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TARS 2018: Young Gen Shrimp Farmers at Hard Talk

Eyes on Indian Shrimp Farming

Cholesterol and Bile Salt in Grouper and Shrimp

Crayfish Farming in China

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

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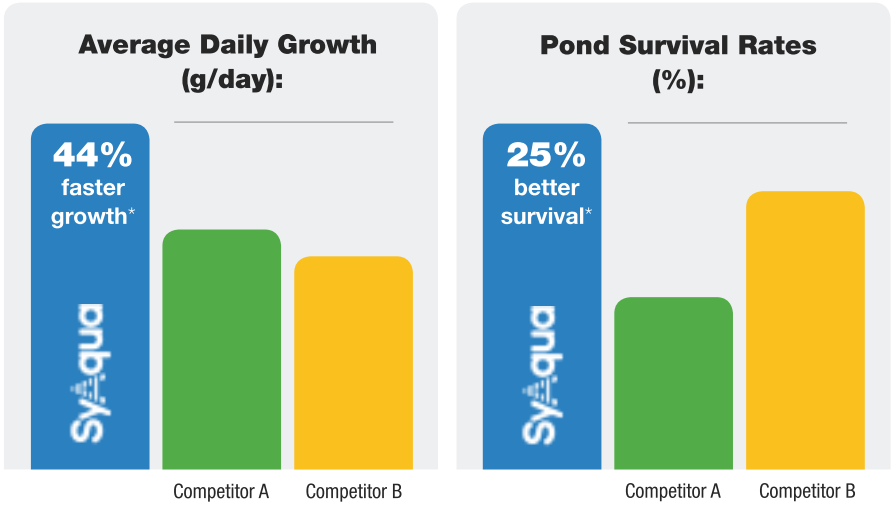

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A tale of two industries

Zuridah Merican

It is interesting to note that shrimp aquaculture in Southeast Asia and the European salmon aquaculture industry both started at about the same time in the early 1980s. Both industries have grown tremendously, taking different paths on their respective journeys, having been through the best of times and the worst of times. This was well highlighted at two separate presentations recently. TARS 2018 held in Chiang Mai, Thailand focused on the shrimp aquaculture industry with the theme "Need for Change". Robins McIntosh, Charoen Pokphand Foods, Thailand presented the state of the industry address entitled "Thriving (or surviving) in a changing world." Half-way around the world and exactly 11 days later, Jon Grottum, Director of Aquaculture at the Norwegian Seafood Federation presented at the press conference in Montpellier – "Salmon farming as an example of interdisciplinary approach in developing more sustainable farming practices".

Shrimp farming in Southeast Asia started with the black tiger shrimp *Penaeus monodon*, indigenous to the region. The demand from Japan provided high prices until the Emperor passed on in 1989 and Japan went into austerity mode. In the 1990s, shrimp culture became efficient and increased world supply by selling into markets in Europe and US, but the end of the decade saw increasing disease problems with WSSV and monodon baculovirus. In the early 2000s, diseases decimated the industry and farmers were at a loss, both profitability and direction-wise. The availability of domesticated and SPF *P. vannamei* broodstock could not have been better in terms of timing. The proverbial push-pull effect provided a perfect match and within 3 years, Thailand, a major shrimp producer had crossed the 80:20 ratio for vannamei vs monodon shrimp. The switch was an easy decision as one could produce at least 3 times more volume with the former compared to the latter due to higher stocking densities. The industry has always had to deal with WSSV, but the decade of 2010s saw new and emerging diseases, from AHPND to EHP and WFD. Since then, various producing countries have taken different approaches. While some countries were late in switching to the vannamei shrimp, others abandoned current 'diseased' sites looking further afield for new 'cleaner' sites. While Thailand is looking at higher efficiency and producing more from less hectarage, there are others looking to revert to the black tiger shrimp.

Salmon aquaculture had encountered controversy from the start due to the perception that it pollutes the environment and fish escapees disturb the genetics of the wild salmon stock. In Norway, when the number of farms exploded in the 1980s, there was concern that uneaten feed and fish faeces would pollute the pristine waters of the fjords and inlets. The problem brought research, competent authorities and the private sector together as a triumvirate to find solutions so as not to impede a growth industry. Solutions included mandatory fallow periods to allow water quality to recover. In the 1990s the industry faced diseases which saw rampant antibiotic use. The triumvirate opened doors for vaccination of fish as prophylaxis treatment and strictly enforced antibiotic use and since 1995, antibiotic use has been close to zero. In the 2000s, NGOs and activists rallied against fish escapees and regulation was put in place to strengthen fish cages and subject to strict reporting. Today, the biggest challenge is sea lice where mitigation measures reviewed include special feeds, hydrogen peroxide treatment, vaccination, cleaner fish (wrasse) and even laser guns.

It is clear that the shrimp and salmon industries face different challenges but the strategy used for the management and sustainability of each industry's future could not be more different. The shrimp industry seems to have chosen an individualistic short-term approach and where 'the winner takes it all' while the salmon industry has chosen an interdisciplinary approach with research institutions, competent authorities and the private sector working together for the greater good. Which is better? Perhaps the answer is best illustrated by Cargill's Tim Noonan at TARS on "An investor's perspective on Asia's shrimp industry". Noonan described Asia's shrimp industry as a win big-lose big scenario while Norway's salmon industry has a demonstrated track record in building professional companies which has led to healthy investor demand for salmon producers' shares on the Oslo Stock Exchange (OSL). There are nine salmon companies listed on the OSL today.

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Need for change in Asia's shrimp aquaculture industry

The future is production efficiency; more from less.

TARS 2018 was the eighth in The Aquaculture Roundtable Series and for the fourth time, the focus was on the shrimp aquaculture industry in Asia. There was a wow factor with 250 participants attending the gathering of industry stakeholders in Chiang Mai, Thailand from 15-16 August 2018.

In 2016, the focus was on how to take the industry to a new normal with the realisation that disease-free farming was passé. Moving forward, TARS 2018 highlighted the ***Need for Change*** and called on the industry to look at increasing efficiency and a higher level of control in production.

As commercial shrimp farming in Asia has surpassed almost 40 years, it is time to pass the baton to the next generation. This year's hard talk with farmers featured three second generation farmers taking over the business from their parents (see pages 8-11).

In his welcome address, **Bunchong Chumnongsittathum**, Deputy Director General, Department of Fisheries, Thailand (DOF), said, "At present, Asia's production of vannamei shrimp is increasing but persistent disease outbreaks have increased uncertainty, leading to massive increases in cost of production. Until the end of 2017, farmers have managed due to the strong global shrimp prices, but this will not last and we risk becoming unprofitable.

"Shrimp contributes THB 60 billion or almost USD 2 billion to Thailand's economy. It is also important as shrimp farming holds communities together. Although, our current shrimp production may be less than half of our best of 640,000 tonnes in 2010, the efficiency of our sustainable culture system gives us a high level of production per area."

Post EMS, Thai farmers have adopted strategies and steps to improve survival rates to boost production but at a pace suited to themselves and their farm conditions. "The Department is responsible not only for regulating and monitoring shrimp quality but also provides support to the industry with technical services to farmers and all related sectors."

Khun Bunchong also introduced a panelist at the Hard Talk with Young Shrimp Farmers, Somthida Pakdeepak, a graduate of Kasetsart University. "She is an example of the succession planning aided by DOF and academia. At our universities, we take into consideration, the trial and error experience from the first generation of farmers, and convert this into science for this next generation of farmers."

Participants during the Roundtable session on the second day of TARS 2018

Thriving in a changing world

For the second time, **Robins McIntosh**, Executive Vice President of Charoen Pokphand Foods (CPF), Thailand used his vast industry knowledge as well as his global outlook to present the state of the industry (SOI) address. At TARS 2016, McIntosh had already called for change, change and more change. In 2016, shrimp prices were at their highest and despite challenging times with diseases, the industry was in an expansion mode. Today, the scenario has changed as prices began to drop when supply outstripped demand. This year, in his presentation on "Thriving (or surviving) in a changing world', McIntosh described the new situation with shrimp markets and industry and proposed steps for change.

In the supply and demand balance, high prices up to January 2018, had incentivised and supported the development of new ponds and new farming areas, particularly in India and Indonesia. On the other side, there was the application of new technologies in existing farms to improve farm efficiency. "It is this combination which resulted in a rapid gain in global shrimp production over the past 2 years. But the global average in shrimp costs of production has increased. There is polarisation between farmers who have focused on efficiency improvement and those on development of new areas.

"Today, we have a growth phase, due to the expansion of farming in new areas. This 'false rise' in supply may slow down or even reverse slightly. With production highs in India, in early January 2018, prices came down. "Prices were lower, but will it put farms out of business?"

Evolution and markets

McIntosh said that in response to shrimp market economics, the trend has been for more intensification. "Today, we could have 60% of world shrimp reared through intensive systems. Hyper intensive is the next level but today it comprises only 2% of shrimp production. The message is: nothing stays the same. We will evolve and create change when we have issues in the industry, such as diseases, and reduction in profit margins. All these will be incentives for change and rapid evolution."

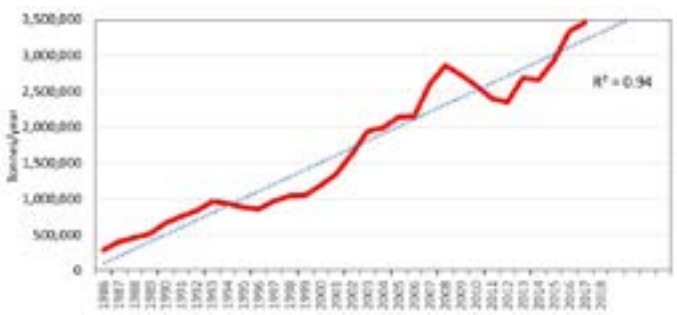

Figure 1. Trend line for global shrimp production since 1986.

McIntosh showed a graph on shrimp production from 1986. "This trend line is interesting in predicting weakening and strengthening of prices. Low price years constitute the redline above the trend line, while years with higher prices are indicated

by the red line below the trend line. Just like the stock market, Figure 1 shows over or under production when we look at the world trend from 1986. A 50% decline in price below the trend line with the introduction of domesticated specific pathogen free (SPF) vannamei shrimp."

> **"Less land more shrimp, less water more shrimp, less feed more shrimp; less energy more shrimp, that will be the evolution. It will happen faster in some places than others."**

China and other markets

Global shrimp producers target the same markets, mainly Europe, Japan and USA. "More recently, China. If I look at the different markets and look for growth, it is in the USA and China. What are the limits to shrimp consumption? In terms of buying power, we can see real income increasing in the USA, at 2% annually but the actual imports, assuming this is all consumed, indicate that Americans are under consuming relative to their incomes today."

The large increases in production in Ecuador and India have been channelled mainly to China. "This surge in shrimp imports into China was attributed to its low production because of EMS/AHPND (early mortality syndrome/acute hepatopancreatic necrosis disease). Prior to that, in 2009, China only imported 5,000 tonnes of shrimp and exported 400,000 tonnes and it was self-sufficient," said McIntosh.

McIntosh added, "EMS/AHPND reduced production to probably 600,000-700,000 tonnes which has been replaced by imports. In terms of real income gains of China, it has increased 5.5% annually. China can afford to import more shrimp." There is however a what if. "Will the surge in imports last? If it is able to resume production, say another 300,000 tonnes, China will require less imports. In contrast, the USA and Europe do not farm shrimp."

Local markets

McIntosh proposed two strategies to "beat" the export market price. "Local markets do not depend on export markets. In Thailand and Brazil, local prices are better than the export prices. During the last week in May 2018, export prices for Thai shrimp was USD 5.97/kg for size 30/kg, USD 3.60/kg for size 70/kg and USD 3.50/kg for size 80/kg. It was USD 6.60/kg; USD 4.00/kg and 3.85/kg respectively for local sales. Similarly, local prices were USD 7.50/kg (size 30/kg); USD 5.50/kg (size 70/kg) and USD 5.15/kg (size 80/kg) in China and USD 10.60/kg (size 30/kg) and USD 5.30 (size 80/kg) in Brazil.

"Furthermore, a strategy going forward is not just depending on selling raw commodity or products into local markets that everybody is selling into. We should look at branding and value added where we can make more money than just selling raw products as the final product," added McIntosh.

Efficiency in production

World shrimp production has increased but clearly, EMS/AHPND, *Enterocytozoon hepatopenaei* (EHP) and white spot syndrome virus (WSSV), are still prevalent everywhere. The increase is due to some farmers who have been more efficient in handling the disease and the opening up of more farms and ponds. "Higher global prices always stimulate new investment activities, new farms, farm improvements, and new ponds especially in India and Indonesia. But the question is efficiency."

McIntosh recounted an episode with CPF staff during the monodon days, when survival was low, and farmers were losing money. The first strategy proposed to improve the situation was to cut costs. "However, the experience showed that by improving the survival from 10% to 20% we double the revenue. If we go from 20% to 40% we double the revenue again." He reiterated that this is moving towards efficiency and performance to save the business (Table 1).

