% by 2040) at the global level. We are thrilled to welcome Balnova and to be able to count on the know-how of teams on the Ecuadorian market in order to reinforce future innovations. Ecuador will be a key country for Neovia, where we plan to increase our exports, especially to Peru." www.neovia-group.com

Aqua Culture Asia Pacific in 2019

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Issue focus *Trending issues and challenges for the next step*	Fish/Shrimp Nursery	Health & Disease Management	Hatchery	Sustainable & Responsible Aquaculture	Genetics & Genomics	Integration and supply chain
Industry Review *Developments, outlook, demand & supply*	Marine Shrimp	Marine Fish	Aqua Feed Production	Tilapia	Functional Feeds	Catfish & Freshwater Fish
Feeds & Processing Technology *Technical contributions from feed industry*	Fish meal Replacements Feed Enzymes	Feed Additives Omega 3 oils	Health/Safety/ Environment in feedmills	Lipids & Minerals Nutrition	Extrusion & Processing	Larval & Nursery Feeds
Production Technology *Technical information and ideas*	Controlled systems/RAS	Offshore and Industrialisation	Innovations	SPF/SPR/SPT shrimp	Post-Harvest Technology/ Processing	Organic Aquaculture
Market and product developments, market access, certifications, branding, food safety etc)	Shrimp	EU	Tilapia	China	USA	Marine Fish
Aqua business *Feature articles*	Experiences from industry and opinion article covering role models, benchmarking, health management, SOPs, social investments, CSR, ancillary services, self-regulation etc					
Company/Product news	News from industry including local and regional trade shows					
Technical articles	**November 16, 2018**	**January 18**	**March 15**	**May 17**	**July 12**	**September 13**
Advert booking	**November 23, 2018**	**January 25**	**March 22**	**May 24**	**July 19**	**September 20**
Show Issue & Distribution at these events as well as local and regional meetings ****Show preview***	**Brackishwater Aquaculture 2019** January 23-25 Chennai, India **VIV Asia 2019** March 13-15 Bangkok, Thailand	**Seafood Expo Global 2019** May 7-9 Brussels, Belgium **12th Asian Fisheries & Aquaculture Forum (12AFAF)** April 8-12, Iloilo City, Philippines	***Asian Pacific Aquaculture 2019** June 19-22, Chennai, India	***The Aquaculture RoundTable Series, (TARS 2019) Aquafeeds** August 14-15, Bali, Indonesia **Vietfish 2019** August 29-31 Ho Chi Minh City, Vietnam	**Aquaculture Europe 2019** October 8-10 Berlin, Germany	

More functional feed additives to benefit aquaculture

Nutriad organised a 2-hour customer seminar for its clients at Aqua 2018, a joint EAS/WAS meeting held from 25 to 29 August in Montpellier France. On 26 August, the focus was on "functional feed additives in aquaculture and how to add more." Dr Peter Coutteau, Business Unit Director Aquaculture, Nutriad welcomed over 80 participants, comprising conference delegates, feed mill customers and integrated fish producers, mostly from the Mediterranean region but also with some participants from Norway, Brazil, and Thailand.

The seminar started with an overview on novel sources of oils in the search for sustainable alternatives to fish oil as the source of long chain omega-3 fatty acids (LC-PUFAs), namely eicosapentaenoic acid (EPA) and docosahexaenoic acids (DHA). Dr Mónica Betancor, University of Stirling, Scotland, said that traditionally fish oil is used in salmon feeds. In 2016, a 140g Scottish salmon fish fillet would then contain 3.9 g of EPA+DHA. However, with fish oils being replaced by plant oils, in 2016, a 140g salmon fillet would contain only 1.9g of EPA+DHA. "This meant that we need to eat 3 times more salmon weekly to meet the levels recommended by health advisory authorities. The question is how to boost EPA+DHA levels in fish, like salmon, back to the same levels as 2006."

Betancor discussed "Novel sources of fish oils for fish feed" and listed their advantages and disadvantages. Krill has carotenoids and antioxidants, but this comes at a high price. Copepods contain oils as phospholipids and fatty acid wax esters. The negative aspect is that zooplankton is a finite resource. Marine microalgae are rich in these fatty acids. At the Rothamsted Research Centre in the UK, the plant *Camelina sativa*, with seeds containing 40% oils rich in short chain omega-3 fatty acids, is being genetically modified (GM) by including algae genes to produce oils rich in EPA+DHA. The advantage is that it uses marginal lands and seeds can have more than 20% of EPA+DHA. Betancor said that at Stirling, they have fed salmon with feeds containing the GM derived oils and the result was fillet containing the traditional high levels of EPA+DHA. Next will be to test the feed with this oil over the full life cycle of the salmon, from 200g to 4 kg.