Table 1. Comparison on costs of production in the years pre- EMS, post EMS and managing EMS in 2017

Year	2010	2014	2017
% culture pond	77	77	38
DOC	87	59	81
Stock density /m^2	110	79	135
Failure rate %	0.00	58	0.00
Survival	91	30.5	89
ADG (g)	0.175	0.28	0.30
Mean body weight	15.5	16.5	25.0
Yield (kg/ha/day)	190	156	333
PL Efficiency tonnes/million	13.6	5	21
Total tonnes	940	108	728
Cost USD/kg (direct)	2.80	13.90	3.25
Farm profit (USD million)	1.6	-0.80	2.1

"In 2014, with low survival rates as well as body weights and PL efficiency, the direct cost was USD 13.90/kg. On learning to manage EMS/AHPND, in 2017, we basically achieved lower production, but shrimp size was larger at a lower production cost (USD 3.25/kg)."

His message was by changing and concentrating on efficiency, profits can be increased. However, cost reductions should be considered when there are no measurable benefits or risks.

Profitability in Thailand

There is curiosity on whether Thailand has recovered. McIntosh clearly stated, "Farmers have recovered and exceeded profitability compared to before EMS. They now have a more efficient industry.

There were 27 participants from India. In this picture, from left; N.S. Allada, Synergy Biotechnologies; Dr Manoj Sharma, Mayank Aquaculture Pvt Ltd; K.V. Raju, Avanti Feeds Ltd; Kumuda Chandra Patra, Biomin-India; Vilas Autade, DSM Nutritional Products India; Palanisamy Ravi, The Waterbase Limited and G. Ramesh, Wenger (right). On second right is Dr Fuci Guo, Malaysia.

Dr Pearse Lyons to posthumously receive Muhammad Ali Humanitarian Award for Lifetime Achievement

Founder of Alltech, Dr Pearse Lyons, will posthumously receive the prestigious Muhammad Ali Humanitarian Award for Lifetime Achievement during the sixth annual ceremony to be held in September in Louisville, Kentucky.

For Dr Lyons, making a positive difference in the world was an everyday reality of his personal and professional life. After moving with his young family, wife, Deirdre; daughter, Aoife; and son, Mark to the U.S. from Ireland, he founded Alltech in 1980 with the mission of improving the health and performance of animals, crops and people. The company's endeavours are guided by the "ACE principle" — a commitment to having a positive impact on the Animal, the Consumer and the Environment.

The Alltech ACE Foundation, a 501(c)(3) nonprofit organisation, was established by Dr and Mrs Lyons to put their philanthropic passion into action. One endeavour funded by the ACE Foundation is the Alltech Sustainable Haiti Project, which supports two Haitian primary schools through the sale of Alltech® Café Citadelle.

In Kentucky and Ireland, more than a dozen state-of-the-art science laboratories have been built at primary schools, inspiring students to have greater curiosity about the world around them. The Lyons' passion for education and the arts is reflected in the Alltech Vocal Scholarship Competition, which shines a spotlight on the hopes of young vocalists by awarding top performers with scholarship funds to join the University of Kentucky Opera Theatre.

As an entrepreneur who started Alltech in his home garage and built it into a multibillion-dollar company, Dr Lyons recognised drive and passion in others and encouraged them to dream big. The Alltech Innovation Competition emboldens young entrepreneurs to create businesses that help solve local issues. Winners are awarded USD10,000, the same amount with which Dr Lyons founded Alltech in his garage.

Whether through small acts of kindness or far-reaching scientific achievement, Dr Lyons was committed to empowering others, inspiring lifelong learning and making a difference in the world, a mission he shared with the Muhammad Ali Foundation, of which Dr Lyons was a long-time supporter.

Dr Lyons passed away on March 8, 2018. Mrs Lyons, director of corporate image and design at Alltech, and their son, Dr. Mark Lyons, president and CEO of Alltech, will accept the award on his behalf during the ceremony. www.alltech.com/news.

continued from p5.

This is the correct way to expand instead of building more ponds and more farms. However, we need to also look at reducing unnecessary cost. For instance, industry uses a lot of costly disinfectants, but the benefits are not measurable. Chlorine is costly, but it has never saved any pond from EMS."

Along the supply chain, the industry in Thailand is making evolutionary changes; striving again for efficiency under the new conditions. "Hatcheries have responded with more efficiency, and then the farms change for more efficient models, under the current characteristics and even processing technology is changing."

Intensification model

"The industry will evolve towards intensification, producing more from less. Less land more shrimp, less water more shrimp, less feed more shrimp, less energy more shrimp; that will be the evolution. It will happen faster in some places than others."

As the industry moves towards an intensive sustainable model, McIntosh noted, "Many people in the industry have lost contact with the economics: profit, sales price and cost. In the 1990s, attention was on market price and not on controlling cost. Today, we should aim to be as efficient as we can, have control over production costs and the market will take care of itself." However, he said that farm gate price is created within a country relative to its economy, and world price is created by the world's supply and demand situations. In some countries, there are two supply chains. For example, in Malaysia, farm gate prices are higher than world prices because of lower domestic supply. Indian producers have the lowest farm gate prices as compared to even Vietnam and Thailand.

Last words

Large versus small sizes

"When we talk to retailers like Walmart, the usual belief is that it is cheaper to grow small shrimp. Thus, I did an analysis of the cost per day to grow shrimp of different sizes. The result was that it is more expensive to grow the smaller size shrimp and we are paid less. However, I can get better profit margins by growing big 30 to 40g shrimp as compared to 16g shrimp," said McIntosh.

"With the genetics we have now, we can grow shrimp to bigger sizes and many farms are growing 30, 40, 50 and even 60g shrimp. On costs, more farms can now produce at under USD 3.50/kg, added McIntosh.

Successful models

There are successful models in every country. The evolution is small ponds producing more shrimp at much lower costs, more water exchange in a recycle system, high aeration, reduction of pond depth, stabilisation of pond temperature, use of fish in settling ponds, use of ground water, natural filtration, liners, nurseries, and formulation of diets for fast growth.

Genetics

This will continue to play a major role in creating more efficiency. CP's fast growth shrimp reached 20 in 60 days while CP's AHPND tolerant strain will take 85 days. These are results from trials in raceways with stocking density at 150 PL/m^2. "In time, the aim is fast growing shrimp that can tolerate diseases."

Monodon shrimp

There is a lot in interest with good monodon strains. Prices for the monodon shrimp are sometimes better and more stable. "However, stocking density has a significant effect on growth; yield can be 10 tonnes/ha at a density of 30 PL/m^2 but only 11 tonnes/ha at a density of 60 PL/m^2."

Emerging disease

The new risk is shrimp haemocyte iridescent virus (SHIV), first reported from China and causing heavy mortality, early in the cycle. Of serious concern is PCR positives in broodstock and in polychaetes.

(More on the plenary at TARS 2018 on pages 18-30)

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Young shrimp farmers on new business and farming models, challenges and successes

By Yvonne Nathan

Second generation farmers from the right, Rizky Darmawan, Somthida Pakdeepak and Christopher Adrian Domingo Anglo

Rising second generation shrimp farmers from the Philippines, Indonesia and Thailand provide insight on approaches for long-term sustainable shrimp farming while handling difficulties in balancing economic viability.

TARS 2018 centred on the Need for Change in shrimp aquaculture by looking at new approaches toward farming and facets within the supply chain that can bring about industry transformation to overcome sluggish shrimp production resulting from disease outbreaks and low survival rates.

Three young farmers were invited for this year's ***Hard Talk with Young Shrimp Farmers*** for their diverse perspectives on managing farms. The farmers came from varied circumstances and educational backgrounds to provide their insights on keeping farms productive. The young farmers needed to deal with generational differences in opinion when implementing innovative protocols in their family-run farms.

Young farmers and their farms

In many regards, Generation-Y has been vilified as erratic, and at times inconsistent. These young, industrious shrimp farmers are in fact a dedicated lot, keen to learn, understand and implement new techniques in their businesses. Farm Manager of Aderma Farm in Cadiz City, Philippines, 33-year-old **Christopher Adrian Domingo Anglo** has been running its operations alongside his father and brother since 2015. The farm which started with monodon farming in the 1990s by his grandfather, shifted to vannamei shrimp production in 2015. Christopher Adrian has a degree in an unrelated field, Bachelor of Science in Business Management, but has managed the farm well enough to be awarded Charoen Pokphand (CP)'s 'Most Improved Farm in the New Customer Category' in 2015. His farm features best culture practices and uses CP's 3Cs culture technology (clean post larvae, clean pond and clean water).

Aderma Farm has 6 reservoir ponds and 24 culture ponds, each of 5,000-6,000m^2. Ponds are stocked with 9mm post larvae at 100-120 post larvae (PL)/m^2. With partial harvests, shrimp survival rates range from 80%-100% with harvest sizes of 13-40g. The farm produced 400 tonnes in 2017. Generally, feed conversion ratio (FCR) range from 1.20 to 1.45.

As PT Delta Marine Indonesia's Director, 27-year-old **Rizky Darmawan** oversees the family farm in Sumbawa Island, West Nusa Tenggara, since graduating in 2014 with a Bachelor of Science in Aquatic and Fisheries Science from the University of Washington, USA. Keeping abreast of changes in the shrimp farming community, Rizky is an active member with Shrimp Club Indonesia, Head of the club's Sumbawa Chapter, and is the founder of the Young Shrimp Farmers Association (Petambak Muda Indonesia).

This 500 tonne/year farm in Sumbawa has 30 grow-out ponds, with sizes ranging from 3,300 - 5,000m^2, with 7 treatment ponds, and has plans for future expansion. The stocking density is 120-180 PL/m^2 with post larvae sizes ranging from 11 to 13mm. FCR fluctuates, depending on shrimp conditions. Rizky cited the special features at the farm: a >600 m inlet pipe into the ocean, waste settling ponds with mangroves at its end, laboratories for water quality and culture tanks for shrimp waste conversion.

Similarly, 23-year-old **Somthida Pakdeepak** began working on the family farm right out of Kasetsart University's Faculty of Fisheries Aquaculture in Thailand. The 35ha Ao Kho Farm in Chumphon Province, Thailand was founded in 1987 and originally farmed the black tiger shrimp. It shifted to farming vannamei shrimp in 2001. Somthida was appointed Assistant Farm Supervisor in 2017. Ao Kho Farm comprises eight culture ponds, two reservoir ponds, as well as treatment and settling ponds. Stocking density of PL12 ranges between 170 to 190 PL/m^2. Generally, survival rates are good, around 80% to 95%. A total of 250 tonnes were produced in 2017.

Traditional *vs* modern strategies

These young entrepreneurs recounted their experiences when transforming the farm to ensure long term sustainability and economic viability. It is apparent that their main hurdle was changing the mindset of the older generation and instilling change.

Working to grow the farm with his family, Christopher Adrian said shrimp farming began by chance. "My father and I were cropping tilapia and sugarcane when colleagues from the prawn cooperative advised him to try farming the vannamei shrimp," he said. However, there was resistance. "My father was very reluctant at that time because during the 1990s the black tiger shrimp industry was at its best, and then collapsed suddenly in the Philippines," added Christopher Adrian and it took some

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persuasion before they gave it a shot. “The difference between my father’s and my time was not only the shrimp (black tiger versus vannamei) but also that with the black tiger, it was purely an export market. Today, we have both local and export markets with the vannamei shrimp. I convinced the first generation, especially right now that R&D is so vast, that we have to follow what is new to succeed because if we go back to the old ways, we are probably not going to make it again.”

Sustainability

“I think we (younger generations) are thinking more about sustainability.”
- Rizky Darmawan

Rizky on the other hand finds a lack of interest on ecological farming practices among many of the earlier generations. “I think we (younger generations) are thinking more on sustainability. For example, in my new facility I am trying to build a settling pond to control the quality of discharge water. But my parents do not see a need for this and preferred another culture pond. When they first built this farm, they had massive successes for 2 years and then it went downhill for a couple of years. I started changing how they worked and right now the production is stabilising. We are profitable, and I think that's the most important thing about this business.

“So, one of the things I applied when I inherited the business was risk management,” said Rizky on learning about the science behind shrimp farming and harvesting early where necessary to mitigate losses. He also elaborated on the scepticism of family and friends as he attempted to apply what was learnt at school and the mistakes he made at the beginning. “I started as a farm technician handling eight ponds. I tried to apply what I learnt in school and failed. I guess how you change the senior’s mind is to slowly show that you can learn and little by little they will start to trust you.”

Changing technology

Somthida’s plans to involve her parents concentrated on three areas. “The first point was technical enhancement. Before I graduated I shared ideas with my father on reducing the number of culture ponds and increasing focus in areas like water treatment and management. We could still maintain the production volume when compared to what we did previously with seven culture

Ponds at PT Delta Marine Indonesia’s farm in Sumbawa.

ponds,” said Somthida. “Starting as farm technician responsible for water quality, feed and shrimp health management, I was learning real farming practices by doing, then implementing what I learnt from my university. I tried using a venturi aerator, an idea from other farms with excellent results.”

She then leveraged on the advantages of studying in a local university by recruiting three former classmates as technicians managing two to three ponds each, to achieve consistency and efficiency. “When we decided to expand the culture areas with this model, we needed more technicians to operate the farm. My father agreed with this idea, even though it will be costly. Today, we have three technicians (excluding me) to manage eight ponds.

“My second venture was to find an alternative market. We previously sold our shrimp to local processing plants but during the crisis in the last 4 months, my mother and I searched for local buyers in Chumphon Province, offering fresher and cheaper shrimp as compared with those from middlemen,” said Somthida. “My father knew that this will incur extra work but cutting out middlemen from the equation, I gained USD 0.30/kg. With demand, we could partially remove biomass from shrimp ponds daily to allow the remaining shrimp to grow faster. We harvest 10g to 44g shrimp, with seven partial harvests over the crop cycle, and with good feed management, we get FCRs of 1.2-1.4. We increase production capacity and earn back part of our investment,” added Somthida.

“Thirdly was digitalising farm data. We began recording data using a Thai Government social media application Thailand 4.0 to get quick reports on emergency incidents and feeding status

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> "At the end of the day, it is still people management – no matter what protocols we use."
> - Christopher Adrian Domingo Anglo

Disease mitigation

While the first generation started with disease-free farming more than 30 years ago, these young shrimp farmers were dropped into the deep end, into shrimp farming beset with diseases. These three panellists then discussed their experience with diseases most likely to hit their respective countries, and their mitigation efforts.

Biosecurity

"Diseases that have occurred in my country are the infamous ones – EHP (*Enterocytozoon hepatopenaei*), early mortality syndrome (EMS) and the most prevalent, the white spot syndrome virus (WSSV). What we do to mitigate them is biosecurity," said Christopher Adrian. He ensures that fry purchased from CP's hatchery have passed all tests before accepting them into his farm. "At the end of the day, it is still people management –no matter what protocols we use; if you do not manage your people to follow the rules and regulations, you will be in big trouble. Our worst survival rate was 65% and that was due to staff issues."

"When I started back in June 2015, we got hit with WSSV once in December of 2015. We do not wish this to happen again because my father is strict when it comes to biosecurity. The main carriers of diseases can be people entering the farm, including harvesters and buyers. "Buyers stay at the perimeter of the farms and we use 10-12 hauliers to bring the shrimp to them."

WFD

Conversely, the worst disease to hit Indonesia is the white faeces disease (WFD). "I think because in the case of WFD, there is no immediate mass mortality. Instead there is chronic mortality, and shrimp are eating but not growing, costing farmers more than WSSV, because they do not know when to pull the plug. So, for me it is risk management. I wait for 1 week or 2 weeks to sample and keep monitoring problematic ponds, so I can make a decision on whether to harvest or not. Our survival rate drops

Feeding time at the Ao Kho Farm, Thailand.

> "What is the scariest disease in my life as a shrimp farmer? It is all diseases without a doubt."
> - Somthida Pakdeepak

to around 55% with diseases," said Rizky, when explaining how he learns through trial and error to manage WFD. "We check the daily feed intake. If the shrimp do not even feed that means that it is bad. Then, when the ADG (average daily growth) is 0.15g or less, we harvest. We had two ponds with WFD at 40 days of culture, but shrimp have started to eat better to reach an ADG of 0.2g to 0.3g. That is a recovery." Rizky's message was to observe shrimp behaviour and not take a rash decision to harvest.

Prevention

"What is the scariest disease in my life as a shrimp farmer? It is all diseases without a doubt," said Somthida. "I find that all diseases are big threats to me because once infected, it is sure to cause damage – increased FCR, lower survival rates, higher production cost or worse we could lose the entire crop," she said. Her approach is through prevention. "In my farm we have five criteria. Firstly healthy, disease-free larvae; secondly clean water, thirdly clean ponds, free from organic matter and contamination, fourthly management through scientific investigations, and lastly good team work. This is the most important approach in my farm. Each one of us is the keeper of success, and all of us have to commit and perform our jobs with a high degree of responsibility."

Shrimp harvest from Aderma Farm, Philippines.

Wish list

As research and development is a key component in the sustainability of shrimp farming, the panellists were asked what areas of contribution they would gain most from – genetics, health management, or feed and processing.

"The thing I would like to see most is tips to farmers on how to improve the culture system. And also, hopefully in the future, improvement on the seed and fry quality for faster growth and immunity to diseases," said Christopher Adrian on his main priorities.

Rizky, however, focussed on robust genetics as diseases continue to evolve, as well as better waste treatment technology.

Soraphat Panakorn, Novozymes Biologicals, (left) with Kanokngoen Pakdeepak, Somthida's mother who is also very active in farm operations.

"I think if you can farm in the middle of the city or beside it, you're closer to the market and can sell fresher produce at better prices," he said adding that improving technology to keep shrimp fresh after harvest would also help.

Measuring all areas as equally important, Somthida believed a combined effort is the ultimate answer. "But if I must choose only one, I find shrimp genetics to be the most important factor because I cannot do it myself and yet it will give the most impact to my farm. It is not easy to operate a shrimp genetics development program. So good quality shrimp post larvae is a priority for my farm."

Despite rampant diseases and production challenges, the three young farmers nevertheless retain a hopeful outlook on the industry. To them, the continuous increasing demands on shrimp production and the time spent in research and development promote a bright future ahead for the industry.

Recharging the shrimp farming industry in Indonesia

By Iffa Suraiya and Safiyra Dina

In Indonesia young shrimp farmers join forces to carry on the sustainability of its shrimp farming industry.

There is general agreement that the shrimp farming industry in Indonesia is a very profitable business, which will result in an increase in the number of young shrimp farmers in Indonesia. The average age of these young farmers is under 40 years old and they have seriously ventured into the industry some 3-5 years ago. A couple of these young farmers met in a seminar in Surabaya in October 2015 and decided to form the organisation PMI (Petambak Muda Indonesia) or Young Shrimp Farmers Indonesia.

Hardi Pitoyo, Vice Chairman of Shrimp Club Indonesia (SCI) described this interest in shrimp farming by the young farmers as very encouraging. "Shrimp farming is difficult and the risks are high. The appearance of these young farmers indicates that the business is thriving. This means that in the long-term there is a future in our shrimp farming business. We look forward to this renewed interest in commercial shrimp farming; some of us, first generation shrimp farmers have been farming for more than 30 years and will retire soon," said Pitoyo.

At the Yanuar Farm, paddle wheel aeration in one direction.

Pitoyo added that these young Indonesian farmers have quite interesting background. "Nearly 70-75% of them have inherited the shrimp farming business from their parents. The rest (25-30%) are newcomers interested in this business. Unlike many of the first-generation shrimp farmers, most of these young farmers

are well educated. More than 75% are overseas graduates. They also have good networking skills and of course, they are able to speak English well which enables them to keep abreast with the latest information on farming technology from international sources".

A recharge

This is how Pitoyo sees this development. “The emergence of these young farmers can be a recharge for shrimp farming in Indonesia. Why not? In terms of age, they average below 35 years. They even suggested that PMI members should not exceed 40 years old. They are also members of Shrimp Club Indonesia (SCI) but the activities of PMI and SCI are quite different Because of their youthful nature, they combine leisure, fun and learning while visiting and learning from successful farms."

Jokingly, Pitoyo added, "They also like to party! But they still stay focussed on their business. Although they are newcomers, they have the ability to analyse pond conditions and are quick in learning and adopting new skills."

Rizky Darmawan, founder member of PMI said, "The group was created to share insights and information on aquaculture, in a fun way. We as the young generation want to focus more on matters that are more recent and progressive, such as problems that are often ignored by our seniors, which include those of environmental degradation, sustainability, and social responsibility."

Rizky entered the shrimp farming business 4 years ago. His farm with 30 ponds is in Sumbawa Island. He took over management of this farm from his parents. He is continuing his parents' business because he believes in the potential opportunities in shrimp farming. "I believe that Indonesia with its extensive coastal region and pristine water source has great potential in developing a flourishing aquaculture business."

Two other young shrimp farmers, Zeno Lim and Gemilang Lim expressed the importance of organisations such as SCI and PMI. "We are very grateful to have the opportunity to join PMI, where we can meet and learn from the professionals and industry experts. These learning experiences help us to improve our practices in shrimp farming. We feel very much welcomed in PMI even though we are newcomers in the industry. All the members are very supportive. Maybe because we have the same hopes and dreams. Hopefully we can make great strides in shrimp farming in the future."

Diky Wicaksono and Dony, young shrimp farmers from Garut in West Java

Haris Muhtadi (standing) with Steven Kunaidi and wife (left) and Reynard Suharja and partner.

Yanuar (second left) with his technicians and laboratory staff

The Lims are in the shrimp farming business for the same reasons. "We choose to be in this industry because we are confident in its future prospects." Three years ago, these two brothers started their business in a farm located near Pontianak.

Innovative and forward looking

Haris Muhtadi, General Manager of CJ Feed Indonesia said "The emergence of these young farmers is very interesting. They are more innovative and open to new ideas. They often try to have discussions on customised feed to overcome feeding problems. Currently, the main problems in shrimp farming in Indonesia are viral diseases and WFD."

As the Chairman of the Aquaculture Division of the GPMT (Gabungan Perusahaan Makanan Ternak Indonesia or Association of Animal Feed Producers) Haris, has close interactions with farmers. He said, "Some young farmers, as the successor of their parents' business, have expanded into new areas which have good water quality and better environment, such as Lombok, Sumbawa and Sulawesi. The old areas such as Java, are now overcrowded and are challenging for successful shrimp farming. As these young farmers are encouraged to undertake expansion, the challenge now is for the feed industry to have the same courage to make a breakthrough and expand as well. "

Sharing and learning

On the sidelines of the PMI discussion held in Banyuwangi in July 2018, Diky Wicaksono, a young farmer from Garut in West Java, expressed his opinion on PMI activities, "Discussion and comparative studies must not be confined only to farms in Java but these studies must be carried out also in farms outside Java. Problems in shrimp farming will continue to exist."

"We are young and lack experience. But we are ready to learn. I am very serious that I want to develop this business. It can only be done by collaborating and networking with other young Indonesian farmers. To develop this business, we need to be together," said Diky.

Yanuar Farm

During this PMI meeting, the young farmers also visited the Yanuar Farm in Banyuwangi, West Java. Yanuar Toto Rahardjo who is Secretary of SCI Banyuwangi is a 50-year-old farmer who in the last 5 years has been using a new and proven farming technology for disease-free farming. In an article in Trobos Aqua (October 2016), Yanuar said that Banyuwangi is crowded with intensive farms stocking at 150-250 post larvae (PL)/m^2. Here farmers have small farms with 1-2 ponds (3,000 m^2); they previously farmed the black tiger shrimp and now farm the vannamei shrimp with stocking density of 50 PL/m^2. Farming has been difficult with deteriorating water quality.

Yanuar's technology requires moderate stocking density, just around 80-90 PL/m^2. Feeding is by autofeeders and the feeding regime is developed for fast growth. Yanuar has targeted 75 days and to a maximum of 80 days, to harvest size 17-20g shrimp. On whether he has any specific requirements on the feed used in this technology, Yanuar said, "All brands of feed can be used, although we prefer low-protein feed with balanced amino acids. If the pellet is good, they will not pollute the water. Also, the attractability of the feed is very important".

Related article: Young shrimp farmers on new business and farming models, challenges and successes, p8-12

Iffa Suraiya

Safiyra Dina

Iffa Suraiya and **Safiyra Dina** are contributing writers based in Surabaya, Indonesia

PMI members and partners, together with some first generation farmers from SCI. Pitoyo (second row, fourth left) said, "Nearly 70-75% of them have inherited the shrimp farming business from their parents."

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TARS 2018

Shrimp Aquaculture: Need for Change

Part 1: Industry challenges, managing disease to the revival of the black tiger shrimp

The plenary at TARS 2018 comprised five sessions: State of Industry and Challenges; Productivity in the Supply Chain; Nutritional and Health Interventions; Revival of the Black Tiger Shrimp and Investing for the Future. During the interactive roundtable session, participants discussed where do they see the need for change in these key areas; 1) Genetics, Hatchery and Nursery, 2) Culture Technology and Innovations and 3) Feeds, Health and Environment. (Note: The State of Industry (SOI) presentation by Robins McIntosh is featured on page 4-6 and the Hardtalk with young shrimp farmers on pages on pages 8-11).

TARS 2018 was organised by Aqua Culture Asia Pacific and Corporate Media Services, Singapore and was supported by the Department of Fisheries, Thailand. Participation came from 29 countries; the largest groups came from Thailand, India and Ecuador. Industry sponsors were Inve Aquaculture, Biomin, Nutriad, Diamond V, BASF, BioMar, DSM, Diana Aqua and Jefo.