The issue with this GM plant as a source of EPA+DHA is consumer acceptance, especially in the European Union, despite that 90% of soybeans used in the food industry are GMOs. Therefore, education is the key. In the case of the Camelina, planting GM crops are banned in Scotland. The question for the industry is whether we want to maintain the same levels of DHA+EPA in fillet as 12 years ago?

With regards to using functional feed additives to promote aqua health, Dr Maria Mercè Isern-Subich, Business Development Manager Aquaculture Health, Nutriad, gave a global view of Nutriad's approaches in fish health. She said that multiple infections do not involve just one type of pathogen but implicate opportunistic and primary pathogens to cause morbidity, mortality and sub clinical situations. Fish do not grow and give the expected feed conversion ratio, said Isern-Subich.

In 2014, there was the tilapia lake virus (TiLV) in Israel and now in 2018, TiLV is a global issue. Whether it is the Thai or Colombian case incident, it is the same fish and same virus. Juveniles are more sensitive than adult fish and can build immunity. She outlined how some products promote in-host resistance, gut health and provide immune modulation. With parasites, Nutriad's way is to build an empirical approach with customers and conduct *in vivo* testing to control the infection and show the trajectories over the treatment period. Isern-Subich's final words were that the functional feed additives are integral to the production strategy and are not magic bullets.

Nutriad team, first row, from the left, Dr Peter Coutteau, Alexander van Halteren, Dr Pierre-Andre Geraert, Director Scientific Marketing Adisseo, Dr Waldo Nuez Ortin and Dr Maria Mercè Isern-Subich (second row, left) with speaker Dr Mónica B Betancor.

There are benefits with using functional feed additives to enhance digestive/metabolic processes, said Alexander van Halteren, Business Development Manager Aquaculture Nutrition. He discussed some ways to reduce feed cost by maximizing the feed efficiency. He focused on emulsifiers as production aids. Specific feed emulsifiers increase emulsification in the lumen, are co-factors of enzymes and increase membrane permeability. Van Halteren stressed that these functional emulsifiers are different active compounds compared to the surfactants used for better sinking characteristic of pellets, increase lubrication during the pelleting process and prevent oil leakages in high fat feeds. In the product Aqualyso, based on lyso-phospholipids, micelles increase emulsification and increase metabolic efficiency. He also discussed trials conducted at Taiwan's National Pingtung University of Science and Technology on the replacement of cholesterol with bile salts as precursor of ecdysteroids. In the pangasius, the higher dosage of another product Aquagest® in the nursing phase gave an average daily growth (ADG) of 3.03g versus the control without the additive at an ADG of 2.92g.

In the final presentation, Dr Waldo Nuez Ortin, Lead Scientist Aquaculture, Nutriad, introduced Adisseo's Selisseo®, a novel source of organic selenium for aquaculture. This is an organic selenium produced from a 100% chemical process and is highly stable in feeds. The product is also safer to use at the feed mill compared to other sources of organic selenium. Nuez Ortin described the production of ROS (reactive oxygen species) during stress having negative consequences such as breakdown of free radicals, capturing of free radicals such as vitamin A and carotenoids resulting in elimination of oxidised products, lipid oxidation and breakdown of protein. He detailed some benefits of adding Selisseo® in feeds for the shrimp and fish. It is an essential micro element that must be added to premixes for aquafeeds in trace amounts to ensure optimum antioxidant status, growth, performance and disease resistance. In a trial in China, supplementation of Selisseo® to *P. vannamei* diets formulated with a lower fish meal (15%) helped to overcome the growth deficit. www.nutriad.com

Aquaculture research and innovation for continued growth

From August 25-29, AQUA 2018 gave recognition to aquaculture as one of the most important food production industries in the world. Aquaculture is the most efficient producer of high-quality food, contributing to global health and wealth while respecting the environment, creating employment and offering significant investment opportunities.