Eyes on Indian shrimp

India, one of the largest producers of farmed shrimp has been shaking the shrimp markets since early 2018 and there has been some curiosity on what was happening in India. As a farmer and active in industry forums, **S. Santhana Krishnan**, CEO, Marine Technologies and Founder President, Society of Aquaculture Professionals (SAP) was the right person to give an insight into the pressing issues and challenges in India in his presentation on, "Shrimp Farming in India: Fast & Furious – Controls and Caution to Growth."

In 2016/2017, India produced 566,000 tonnes of shrimp and the projection for 2017/2018 was 697,000 tonnes. For the financial year 2017/2018 (April 1st 2017 to March 31st, 2018), India's shrimp exports were 456,401 tonnes valued at USD 3.7 billion. In 2018/2019, an increase of 13.5% in production is expected.

"Since 2014, shrimp farming expanded exponentially in India. We had large increases in farming areas and large investments. There are many new players: feed millers, farmers, hatcheries, input suppliers etc. India became the focus of big buyers in large emerging markets. This growth propelled more investments and new entrants into the industry in 2017. Some states such as Andhra Pradesh, Gujarat, Orissa and West Bengal have very promising areas for growth," said Santhana.

India's farmers have the advantage with investments in shrimp processing. "Both on the west and east of India, there are many new shrimp processing plants. These help us cope with the huge production of vannamei shrimp. For the year 2018/2019, we predicted that we will export around USD 4.20 billion worth of shrimp. There will be a higher value realisation in Indian rupee since the currency has depreciated by approximately 8% in the last 6 months."

> **"Every Indian shrimp farmer wants to produce large shrimp but due to WSSV, most only managed to harvest smaller shrimp in 2017."**
> **- S. Santhana Krishnan**

Markets and perceptions

"It is the wish list of our farmers to sell large size shrimp for large profits, which is often difficult," said Santhana, "Usually, in March to May, most of the harvested shrimp are less than 14g. From June to December, most of the shrimp are in the 20-25g range and then from October to December, sizes are mixed: small, medium and large."

Santhana countered the latest perception among buyers that India produces small size shrimp. "No, we do not deliberately produce small sizes. Because of the rampant disease outbreaks, we get mixed sizes which coincide with the seasons of the year. Every Indian shrimp farmer wants to produce large shrimp but due to the white spot syndrome virus (WSSV), most only managed to harvest smaller shrimp in 2017."

Santhana added, "Everybody thinks India still produces only headless shrimp. No, we have various value-added shrimp. There have been huge investments made on processing plants which are of international standards. In fact, China has started to import value added shrimp such as PD, Butterfly and EZ Peel from India, demonstrating that India has the capacity as well as technological investments and innovations to bring very high quality shrimp to the markets."

In terms of markets, China and Southeast Asia have emerged as very large importers of Indian shrimp since 2014. Almost 34.8% of exports are to China, followed by Japan, and the Middle East. "But, the US remains the biggest single large importer of Indian shrimp. Our exports to the European Union have dropped to 15.8% from almost 32% a few years ago, because of media reports on alerts on antibiotic residues. US buyers are all looking for long term contracts with a minimum of 6 months, not spot buying."

Cascading effect of low prices

Santhana described the sequence of events leading to an oversupply of small shrimp and prices easing. "All was well until early in 2018 when we had a massive disease outbreak, predominantly WSSV in March and April. Many farmers had stocked ponds in December 2017 - January 2018. Farmers then harvested their small shrimp for processing plants leading to a supply overload and prices dropping."

There was a cascading effect of lower prices. "In Table 1, there was a drop of almost USD 1.5/kg in May, enough to drive farmers out of business. They then preferred to stop stocking, fearing that if they stocked and harvest in May or June, prices will drop further. With no demand, hatcheries drained away an estimated 1.2 to 2 billion post larvae in March to April 2018. We estimated this industry expected to produce 500,000 tonnes of shrimp, but I think, ultimately, in the first half we produced 380,000-400,000 tonnes only. A raw material shortage is reflected by price increases. Starting in August and September, there will be an acute short supply in India."

Table 1. Vannamei shrimp farm gate price in India in USD (mid-February to end May 2018)

Months in 2018	30c	40c	50c	60c	70c	80c	90c
Mid-February USD 1 = INR 65.80	7.14	5.77	5.31	4.80	4.77	4.40	4.10
May USD1 = INR 67.80	5.16	4.71	4.12	3.83	3.53	3.24	2.94
*30c=30 count or size 30/kg. In India, count is usually used.							

Ravikumar Yellanki, Vaisakhi Bio-Resources (P) Ltd, India

P Maheswari, The Waterbase Limited, India

Bent Pedersen, DSM, Denmark

Sander Visch, Shrimptails/Seafood Trade Intelligence Portal, Netherlands

Jerome Le Friec General Manager, Diana Aqua (centre), and his team. From the left, Parinda Kamchum and Fabio Soller (Thailand), Chuyen Ngo Tan Huynh (Vietnam) and Kurniawan Ristono (Indonesia)

Allen Ming-Hsun Wu, Nutriad (left) and Grace Chu-Fang Lo, National Cheng Kung University, Taiwan

Santhana added, "Even the farmers with a normal crop went into panic mode and began to harvest quickly. If they had continued the crop, they would have changed the situation." Other countries, Vietnam, Thailand and Indonesia observed the situation in India. "Until May, the price of Indian shrimp in the international market was almost stable, while other countries experienced falling prices."

Industry saviours

Within India, there were initiatives to motivate farmers to stock ponds and reverse the low supply situation. Many feed millers started extending their credit support to the farmers and to feed dealers. But this did not work. "We talked to farmers, we told them, do not predict prices. We asked them to stock at the right season and not to delay the season."

Andhra Pradesh state which produces 65% of Indian shrimp intervened with a minimum support price. Processors agreed to increase prices slightly, but to little avail. Feed millers supported with a temporary reduction in feed prices. Processors went on for spot and advance payments to support farmers. There were moves to reduce electricity tariffs. Despite all these efforts, Santhan added, farmers were not convinced.

The good news on prices

The raw material shortage continued until the end of July. In August, farmers started stocking the ponds. "This happened because in the second week of August, the ex-farm price of Indian shrimp rose by USD 1.50/kg. Every exporter with a forward contract knew that they had to pay the higher price for whatever raw materials available to meet their export contracts, before the end of September. Exporters took the brunt of this price increase," said Santhana.

Profitability and stocking

The decision of the farmer on whether to restock his ponds will very likely be influenced by the potential massive mortality due to WSSV, and by other reasons such as slow growth, *Enterocytozoon hepatopenaei* (EHP), high feed conversion ratio (FCR), low average body weight (ABW) and increased costs of production. Santhana noted, "With white faeces disease (WFD), farmers still have hopes as shrimp are not dying. Usually no farmer will harvest the pond, as they will be hoping for a miracle to push up growth. As farmers usually target 30g shrimp, it may take him almost 5 months with the FCR of 2 to almost 2.5!"

What next: caution and concern

"As much as we have huge areas and huge production, diseases are also very widespread and pose major concerns. What is next? It is without doubt that, we are looking at very high expansion and higher production. There are many new entrants with no shrimp farming experience. Unfortunately, these are investors with no regard for the environment, disease control etc. Industry stakeholders such as SAP, Vaisakhi Group, feed millers and the Seafood Exporters Association of India (SEAI) want to educate such newcomers on developing a sustainable industry," said Santhana.

On his wish list are the following:
"We would like farmers to better understand their farming business and that media is more cautious when reporting on antibiotics in Indian shrimp. Production losses, due to diseases are part of the business and we need to live with them; we need also to learn how to cope better with diseases."

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Science in shrimp farming in Vietnam

"In Vietnam, managing diseases and the push towards efficient shrimp farming continue to be very challenging," said **Dr Tran Huu Loc**, Founder-Director, ShrimpVet Laboratory, Vietnam, in his presentation titled "Science in Shrimp Farming and Recent Innovations in Hatchery and Production Systems in Vietnam". Loc was part of the team of Dr Donald Lightner at the Aquatic Pathology Laboratory, University of Arizona, which was instrumental in identifying the *Vibrio parahaemolyticus* strain causing AHPND in 2013. Loc is an example of the millennial returning (in 2014) to contribute to Vietnam's (and Asia) shrimp farming industry.

"Unfortunately, with the current situation, the use of antibiotics is rising, judging from the rejected containers of shrimp with antibiotic residues. We need to act; we need to have replacements for antibiotics and a safer farming methodology."

Caution on infection routes

"The major challenge in disease in Vietnam is still EMS/AHPND, WSSV, EHP and white faeces disease (WFD) which have become more severe. As for SHIV, we are not sure whether this is already in Vietnam, but we are setting up the diagnostics with PCR," said Loc.

Analysis carried out at ShrimpVet laboratory by Loc showed the clear route of infection (Figure 1). "We have 3 to 5% of live feed (polychaetes) tested positive to AHPND. Recently in Phan Rang where most of the hatcheries are located, this rose to more than 90%, when there was a change in the environment in August. "In the case of EHP, Loc noted that an estimated 5% of the polychaetes, oysters and squids were positive to EHP. About 8% of the post larvae samples were positive to EMS. Random sampling showed that about 20% of ponds tested, gave positive results to EHP and close to 15% of shrimp samples were positive to EMS.

"There is evidence that most infections start with broodstock feed. Industry desperately needs replacements for live feed, or methodologies to make them safer such as gamma radiation or frozen products. Transmission of EHP spores is via oral route or lateral infection. Thus, it will be very difficult now or in the near future in terms of EMS and EHP control in hatcheries."

Efficiency parameters

"We have to accept that specific pathogen free (SPF) stocks are very clean and we need to invest more on tracking EHP and EMS. In the case of post larvae, we need to move towards antibiotic free hatchery protocols. With these in place, we then need to get good average daily growth (ADG) during the grow-out."

Loc said that based on calculations, farmers cannot make enough profit if they produce 20g shrimp at ADG of less than 0.25g. An ADG of 0.3g is the breakeven point, which is possible with the current genetics developed for fast growth. However, efficiency also starts at the hatchery. The recommendation is antibiotics-free hatchery protocols to produce clean and good post larvae with coefficient of variation of less than 12%.

"PCR diagnostics are so important to check on the critical points: broodstock feeds and post larvae. Diagnostics also have their limitations, especially with AHPND diagnostics. If checking

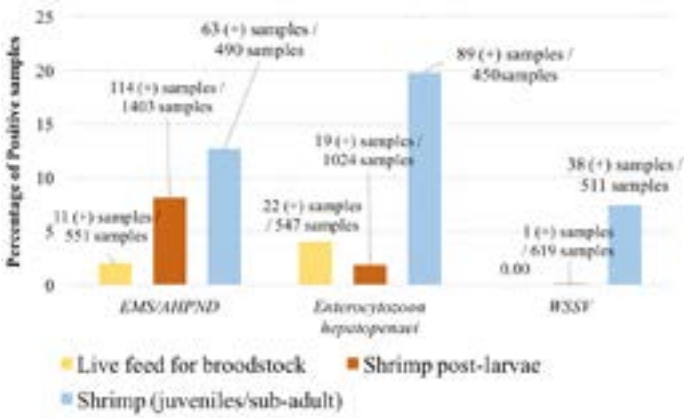

Figure 1. PCR results Q1-2/2018 at ShrimpVet Lab (courtesy of ShrimpVet Lab)

for CFU/mL of less than 10^4, a conventional PCR, or nested PCR will give negative readings. You will need to enrich the sample prior to running diagnostics."

It is impossible to keep the hatchery sterile and Loc suggested using probiotics to outcompete *Vibrio*. "We have a small hatchery and even with the best water treatment system or the best biosecurity protocol, we could still have pathogens present."

The good, the bad and ugly bacteria

Biosecurity and micro biota balancing are two key points to reduce problems with AHPND. "We start with a completely sterile environment after numerous water treatments and disinfections. On day 1, the *Vibrio* count is zero but will surge to 10^4 CFU/mL by zoea 2-3 stage. Later at PL1-5 stages, *Vibrio* will proliferate with the addition of feeds," said Loc.

"With the addition of some slow growing bacteria or probiotics, at the nauplii 5 stage, we can reduce *Vibrio* at the mysis stage, and then at the PL stage. *Vibrio* will thrive again with the feeding of *Artemia* and artificial diets. In our environment we always have three groups of bacteria, the bad, the good and the ugly. Bad are obligate pathogens, such as the luminous and *Vibrio*; they are initially present at low density but will increase rapidly. The good, the probiotics, are the ones we introduce into the system, and the ugly are the commensal bacteria. In our bioassays in the laboratory, there is competition between probiotics and obligate pathogens. The pathogen is efficient and always wins. The message is bioremediation via probiotics is never a remedy for bacterial disease; it is a tool."

"We need to make shrimp farming more science based and predictable. In Asia, we also need to make it simple for farmers to understand."
- Loc Tran

Loc suggested, "Before stocking, a jump start is a daily 10^{4-5} CFU/mL inoculation. Refrain from providing the bad and the ugly bacteria with nutrients and the rule of thumb is to have the good bacteria at a ratio of 100:1 to that of the ugly and/or bad bacteria."

Managing EMS and EHP at the farm level is similar to that in the hatchery. "The risk factors are overfeeding and microbiota imbalance. These are indicative of either EMS or white. Waste management and siphoning are ways to remove potential sources of toxins and nutrients for bad bacteria. Polyculture also helps in micro biota balancing."

Functional diets and EMS

Loc also discussed some results with functional diets which have been positive in reducing the impact of AHPND and WFD. "In the trials in lined ponds, using functional diets and waste water tested positive for AHPND and EHP, gradually shrimp in all the ponds were positive for EMS, EHP and WFD (which most farmers live with), but the survival rate was good at 75% for the control ponds. With functional diets, survival reached 78-96%, the ADG was better and final weight higher. The functional feed with immunostimulants help to reduce infections. I would say that in the past, survival rate of 90% is very normal, but now it's about 65%-70%."

Loc concluded, "Antibiotic free hatchery protocols are possible; we just need to educate the community about this. We need to make shrimp farming more science based and predictable. In Asia, we also need to make it simple for farmers to comprehend. Farms should not top dress but work with feed millers to add the additives into feed formulations."

Challenges and opportunities in Ecuador

The industry in Ecuador is challenging global trends and increasing production year on year. Ecuador contributes 50% to shrimp production in the Americas. **John Tinsley**, Technical Director, BioMar Americas looked at "The Road Towards Sustainable Shrimp Industry: Challenges and Opportunities in Latin America from a Feed Producer's Perspective." Securing the economic sustainability of this industry covering 3,070 farms spread over 230,000 ha is a social responsibility as it involves, direct and indirectly, around 7% of the working population. Two-thirds of shrimp farmers are small (0-50 ha) and medium (50-250 ha) producers.

"Driven by growth in export markets and a favourable biological situation, Ecuador has shown a consistent track record for growth, from 220,000 tonnes in 2010 to 425,000 tonnes in 2017. For the rest in Latin America, environmental conditions, larvae quality, and the political situation have affected production, however there are signs of stability," said Tinsley.

Ecuador vs Asia

Tinsley described the typical well managed farm in Ecuador. Shrimp production starts with nursery stocking of 4 post larvae (PL)/L of sizes 3mg/PL. The nursery rearing is 15-18 days to produce 0.20-0.50g/juvenile. Juveniles are transferred to grow-out ponds at 120,000 juveniles/ha and it takes 100 days to reach 20g under well managed conditions. The average daily growth (ADG) is 0.19g. Survival is 80-85% and FCR 1.5 – 1.8. Profits are USD15/ha-day. Some 3.5 cycles/year is a reality.

"While Asian shrimp producers focus on the exclusion of pathogens and their hosts by using SPF broodstocks, water disinfection and heavy aeration to maintain stable conditions, we co-exist with the pathogens and the microorganisms in our systems. We use tolerant and resistant stocks, we use functional feeds to reinforce the immune system and reduce shrimp stress by stocking at low densities. Our yields are around 1 tonne/ha as compared to 10 tonnes/ha in Asia."

The road to a sustainable shrimp industry depends on many factors. However sourcing of sustainable raw materials, improving productivity and health and welfare are three critical issues that need to be addressed.

Brendan Yeo Wee Leng, Blue Pearl Aquatic Sdn Bhd (left) and Weerawut Hiranmateekul, Asia Aquaculture (M) Sdn Bhd, Malaysia

Raw materials and sourcing

Feed plays a leading role in the global industry; as aquaculture grows the demand on feed increases. Raw materials and their sourcing are the foundation. "Today, the trend in the Americas is certification and traceability for the established raw materials. We still rely on traditional raw materials that fluctuate with currency, supply and various other market factors. There are opportunities to include alternative ingredients in feed; great steps have been taken by the supply chain to develop such raw materials but their use lags behind other aquaculture markets", said Tinsley. "The future is to focus on raw materials which do not compete directly with stable food resources."

Efficient productivity

Growth rate and survival, is influenced by genetics, environmental conditions and farm management. "The important values are dollars/ha-day and dollars/kg of shrimp and not only FCR and growth rate. Important for the producers in Ecuador are these metrics. The challenge is to improve efficiency and ultimately profitability at a time when shrimp prices are at their most volatile and competition on the global market strongest," said Tinsley.

"A strategy to improve productivity is the nursery phase. Proper use is allowing the industry to improve the robustness of our post larvae transferred to ponds, reducing the pathogen pressure and increasing feed efficiency. So overall, these would have been the contributions to efficient productivity."

Traditional large ponds dominate production in central and South America. To reduce stress points as well as triggers for any diseases outbreaks, recirculation is one method to stabilise

Christopher Co, Oversea Feeds Corp (left), Alfredo Medina, INVE Aquaculture, Thailand (middle) and Cao Khanh Ly, Zeigler Bros., Inc. Vietnam.

From left, Apirum Wanaputh, Biomin; Rutchanee Chotikachinda, DSM; Apirux Kimawanit and Thummanoon Srivivhean, TRF Feed Mill Co., Ltd.,Thailand.


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> **Collaboration will bring results throughout the supply chain. Specific to the example of raw materials, collaboration can open doors to developing specific high value products to cater to the dynamic requirements of consumers. - John Tinsley**

environmental conditions and improve productivity. "Producers, where possible, have invested and converted farms towards recirculation systems which require a high level of technical expertise and capital investment. But they show improvements in yield and survival," said Tinsley.

Health and welfare

In Ecuador, since the WSSV outbreaks in 1999, industry learnt lessons and took initiatives to reduce risks. The focus is on genetics, management and healthcare. "In the Americas, integrated management strategies to support health and welfare are proven. Production strategies focus on how to maintain water quality, preventative healthcare through the use of functional feeds and robust post larvae. In health assessment and diagnosis, we are learning to be proactive rather than reactive, and today producers are committed to reduce their reliance on traditional medicaments and are looking at alternatives."

With regards to probiotics, Tinsley said, "It is widely documented that microbial additives are efficient tools to mitigate the sensitivity of shrimp to bacterial pathogens. The challenge is to bring the next generation ideas to the market safely and quickly. We need more tools in the box".

Research and development

Looking back at the R&D on fish meal replacement in salmon, the feed industry spent USD 175 million on R&D to reduce the reliance on marine raw materials. The outcome was gaining knowledge on nutrition, welfare and new technology. The supply chain invested in new processing technology to implement new raw materials. Overall the industry moved from a model dependent on traditional marine ingredients to a model which now is no longer reliant on these ingredients. In addition, through an improved understanding of the biology and nutrition, FCR has been decreasing and growth rates improving while the health and the product quality is being maintained. "All of this comes from a relatively small investment, but the return of the investment has been enormous (USD 1.3 billion). Salmon feed prices have been reduced to just over USD 1/kg. This knowledge has obviously been transferred to many species, including shrimp. However, we still have more to do."

Part of the team from the Department of Fisheries Thailand. From left, Dr Jumroensri Thawonsuwan, Songkhla Aquatic Animal Health Research Center; Dr Chutima Khomvilai and Kanonkporn Kessuwan, Department of Fisheries, Bangkok

Another opportunity is collaboration. "Feed producers hold the key position in the value chain. We are responsible for sourcing, transparency and food safety. Feed connects the whole value chain, from the farmer to the retailer."

Tinsley noted that several years ago, there was an evolution in product development within the salmon industry. "Can we take this further to the shrimp industry? The salmon industry is growing, with the desire to increase traceability and transparency. There are true value chain collaborations opening doors which have not had access to markets previously." He cited the example of Marks & Spencer's LochMuir branded salmon which is offering the British retailer a point of differentiation using feed regimes designed for the consumer eating experience and independently verified feed raw products.

Tinsley's take home message is, "Collaboration will bring results throughout the supply chain. Specific to the example of raw materials, collaboration can open doors to developing specific high value products to cater to the dynamic requirements of consumers. R&D is a key tool, not just for feed, but for the entire industry, we must use it. As a feed producer, we understand our responsibility within the value chain and our contribution to a sustainable industry, supplying our growth potential".

Some of the 19 participants from Ecuador.

Achmad Fauzi, PT Matahari Sakti (left), Setiawan Aditia PCTS Specialty Chemicals (M) Sdn Bhd (middle) and Sutopo, PT Malindo Feedmill, Indonesia.

Disease threats and managing trigger points

Diseases in Asia are not homogenous. Different countries face different disease challenges. **Anwar Hasan**, Regional Technical Manager – Aquaculture, BIOMIN had a difficult task of covering updates on shrimp diseases in Asia, the probable trigger points of diseases and follow-up production strategies to mitigate them, all within 30 minutes.

Shrimp production has dropped during the period 2010 to 2013, due to EMS/AHPND. Shrimp price was highest in 2013 at USD 7/kg ex-farm Indonesia for size 50/kg. However, since 2014, Thailand been experiencing a 5-10% recovery. India is now a major contributor to global supply.

"Fortunately for the global industry the short supply raised prices, but unfortunate for farmers, this comes with higher costs of production. Thus, how real a threat are diseases in our shrimp industry?" asked Anwar. "Or should we acknowledge that with disease, the global shrimp supply can be managed well for farmers to get better prices?"

From viral to bacterial pathogens

Anwar shared updates from India, Thailand, Vietnam and Indonesia on production trends and current state of shrimp diseases.

"In the past, most of the very damaging diseases in shrimp were caused by viral pathogens, but now it is found that natural bacterial and microsporidian/fungi are major pathogens. During Asia's monodon shrimp era, the main pathogens were WSSV, monodon baculovirus (MBV) and yellow head virus (YHV). Since 2010, the most devastating disease has been bacterial causing EMS/AHPND. Even though the main shrimp species in Asia is now the vannamei shrimp, WSSV is still a major threat. Since 2015, AHPND, WFD, EHP, running mortality syndrome (RMS), infectious hematopoietic necrosis virus (IHHNV) are common for some countries." Only infectious myonecrosis virus (IMNV) is present in Indonesia but Anwar indicated that in other countries, another virus with similar symptoms to IMNV has been reported as covert mortality disease (CMD).

The Q&A on "Investing for the future", from left, Dr M A Kabir Chowdhury, Jefo Nutrition Inc., Canada; Dr Suraphol Pratuangtum, Thai Marine Shrimp Farmers Association; Tim Noonan, Cargill Animal Nutrition, USA; and Soraphat Panakorn, Novozymes Biologicals, Thailand

> "There is the possibility of co-infections."
> - Anwar Hasan

"Indonesian farmers grappled with WFD while many others in Asia were faced with AHPND. We need to be aware of new emerging diseases. The new challenge is iridovirus in shrimp which has been shown to be very severe in marine fish and probably in shrimp too," added Anwar.

In **India**, with the introduction of the vannamei shrimp, productivity rose from 1 tonne/ha (in 2010) to 3.5 tonnes/ha in 2015. Even at this production level, disease was very present with 80% of ponds were infected mainly WSD, Black Gill Disease (BGD), RMS, loose shell syndrome (LSS), WFD, white muscle disease and IHHNV.

Farms in **Vietnam** have focussed on biosecurity and started lining or semi-lining ponds and use biofloc or semi-biofloc. Nursery phase with zero-water-exchange is common. "The concern is flushing of waste water into the environment after the pond has had a disease. Antibiotics is also a big concern in Vietnam. Some farms stock more than 200 PL/m^2. Today, the main diseases are EMS/AHPND, WFD and WSD. EHP and BGD is also common. Recently, white muscle disease with symptoms like that of IMN but negative to IMNVwas reported." Anwar added.

In **Thailand**, the concerns are EHP, AHPND and WFD. Thai farmers have managed well with initiative and innovation. Many farmers try to mimic Thailand regarding their shrimp toilets. Thai farmers also have indoor and outdoor recirculating systems as well.

A major impact on the industry in **Indonesia** has been WFD which according to Anwar, forced closures of two large farms as well as several mid-size and small farms. "WFD occurred even at low stocking (20 to 40 PL/m^2) with poor biosecurity and water management. WFD is found in many locations." Anwar added, "Indonesia's industry suffered from IMNV from 2008 until 2012. The pathogen apparently disappeared, and producers were happy as 2013, prices were high and other countries were suffering with low production because of EMS/AHPND (Thailand, Malaysia, Vietnam and China). But this year, IMNV is more virulent and occurs earlier during culture. Previously, maximum mortality was 60%, now it can reach as high as 90% . A possible co-infection (EMS, IMNV and WSD) is suspected."

Trigger points

Farmers have been facing a dilemma as they look to deploy various strategies to manage these diseases and to better understand the pathogens present in the farm environment.

"Initially, we manage the likely trigger points adapted from WSD; post larvae, water source factors, predators and some other carriers," said Anwar. "So, we minimise impacts with biosecurity, but disease is no longer caused by one single pathogen. With WFD, we do not know the actual pathogen."