This year, the conference and trade show which took place in Montpellier, France, was a joint European Aquaculture Society (EAS) and World Aquaculture Society (WAS) aqua event. In addition to the scientific conference, other events included: a world press day organised by the Food and Agriculture Organisation (FAO) and European Community (EC), industry forums and dinners, workshops and student events. AQUA 2018 highlighted the latest in aquaculture. Organisers gave some statistics: 3,003 participants from 109 countries; 175 trade booths; 800 oral and 317 poster presentations; 10 industry sessions and pre- and post- event tours.

Three keynote speakers opened the conference. **Dr Árni Mathiesen**, Assistant Director General, FAO Fisheries and Aquaculture Department gave the FAO update on the status of world aquaculture. He focussed on antimicrobial resistance arising from the abuse of antibiotics in aquaculture and the threats posed. Two leading industry stalwarts gave their views on how to achieve sustainable aquaculture in the shrimp industry in Thailand and salmon farming in Europe, respectively.

Changing the face of Asian aquaculture

Charoen Pokphand Public Foods Limited (CPF) is a leading multinational in Asia, involved in livestock and aquaculture production and feed processing. **Robins McIntosh**, Vice President in the aquaculture business described the journey of the company as it develops into the leader in shrimp farming in Asia and the challenges along the way.

CPF has its roots in the rice seed business and today, the group is led by Khun Dhanin Chearavanont and Dr Chingchai Lohawattanakul. The CPF shrimp business unit started in 1986, and is a leader in the shrimp farming business in Asia. "CPF provides leadership for the industry; the Thai shrimp industry is well supported by industry, business associations, Department of Fisheries and universities." Over the years all went well until 2000 when industry faced the monodon slow growth syndrome which led to the introduction of vannamei shrimp culture. "This came as an awakening and industry had to move to more sustainably controlled environmentally friendly farming. Next came modernisation of hatcheries and broodstock development," added McIntosh. Starting with 24g in 140 days, CPF's genetically selected shrimp reached 30g in just over 70 days with the 2017 generation.

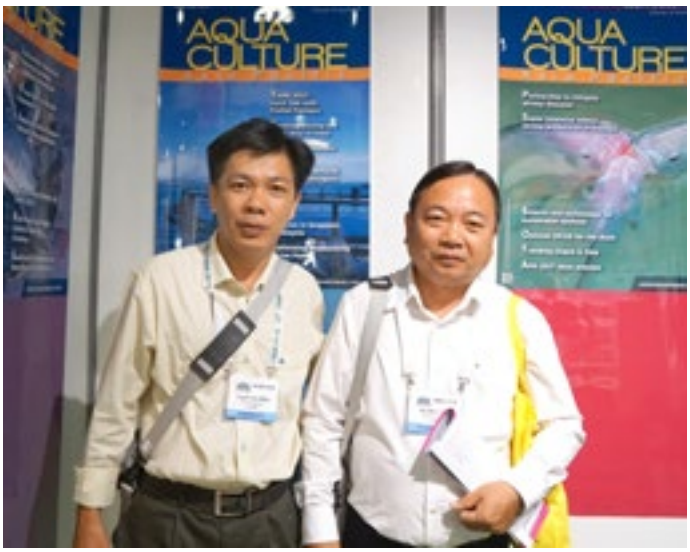
The next crisis came with acute hepatopancreatic necrosis disease (AHPND) in 2012 and again industry opted for sustainable intensification. "By 2016, productivity reached 105 tonnes/ha/year while the survival rate was 75% versus 8 tonnes/ha/year with 45% survival rates in 2014. The trend is now more from less; less labour and more precision with automation and more biotechnology. Indoor shrimp farming maybe the future and processing moving to value adding from commodity." McIntosh added that CPF is not only active in Thailand, but is also active in Indonesia, Vietnam, Malaysia, India and the Philippines.

Leading the blue ocean

Marine Harvest, ASA (MH), is the global leader in salmon farming with operations in 24 countries. It produced 370,346 tonnes of fish in 2017. It is vertically integrated with its own salmon breeding program. In 2014, it began feed milling to supply 85% of the feed requirement and by 2019, it aims for 100% self-sufficiency. The advantage with salmon was the all-time high prices in 2017 but production costs also rose. In presenting the "Technological Innovation in Salmon Farming," **Øyvind Oaland**, CTO, gave an insight into the current challenges that MH is facing and how technological innovations and new production platforms will facilitate sustainable growth.