In his presentation, Anwar focussed on three trigger points; stocking density, the trigger factors of disease in healthy shrimp, and managing water quality including blue-green algae.

"In Indonesia, after experiences with IMNV, farms focussed on carrying capacity. They reduced stocking density significantly, and found the maximum carrying capacity and stocked that number into ponds. In areas surrounded by ponds, keeping to 100 PL/m^2 -120PL/m^2 or less is suggested. In the management of WFD, low stocking density was suggested as well as zero-water exchange."

Anwar questioned whether post larvae stocking size of PL9-11 is the right size, particularly in managing AHPND. A nursery phase will grow post larvae to 3-5g and stock stronger and exposed to pathogen shrimp in ponds. "During the nursery as well, immunostimulants or hepatopancreas protector can be added, to counteract WFD or EMS."

The big concern is toxins which can also damage shrimp hepatopancreas. Producers need to be aware of three sources of toxins; cyanobacteria, pathogenic bacteria and contamination in feed. Cyanobacteria and pathogenic bacteria produce endotoxins and exotoxins, while mycotoxins are common in contaminated feed material. He said an Indonesian research found toxin of cyanobacteria in water deposited in hepatopancreas of shrimp infected by WFD. Toxins reduce the immune system of the shrimp. "When a blue-green algae bloom crashes, the disease comes in the next couple of days. Either probiotics or chemicals can be treatments; chemicals work faster but plankton domination changes quickly, releases endotoxins, increases organic matter and promote *Vibrios*. Probiotics will take 2-3 days," added Anwar.

Anwar had the following message, "Diseases related to white muscle syndrome (IMN, PvN, and/or CMN disease) are more virulent lately. There is the possibility of co-infections. Determining stocking density and/or nursery system is important as a strategy to manage direct or indirect effects of several diseases. As dissolved oxygen and water quality trigger diseases, managing these 2 factors could help farmers to manage the worst effects of diseases. Managing algae has become important to avoid disease outbreaks."

From left, Kritsada Hongrath, Pen Ngern Feed Mill Co., Ltd; Dr Jarin Sawanboonchun, Ridley Corporation (Thailand) Co., Ltd; Phon Songsiritanaphat, Evershining Ingredient Co., Ltd; and Dr Wee Kok Leong, Behn Meyer Malaysia Sdn Bhd.

Roundtable on Feeds, Health and Environment

Revival of the black tiger shrimp

In this TARS 2018 session, in her presentation "WSD-Resistant monodon shrimp: Part of the solution", Professor **Grace Chu-Fang Lo**, National Chair Professor, Department of Biotechnology & Bioindustry Sciences, National Cheng Kung University, Taiwan, discussed the difficulty in controlling WSSV and the R&D work to produce F3 generations of resistant lines of black tiger shrimp *Penaeus monodon* with additional desirable traits to enhance its commercial profitability.

In Malaysia, since late 2017, there has been a renewed interest in farming the black tiger shrimp and **Catherine Lee May Ying**, Senior Manager, Group Corporate Sales & Marketing at the shrimp farm, Blue Archipelago Bhd, Malaysia, discussed the "Push and Pull in Black Tiger Shrimp Farming."

The difficulty with WSSV

WSD is a global pandemic, with reports of outbreaks even in areas once free of WSSV. Lo detailed the difficulty in controlling the virus. "WSSV has many unique properties. It has very broad host range and replicates very rapidly in shrimp. After replicating successfully, the virus can spread horizontally, and vertically from broodstock to offspring. When shrimp are stocked in ponds with a WSSV carrier with a low level of infection, replication of the virus triggered by environmental or physiological stress, will lead to a crop failure."

"Looking beyond diagnosis and quarantine, we need to have the host most successfully defend itself against WSSV and a solution might be resistant shrimp."
- Grace Chu-Fang Lo

WSSV expresses anti-host defence genes at all stages of infection and also has a wide range of hosts. Among them, copepods and hermit crabs which although healthy looking are heavily infected; the virus load is much more than in heavily infected shrimp. Lo said this was demonstrated by feeding a clean broodstock in the hatchery in Vietnam with hermit crab and within 2 days, the broodstock was heavily infected. "The standard recommendation is to use SPF seed stock and good biosecurity practices, but even so, it is very hard to guarantee that any commercial system will remain WSSV-free."

The arms race

This is how Lo described the combat between virus and host (shrimp). The virus has 2 fundamental strategies and objectives; it accomplishes a step necessary for infection and replication, and simultaneously overcomes specific cellular defences initiated by the host. The defence mechanisms used by the host to stop invasion attempts by the virus and counter mechanisms that are used by WSSV to infect the shrimp host, have been the subject of research on WSSV at the NCKU laboratory for the past 2 decades.

"Shrimp ROS-or reactive oxygen species is an important line of defence designed to kill an invading pathogen, but the virus easily neutralises the host's ROS defences at the initial stage of infection. The shrimp uses its iron withholding defense mechanism which the virus then counter attacks with protein PK1 to defeat this withholding defence mechanism by interacting with host ferritin," explained Lo.

"Usually in response to stress, defence proteins (e.g. NFkB and STAT) will be activated and move to the nucleus to trigger the production of the immune response related protein. However, if the WSSV genome is present in the cell, the WSSV IE1 gene hijacks this activated STAT and triggers replication of the virus and thus a full outbreak of WSD occurs."

In broodstock, Lo noted that the levels of activated STAT increased post-spawning. This stress of spawning triggers a rapid increase in the virus. Before spawning, the virus was present at 10^1 (copies/µg DNA) and after spawning, in just a few hours it rose to 10^7. Consequently, successive spawning becomes very rare and usually the shrimp dies after a single spawning. So, it is a losing battle with shrimp infected with WSSV. "One would think that to successfully control WSD, it is just to monitor and survey the presence of the virus and then quarantine, or otherwise keep separate the virus and its shrimp host," said Lo. "But this is often not the case.

"WSSV is present almost everywhere in the environment. Looking beyond diagnosis and quarantine, we need to have the host most successfully defends itself against WSSV and a solution might be resistant shrimp."

WSD-resistant shrimp

This work is carried out at the NCKU's Center for Shrimp Disease Control and Genetic Improvement. It has a shrimp genome biology laboratory, a shrimp disease laboratory and reference laboratory for white spot disease and recently, AHPND. The two new breeding centres each have facilities for the complete maturation cycle, multiplication for shrimp family of interest, hatchery and nursery facilities. It has a high level of biosecurity using recirculated water with smart IoT water quality monitor system for broodstock maturation. A central detection system monitors hourly temperatures, dissolved oxygen, salinity, ORP and pH and real time water quality. All shrimp in this centre are at least SPF.

Firstly, Lo explained, "The difference between WSSV-resistant shrimp and WSSV-tolerant shrimp is that in tolerant shrimp, although the virus does replicate, the infected shrimp is still able to survive. What we are primarily interested in is resistant shrimp; shrimp in which the virus is unable to replicate."

It has been well documented that WSSV replication is supressed in shrimp cultured at 32°C water temperature. But at transfer of shrimp to lower water temperatures (25°C) the virus replicates very rapidly. "The virus is not being killed at 32°C, but its replication is being suppressed. We then looked at some factors that are critically different between these two temperatures," said Lo. "We identified the host genes that are critical for virus replication. So, we have 152 genes candidate genes, related to virus replication."

Broodstock was collected from a wide range of habitats to obtain genetic diversity, confirmed as SPF shrimp and offspring were tested for resistance by WSSV challenge tests. Those in the population showing resistance were grown to broodstock. "Unlike breeding programs that are limited to a single source population, non-exclusive collaboration agreements giving simultaneous access to different populations of shrimp should have a multiplicative effect to produce stronger resistance," said Lo.

To date, the centre has WSD-resistant shrimp over three generations. "Now the next big question is will the WSD resistant trait pass on to subsequent generations? The answer is yes. While in the parental generation, we did not know the status of resistance, in the F1 generation phenotype, it is 17:13 resistant: susceptible. In the F2 generation, we confirm that resistance can be passed on to the subsequent generation. We have also confirmed that the population of resistant shrimp can be increased in subsequent generations".

The message Lo brought across is, "Production of resistant shrimp is just part of the solution. In the breeding centre, we support the resistant shrimp through their complete life cycle using an indoor culture facility with a high level biosecurity. In commercial farms, we need to improve biosecurity for grow-out ponds, a stable ecosystem and an ideal feeding regime."

The shift to black tiger shrimp

Malaysia started its commercial shrimp farming industry in the 1980s with the black tiger shrimp, which in turn developed its shrimp processing industry. WSSV wiped out its farming and vannamei shrimp, in 2005, gave shrimp farmers new hope. Fast forward to 2016, Catherine Lee May Ying said, "Towards the end of 2016, high offer prices for both vannamei and black tiger shrimp, mainly because of persistent disease problems with the vannamei shrimp and the weak Malaysian ringgit, encouraged exports. We had one of the highest local prices for our shrimp. In 2017, it rose to MYR 29/kg (USD 7.25/kg) for 14g vannamei shrimp. Prices for 25g black tiger also rose to MYR 36/kg (USD 9/kg)."

After March 2018, the price gap widened, with imports of vannamei shrimp coinciding with the harvest in southern Thailand and the relatively cheap imports of Indian shrimp. "However, prices of black tiger shrimp remained stable and high. Processors saw the opportunity to export live frozen, or live cooked premium quality black tiger shrimp. They also could offer premium price for harvesting live shrimp," added Lee.

This was most evident in 2017 and mainly with farms in the northern state of Perak. Lee said that the reason given was the failed harvests with the vannamei shrimp and farmers trying their luck with the black tiger, which was surprisingly successful. In early 2018, with the large drop in global vannamei shrimp prices, processors refused to buy vannamei shrimp. Discouraged, farmers did not restock ponds. But the export price for black tiger was relatively stable. Price became the pull factor.

Malaysia has a relatively high local shrimp consumption and processors usually compete with local wet market buyers. When supply exceeded demand with imports, there was no competition to buy shrimp and local prices dipped. "Our advantage in Malaysia is the export of live, live frozen and live cooked shrimp to China. This became the competitive edge for farming black tiger shrimp," said Lee.

Vannamei versus black tiger

Lee compared costs of farming both shrimp at a 17-pond farm in Perak. With the vannamei shrimp, stocking at 100-120 post larvae (PL)/m^2, harvests reached 5-6 tonnes/ha. The domestic market demands 14g, harvested within 60 days of culture (DOC 60). Ex-farm price is MYR 19/kg (USD 4.75/kg). In comparison, the black tiger shrimp grown to 25g after DOC 110-120 has an ex-farm price of MYR 32/kg (USD 8/kg). "Based on the cost of production of MYR 15/kg, for the vannamei shrimp, the farmer profits around USD 1/kg, but for the black tiger, the margin is almost MYR 14/kg (USD 3.5/kg) when the cost of production is MYR 18/kg (USD 4.5/kg). The revenue per pond basis is 35% higher with black tiger shrimp farming, if the farmer is successful."

However, there are biological factors. The vannamei shrimp growth rate is linear but for the black tiger shrimp, during the first 55-60 days, growth is slow at 0.14g/day, after which it jumps to 0.40g/day. "Farmers who have failed in black tiger farming looked at growth rates and saw the slow growth at DOC 50s. They then made the decision to cut losses rather than wait for growth to pick up." Lee added, "The decision depends on the risk appetite."

Risk appetite

How much risk will a farmer take? Lee presented a scenario of a farmer farming both shrimp up to 50 days. At DOC 50, the vannamei shrimp size is 8g which will fetch an ex-farm price of MYR 12/kg (USD 3/kg). At 50% survival, the production is 2 tonnes/ha and revenue reached MYR 24,000 (USD6,000). If cost of production was MYR 7/kg, the profit would be MYR 12,600. However, with the black tiger shrimp, in 50 days, the size will only be 6g which in the case of the Malaysian market is usually not saleable. Selling even at MYR 4/kg (USD 1/kg) still meant a loss for the farmer, even if survival rate was 70%.

"Based on current price in Malaysia, the pull to farm black tiger is strong, because of the premium the processors are willing to pay."
- Catherine Lee May Ying

The turning point

"For the farmer, where is the turning point? With a successful crop to DOC 100, the size is 18g for both shrimp with some partial harvests. The final crop for vannamei shrimp can reach 7.2 tonnes/ha at stocking density of 100 PL/m^2 and survival of 80%. Ex-farm price Malaysia is MYR 22.25/kg. The margin is MYR 7/kg. But at DOC 100, the black tiger shrimp reached 28g with ex-farm price of MYR 35/kg but based on the stocking density of 40 PL/m^2, the biomass is about 4.5 tonnes. Profit-wise, it is the same for either shrimp," Lee pointed out.

There is also the question of post larvae supply and genetic characteristics. Lee explained that in Malaysia, post larvae are from genetically selected brood stocks; Moana, CPF and from Madagascar, Mozambique and of unknown origin. Availability of a specific source of post larvae has been an issue in Malaysia and may be further aggravated by the news that farmers in southern Thailand are switching to farm the black tiger shrimp. "Currently, the preference is for Moana post larvae which farmers say is fast growing, has a slimmer head, and is favoured by processors for fresh frozen products. It is however not suitable for cooked products as there is colour variation. Farmers also like the Mozambique origin black tiger shrimp, because of the large head which adds weight and the even colouration suits live cooking," said Lee.

"Export price continues to be attractive and with the weak currency, processors will continue to demand for black tigers which will push farmers to this shrimp. For the processors, black tiger shrimp will still be attractive, especially when in 3Q and 4Q, they know prices will increase, as it happens every year."

Lee concluded, "Whether it is black tiger or vannamei shrimp, the choice made will be an interplay of factors; both price and biological factors."

In the next issue, we will report on presentations covering productivity in the supply chain, nutritional and health interventions and investing for the future.

TARS 2019 will be on Aquafeeds; Fit For Future and will be held on August 14-15.

Plant-based aquafeeds: Nutritional concepts for cholesterol and bile salt in the grouper and white shrimp

By Yu-Hung Lin and Li-Chao Zhuo

Cholesterol or bile salt supplementation can improve molting relative gene expression in the white shrimp while bile salt supplementation can enhance lipid utilization for grouper.

The aquaculture sector is still highly dependent upon marine capture fisheries for sourcing key dietary nutrient inputs, including fish meal and fish oil (Tacon and Metian, 2008). Aquafeeds are largely dependent on fish meal as a protein source. However, high quality fish meal is expensive and according to some projections, its availability is expected to decline and the price will increase dramatically. Therefore, it is necessary to identify and utilize less expensive and more sustainable protein sources in fish feed. Soybean meal is the most widely used plant ingredient in the aquaculture industry. However, the use of soybean meal is limited because of the presence of anti-nutritional factors or insufficient nutrient content, such as methionine, lysine, taurine and cholesterol (Francis et al., 2001).

Recirculating rearing system

Cholesterol is a key sterol serving as a precursor to physiologically active compounds, including sex and molting hormones, adrenal corticoids, bile acids and vitamin D in crustaceans (Sheen et al., 2000). It is considered as a non-essential nutrient for fish because fish is able to synthesize cholesterol.

However, recent studies have demonstrated that cholesterol supplementation in diet can enhance growth and feed intake of channel catfish (Twibell and Wilson, 2004) and turbot (Yun et al., 2011) when the fish are fed low-cholesterol diets. Therefore, we need to evaluate the importance of cholesterol for fish.

In aquatic invertebrates, most of the information on cholesterol nutritional physiology has focussed on the crustacean, especially the marine shrimp. It is necessary to supplement cholesterol in shrimp diet due to the absence of cholesterol in soybean meal and also the lack of *de novo* cholesterol-synthesis in the shrimp. Since cholesterol is the most expensive ingredient in shrimp feed, it is worthy to find an alternative for cholesterol. Bile salt is a physico-chemical detergent and plays a key role in the digestion and absorption of lipids, fat-soluble vitamins and other apolar components in the diet or from endogenous sources. The use of bile salt as cholesterol replacer in shrimp feed need to be further investigated.

This brief review introduces the roles of cholesterol and bile salt in aquafeed and our recent works in the grouper and white shrimp.

Grouper study

An 8-week feeding trial was conducted to evaluate the effects of different cholesterol and bile salt levels on growth, nutrient digestibility, cholesterol status, cholesterol-synthesis enzyme, 3-hydroxy-3-methylglutaryl CoA (HMG-CoA) reductase and gene expression for the giant grouper, *Epinephelus lanceolatus*. We replaced 40% fish meal protein with soybean meal in the control. The 8 experimental diets was this control diet with added cholesterol or bile salt at 0.25, 0.5 and 1%. An all fish meal diet without cholesterol and bile salt was also included for comparison.

After the 8-week feeding trial, weight gain of fish fed the all fish meal diet showed the highest weight gain ($P<0.05$) when compared to fish fed the diets with a high level of soybean meal (Figure 1). The lowest weight gain of the fish was found in the 1% bile salt group, suggesting that a high level of bile salt for the grouper could be toxic. Apparent lipid digestibility was higher in fish fed the all fish meal diet than fish fed the control diet. This clearly indicated that replacement of fish meal protein by soybean meal depressed lipid digestibility in the grouper. Lipid digestibility was improved when the diets were supplemented with bile salt, a strong emulsifier which could improve lipid utilization in fish. It should be noted, however, that the adequate level of bile salt in the feeds should be evaluated carefully due to its potential toxicity.

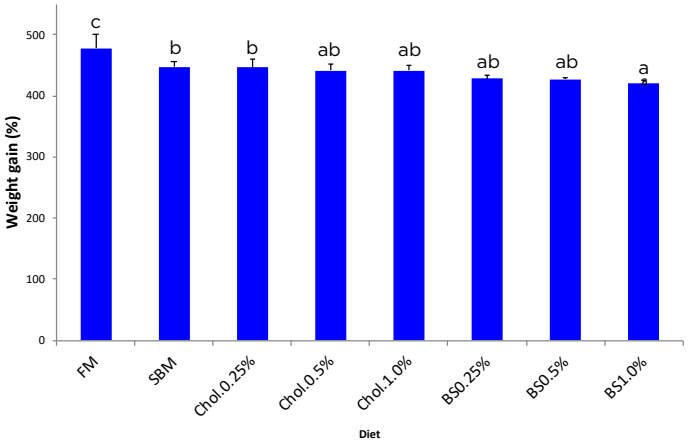

Figure 1. Weight gain of grouper fed diets with different levels of cholesterol and bile salt for 8 weeks.

In this study, we also measured the hepatic cholesterol concentration and the key enzyme for cholesterol synthesis, HMG-CoA reductase gene expression (Figure 2). Results indicated that the hepatic cholesterol concentration increased while the dietary fish meal protein was replaced by soybean meal, and decreased in fish fed the diet with 1% cholesterol. HMG-CoA reductase gene expression in liver showed a similar trend with the hepatic cholesterol concentration. It suggested that the grouper can regulate the *de novo* cholesterol synthesis when fed the high soybean meal (low cholesterol) diet. The present study demonstrated that cholesterol is not a limiting nutrient for grouper fed plant-based diets.

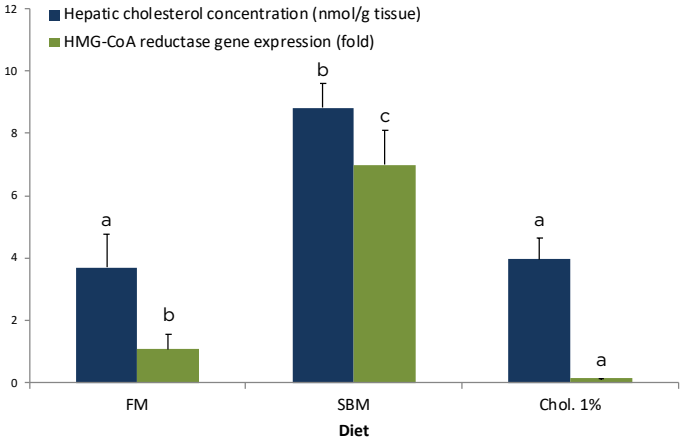

Figure 2. Hepatic cholesterol concentration and HMG-CoA reductase gene expression of grouper fed different diets for 8 weeks.

White shrimp study

Shrimp cannot synthesize cholesterol to meet their requirement. Optimum cholesterol requirements have been well quantified in some shrimp species, for example, kuruma shrimp, *Marsupenaeus japonicas*, black tiger shrimp, *Penaeus monodon* and white shrimp *Litopenaeus vannamei* (Lin and Shiau, 2016), ranging from 0.14 to 2.0%. Because of the limitation of fish meal supply, plant proteins has been widely incorporated into shrimp feed. Some 15 to 20% or even less fish meal is now commonly used in commercial shrimp feed. Fish meal, such as prime grade (60%), contains about 0.8-1.2% cholesterol at dry basis (laboratory analysis data). This low composition of fish meal may cause cholesterol deficiency, which may negatively affect growth and molting of shrimp. It should be noted that the cost of synthetic cholesterol has increased tremendously in recent years but such an alternative source of cholesterol is becoming important as feed formulators reduce the fish meal component in shrimp diets. We conducted a series of experiments to evaluate the roles of cholesterol and bile salt on growth as well that between cholesterol and molting relative gene expression in white shrimp fed diets containing a high level of soybean meals.

In the first trial, dietary fish meal protein was replaced by soybean meal at 0, 20, 40, 60, 80 and 100%, resulting in the analyzed cholesterol concentrations at 0.41, 0.35, 0.27, 0.19, 0.13 and 0.11%, respectively. Results indicated that the cholesterol concentration in hepatopancreas and hemolymph decreased linearly with increasing soybean meal inclusion levels. Hypocholesterolemia effect was found in the shrimp fed soybean meal; possibly induced by the antinutritional factors in soybean meal, such as saponin, phytosterol and non-starch polysaccharide, or by the absence of cholesterol in soybean meal.

Cholesterol and molting

A following trial showed how a 0.05% cholesterol supplementation in a plant-based diet (60% fish meal protein replaced by soybean meal) can improve growth and whole body cholesterol concentration of the shrimp (Figure 3).

> **"Shrimp can convert cholesterol to 5ß-diketo, and then synthesis molting hormone (ecdysone).."**

Shrimp can convert cholesterol to 5ß-diketo, and then synthesise molting hormone (ecdysone). However, the pathway from 5ß-diketo to ecdysone is still unknown. Thus, some molting relative gene can be used as a molecular parameter for evaluating the molting status. For example, ecdysteroid receptor and retinoic acid X receptor for molting signal transmission; chitinase isoenzyme and chitin synthesis for chitin metabolism; and alpha-actin, ß-actin and myosin heavy chain for muscle growth. In addition, during the molting stage, shrimp require more oxygen for these physiological responses. Therefore, hemocyanin, oxygen carrying protein in crustacean, can also be measured. All of the molting relative gene expression showed similar trend with weight gain and whole body cholesterol concentration (Table 1).

Bile salts and lipid utilisation

In the third trial, bile salt was supplemented in plant-based control diet (60% fish meal protein replaced by soybean meal) at 0.1 and 0.2%. An all fish meal diet was also included for comparison. Weight gain of the shrimp fed the all fish meal diet was higher than the other groups. Weight of shrimp slightly improved by adding 0.2% bile salt in the diet (Figure. 3). Bile salt shows the emulsifier function for lipid utilization of animals. So

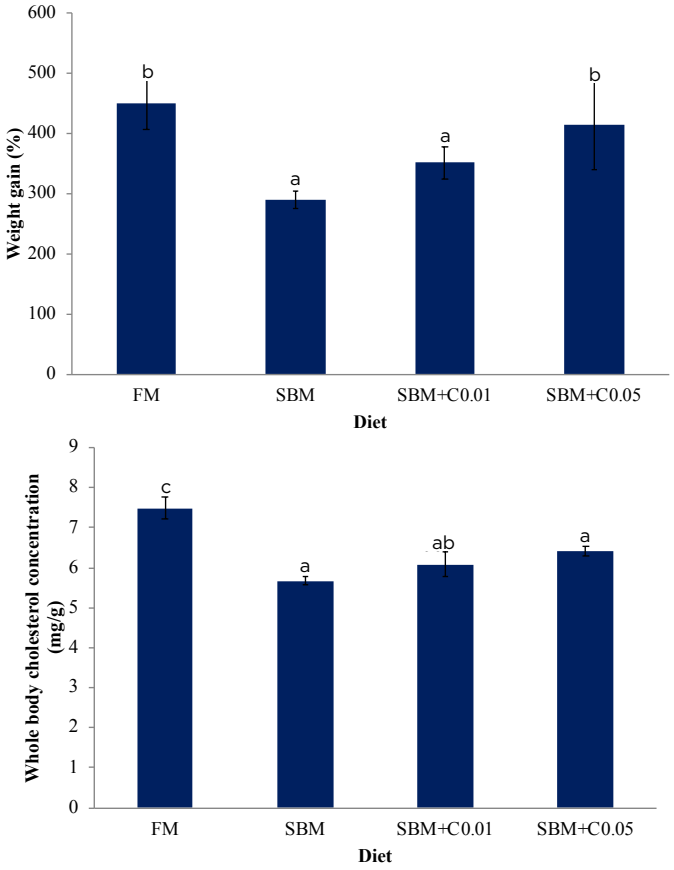

Figure 3. Weight gain and whole body cholesterol concentration of white shrimp fed different diets for 8 weeks.

Table 1. Molting gene expression of white shrimp fed diets with different levels of cholesterol for 8 weeks.