Salmon farming is the solution for replenishing the global fish supply and compared to beef, has a carbon dioxide footprint of 2.9 versus 30.0kg CO_2/kg. The main characteristic of this industry is, "We do not own the production area (open seas) and are exposed to farm to farm impacts. We are still a young

Robins McIntosh (left) and conference delegates from CPF Thailand, Dr Chawalit Orachunwong (right) and Dr Suphol Phantumaophas.



Dr Bui Minh Tam, (right) and Dr Huynh Van Hien, Can Tho University, Vietnam.

ASIAN PACIFIC AQUACULTURE 2019

This event includes:

Asian Pacific Aquaculture 2019

ISTA 2019

APA'19

Chennai Trade Center

Chennai - Tamil Nadu - India

June 19 -21, 2019

Aquaculture for Health, Wealth and Happiness

APA'19

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JUNE 19 - 21

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The Phileo Lesaffre Animal Care team, from right, Dr Philippe Tacon, Singapore; Otavia Castro, USA; Dr Emerson Kagoo, India; Marcelo Borba, Brazil and Lin Wang, France. Phileo Lesaffre sponsored a session on "Nutrition: novel feed ingredients".

Frank Tan, Aquaculture Centre of Excellence Ptd Ltd, Singapore (middle) with IDEE Aquaculture's Jerome Bosmans (right), and Jean Marc Cochet. IDEE is an engineering and consultancy team, developing aquaculture, from conception and engineering to project management as well as R&D, technical support and strategic and financial analysis.

industry and is disadvantaged by knowledge gaps especially in the biological areas," said Oaland.

Sea lice control and digitalisation

In the last few years, growth has been retarded because of sea lice outbreaks. There was enforcement to reduce production and Norway introduced the "traffic lights system" to address the sea lice problem. In an effort to reduce the impact of lice on wild salmon, the Norwegian Department of Fisheries and Aquaculture has now divided the Norwegian west coast into 13 zones, since October 2017. Each zone will be given a green, amber, or red light, based on the number of sea lice in that area. A green light means farmers can consider production growth, a red light means reduction, while amber means it has to stay where it is.

"Where are the technologies and innovations to combat sea lice outbreaks?" asked Oaland. In 2015, to boost investments in new technologies, the Norwegian Ministry of Fisheries started a new category of licence to incentivise technological innovations. By November 2017, there were 105 concepts submitted with 8 approved. Oaland showed pictures of the MH semi-closed technology, the 20,000 m^3 egg could hold 1,000 tonnes biomass and is 32m in diameter and 44m high. The semi-closed system reduces risks as it prevents the entry of sea lice larvae and other pathogens. MH has also proposed a 'Donut' and the 'Beck cage' concept for offshore exposed areas to avoid sea lice outbreaks.

Oaland showed another innovation, the Neptune for post smolt in the sea in a floating semi closed tank in deep water inlets. This shortens the culture time in open cages to reduce the risk of sea lice and other pathogens. This system covers the 100g to 1kg, stage before the fish are transferred into open cages. R&D work is ongoing.

"Changing the world is machine learning and artificial intelligence (AI)," said Oaland as he listed real time applications such as a pellet detection, feed control (instead of current visual observation of fish appetite), lice detection (counts and predictions), real time fish biomass, behaviour and production related disorders. The ad hoc analytics include root cause of diseases, performance and quality. Today, MH has big cloud-global digitalisation over the value chain. It also has the capability to integrate data from all units (cameras, feeds, environment, volume, tanks, etc.) and has one global service platform and user interphase. It gives real time analyses and benchmarking tools. A specific AI application is Aqua Cloud for predicting sea lice. "This utilises big data/IoT and AI, and is set to become the future foundation for innovation and growth, extracting learning and experience in an efficient manner." Oaland ended with, "As we speak today, the change is coming but will take time."

The next Aquaculture 2019 will be held in New Orleans, Louisiana, USA, March 7-11 and the next Aquaculture Europe 2019 will be in Berlin, Germany, October 7-10.

Extracted from https://aquaeas.eu/images/stories/Meetings/AQUA_2018/AQUA2018_Compilation-of-Session-Summaries.pdf with additional information.

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led by Prof. Thierry B. Chopin, UNBSJ, Canada

For more information, visit

www.asianaquaculture.org

THEMES / SESSIONS

- Aquaculture husbandry and management
- Aquaculture nutrition
- Aquaculture health management
- Innovative aquaculture production systems
- Improved production methods of aquatic seedstock
- Applied genetics for aquaculture stock improvement
- Future technologies for aquaculture in an 'omics' era
- Special Industry Session: Novel industry products and technologies
- Special Session: aquaculture education and training needs for Asia

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World Brackishwater Aquaculture conference and expo (BRAQCON 2019), organised by the Society of Coastal Aquaculture and Fisheries (SCAFi) and ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) is a platform for multi-stakeholder interactions and planning for the future of brackish water aquaculture in India. A National Farmers' Conclave will be held on January 22, 2019.

The technical sessions comprise the following:

- Brackishwater ecosystem
- Aquaculture production systems (including husbandry of fish and shrimp, IMTA), organic and biofloc systems and RAS)
- Aquatic environment and climate change (carrying capacity, water quality, nutrient cycles and budgeting)
- Aquaculture genetics and biotechnology
- Reproduction and larviculture (shellfish and finfish)
- Brackishwater and estuarine biodiversity and conservation
- Fish and shellfish nutrition (feed additives, alternative feeds and ingredients, nutraceuticals, microalgae, live feeds, probiotics and prebiotics)
- Socio-economic issues of fisheries and aquaculture
- Aquatic animal health

There will be a Start Up session to create opportunities in brackish water aquaculture following the Start-Up India initiative by the government of India launched in 2016. The program has attracted new business ventures with innovative ideas in the sector with the assistance of ICAR-CIBA. More information: http://braqcon.org; braqcon@gmail.com

Practical Short Course on Feeds & Pet Food Extrusion

February 3-8, 2019
Texas A&M, USA

A one-week Practical Short Course on Feeds & Pet Food Extrusion will be conducted by staff, industry representatives, and consultants. It will cover:

- designing new feed mills and selecting conveying, drying, grinding, conditioning and feed mixing equipment;
- current practices for production of pet foods, preparing full-fat soy meal;
- recycling by-products and secondary resources;
- spraying and coating fats, digests and preservatives;
- use of encapsulated ingredients and preparation of premixes, and
- least cost formulation

There will be practical demonstrations of pet food, vacuum coating, and several others on four major types of extruders (dry, interrupted flights, single and twin screw), using various shaping dies.

Reservations are accepted on a first-come basis. For more information: E-mail: mnriaz@tamu.edu (Dr Mian Riaz, Director, Process Engineering R& D Centre); https://perdc.tamu.edu/; https://perdc.tamu.edu/extrusion/

2018

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**

November 18-21
8th International Fisheries Symposium 2018
Hatyai, Thailand
http://ifs2018.sat.psu.ac.th/

November 21-23
Taiwan International Fisheries and Seafood Show
Kaohsiung
www.taiwanfishery.com

December 3-6
Asian Aquaculture 2018
Bangkok, Thailand
www.asianaquaculture.org

2019

January 31-February 2
AquaEx India-2019
Hyderabad
https://www.aquaexindia.com/

January 23-25
Brackishwater Aquaculture (BRAQCON 2019)
Chennai, India
http://braqcon.org

February 3-8
Practical Short Course on Feeds & Pet Food Extrusion
Texas A&M, USA
https://perdc.tamu.edu/; https://perdc.tamu.edu/extrusion/

March 7-11
Aquaculture 2019
New Orleans, Louisiana USA
www.was.org

March 13-15
VIV Asia 2019
Bangkok, Thailand
www.vivasia.nl

March 12-14
Annual Seminar on Marine Science and Aquaculture (ICOMSA2019)
Kota Kinabalu, Sabah, Malaysia
www.ums.edu.my/ipmbv2/icomsa/

April 8-12
12th Asian Fisheries & Aquaculture Forum (12AFAF)
Iloilo City, Philippines
www.asianfisheriessociety.org

May 7-9
Seafood Expo Global 2019
Brussels, Belgium
www.seafoodexpo.com

June 19-22
Asian-Pacific Aquaculture 2019
Chennai, India
www.was.org

June 26-28
Aquaculture Philippines 2019
Pasay City, Metro Manila
www.livestockphilippines.com

August 14-15
TARS 2019: Aquafeeds
Bali, Indonesia
conference@tarsaquaculture.com
www.tarsaquaculture.com

August 29-31
Vietfish 2019
Ho Chi Minh City
http://vietfish.com.vn

VIV ASIA 2019

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