	Diet			
	FM	SBM	SBM+C0.01	SBM+C0.05
Ecdysteroid receptor	1.03 ± 0.29^{c}	0.08 ± 0.01^{a}	0.41 ± 0.03^{b}	0.92 ± 0.20^{c}
Retinoic acid X receptor	1.06 ± 0.42	0.34 ± 0.10	0.40 ± 0.01	1.17 ± 0.53
Hemocyanin	1.00 ± 0.04^{b}	0.36 ± 0.06^{a}	0.91 ± 0.26^{b}	0.91 ± 0.13^{b}
Chitin synthase	1.15 ± 0.72	0.18 ± 0.10	0.98 ± 0.06	0.7. ± 0.07
Alpha actin	1.05 ± 0.41	0.76 ± 0.15	0.82 ± 0.32	1.31 ± 0.33
Beta actin	1.01 ± 0.16^{a}	0.64 ± 0.16^{a}	0.68 ± 0.03^{a}	1.81 ± 0.38^{b}
Myosin heavy chain	1.07 ± 0.52	0.54 ± 0.38	0.78 ± 0.33	1.29 ± 0.69

Table 2. Molting gene expression of white shrimp fed diets with different levels of bile salt for 8 weeks.

	Diet			
	FM	SBM	SBM+C0.01	SBM+C0.05
Ecdysteroid receptor	1.01 ± 0.14^{c}	0.10 ± 0.04^{a}	0.60 ± 0.06^{b}	0.92 ± 0.11^{c}
Retinoic acid X receptor	1.02 ± 0.21^{b}	0.45 ± 0.11^{a}	1.06 ± 0.24^{b}	1.02 ± 0.07^{b}
Hemocyanin	1.03 ± 0.29^{b}	0.39 ± 0.08^{a}	0.71 ± 0.16^{ab}	0.71 ± 0.13^{ab}
Chitin synthase	1.09 ± 0.55^{b}	0.34 ± 0.02^{a}	1.18 ± 0.26^{b}	1.05 ± 0.24^{b}
Chitinase isoenzyme	1.04 ± 0.32^{b}	0.25 ± 0.04^{a}	1.06 ± 0.31^{b}	1.12 ± 0^{30b}
Myosin heavy chain	1.00 ± 0.12^{c}	0.41 ± 0.04^{a}	0.70 ± 0.17^{b}	0.73 ± 0.18^{b}

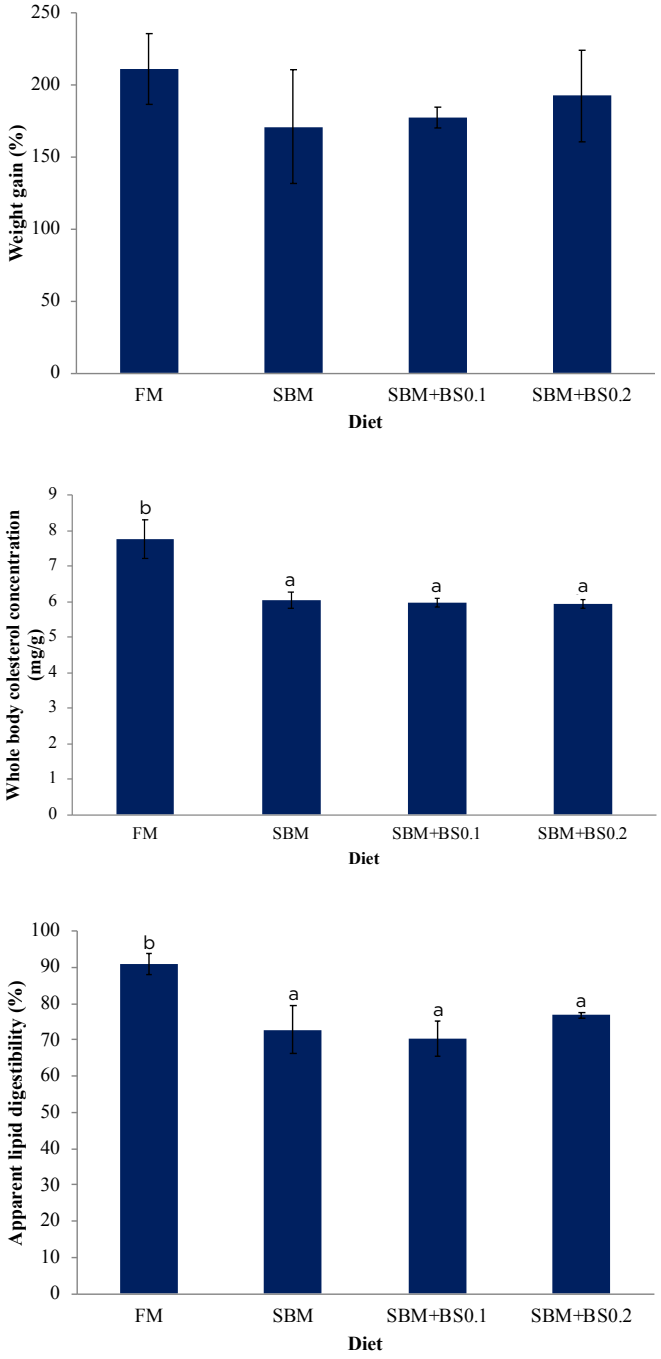

Figure 4. Weight gain, whole body cholesterol concentration and apparent lipid digestibility of white shrimp fed different diets for 8 weeks.

we also determine the cholesterol digestibility and storage in white shrimp. However, shrimp fed the diets with bile salt did not enhance whole body cholesterol concentration and apparent cholesterol digestibility. This phenomenon suggests bile salt may not play a part in cholesterol absorption and storage.

Interestingly, when we analyse the molting relative gene expression, both bile salt dosages showed increment of ecdysteroid receptor, retinoic acid X receptor, chitinase isoenzyme, chitin synthesis, hemocyanin and myosin heavy chain gene expression (Table 2). This result may indicate that bile salt is involved in ecdysone synthesis in the white shrimp. As our study is a very simple dose-dependent study, we recommend further work to confirm how the bile salt functions during shrimp

molting. Our study, however, already demonstrated that bile salt would be a potential cholesterol replacer in shrimp feed.

Summary

Many nutritional issues must be addressed in plant-based aquafeeds. Our recent work demonstrated that cholesterol is not a limiting nutrient for grouper fed a diet with high level of soybean meal, because grouper can synthesize cholesterol to meet their requirement. Bile salt supplementation can enhance lipid utilization for grouper.

However, the use of the bile salt in grouper feed must take into consideration its potential toxicity. The cholesterol level in a diet is greatly associated with molting status of the white shrimp. Shrimp fed diets with high level of soybean meal depressed growth and tissue cholesterol concentration, as well as molting relative gene expression. Cholesterol or bile salt supplementation can improve molting relative gene expression. Our primary study indicated that the bile salt would be a potential cholesterol replacer for the white shrimp.


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Managing challenges in offshore mariculture in Asia

Growing global population, rising food prices and unsustainable aquaculture practices are among the major issues confronting the aquaculture sector. Anwar Hasan gives an insight into offshore mariculture, the challenges involved and the way forward

On the sidelines of the first Offshore Mariculture Conference in Asia in 2018, AAP talked to Anwar Hasan, Regional Technical Manager-Aqua, BIOMIN The 3-day conference was held at the Marina Mandarin, Singapore from 15-17 May, 2018. We sought his views on offshore marine aquaculture: his vision on this enterprise, the challenges confronting the industry and the way forward. Anwar is currently responsible for aquaculture in the Asia Pacific region. He joined Biomin in 2014 and has also taken up the additional role of Global Species Coordinator (aquaculture) since 2016. He is based in Indonesia.

AAP: What is your vision for marine aquaculture?

Anwar: The growing global population, rising food prices and degrading land and coastal environments are some of the challenges faced in the quest to produce more food for the future. With limited land for food production as well as intense competition for land use from various other sectors, mariculture appears to be a plausible solution to increase food production for the burgeoning population. The world comprises 70% of ocean/water. The aquaculture sector has to take this opportunity to further develop mariculture. There are many problems (such as land-use conflicts, environmental issues, and diseases) in land-based aquaculture and inshore aquaculture (e.g inshore cages), so in the future we have to develop more of the offshore marine aquaculture sector. This has been successfully established in Europe, Australia, America and some Asian countries like Japan. However, offshore mariculture is still a nascent industry in Southeast Asia but look at the huge potential it has to meet

the food demands of a growing population. Potential species in offshore mariculture in Asia include the tuna, cobia, Asian seabass and pompano.

AAP: What are the challenges confronting this industry?

Anwar: Operating offshore mariculture, is full of challenges. Globally, only a few companies have succeeded in operating offshore mariculture, and in Southeast Asia various problems still need to be overcome before this industry can take off successfully. It requires high capital investment, and it is also a steep learning curve to mitigate risks in the industry.

As I have outlined in my presentation, the challenges include;

- Technology is a major prerequisite, which includes not only the techniques required in setting up and operating cages, but also knowledge on site selection. In Southeast Asia, we still have a lot to learn.
- Security in offshore areas in Southeast Asia may also be challenging; from thefts and piracy.
- Human resource is another, as offshore mariculture requires skilled manpower, which is in short supply in Southeast Asia.

Finally, market considerations such as the size of the market, and supply chain information such as the availability of broodstock for the intended cultured species.

AAP: What solutions do you propose to meet these challenges?

Anwar: Bringing in experts from other regions who know the technology and working together with them are crucial to the success of this industry, since we lack the experience. As a "new player", Southeast Asia probably needs government involvement to set up a pilot project. Site selection is important; the cage system we want to use needs to comply with the conditions of the sea currents, waves and weather conditions in the proposed culture area. It is also important to choose a secure location, away from piracy, for example. Although offshore mariculture is located in the open sea, disease problems still pose as threats.

Stocking good quality seed is important. Good quality means pathogen free or in good healthy condition and free from stress after stocking. Diseases can also be prevented through the application of vaccines and the use of functional feed additives. We still need to develop feed based on nutritional requirements, which is probably different even within the same species cultured in offshore versus inshore cages. For new species like tuna, we have to determine the nutritional requirement and formulate a suitable feed.

Application of feed additives could be a good solution to increase growth performance. Comprehension on market and supply chain is also important. In terms of species, knowing the market size of each species can lead to the sustainability of the business. Salmon, shrimp and tilapia are major species in the market. If we grow Asian seabass, pompano or cobia, we must find out whether these species are highly acceptable by consumers. Can they compete with salmon and tilapia when mariculture in Southeast Asia expands and fish production increases? When we select a species, we need also to consider whether it is easy to breed and how easily available are juveniles for culture.

The importance of functional feeds in terms of improving health, disease and nutrition

At the OMC conference, Anwar Hasan presented on the importance of functional feed additives for improving marine fish performance. Although offshore aquaculture is considered as a good alternative to increase aquaculture production, it is not without problems. Diseases and nutrition are major concerns for future sustainability of the sector. Both can have a harsh impact on production.

In barramundi, major diseases/pathogens are VNN (viral nervous necrosis) caused by *Lates calcarifer* encephalitis virus (LcEV), big belly disease caused by bacterial pathogen, Iridovirus, *Tenacibaculum maritimum* (*T. mar*) bacteria, streptococcosis caused by *Streptococcus iniae*, scale drop syndrome and diseases caused by parasites (protozoan and monogenean). VNN is acute at the larvae stage and causes mortality up to 100%. Iridovirus is one of the most severe diseases in tropical marine aquaculture. It infects barramundi and grouper. In barramundi, it can cause mortality up to 90% in 10g to 50g fish. As fish are directly exposed to the threat in the environment, it is important to enhance fish immunity.

Functional feed additives are able to improve the growth performance of marine fish. Other benefits include the enhancement of the immune system in the cultured organism, the use of less fish meal in the formulated feeds and improvements in fish fillet quality. At the hatchery/larval stage, the application of probiotics in combination with yeasts and spirulina increased barramundi juvenile survival rates by about 16%. Yeast, ß-glucan, and nucleotides can be used to enhance disease resistance. A study showed that yeasts, ß-glucan and nucleotides increased survival rates of barramundi in a challenge test with *Streptococcus iniae*.

In terms of fish meal reduction, phytogenic feed additives and phytase showed capability to increase growth performance. Phytogenics have the prospects to improve fish fillet since it decreases malondialdehyde formation in the fish fillets. Phytogenics may stimulate secretion of digestive enzymes, increase villi length and density, and raise mucous production through an increase in the number of goblet cells. These effects were well illustrated in a trial conducted on marine species gilthead sea bream, *Sparus aurata*. In this trial, fish were fed a diet with 14% fishmeal supplemented with a matrix-encapsulated phytogenic feed additive at an inclusion rate of 200 g/tonne of feed in order to observe its efficacy on feed efficiency, body composition and nutrient retention. Feed of both treatment and control groups had the same profile, with crude protein at 45%, crude fat, 18.2% and gross energy at 21.5 KJ/g. Gilthead sea bream fed diets supplemented with matrix-encapsulated phytogenics showed better results, with a significant reduction in feed conversion ratio (FCR), increase in weight gain and increase in specific growth rates.

Mitigation of *Streptococcus agalactiae* with immunostimulants

By Loc Tran, Tanuttha Suyawanish and Philippe Tacon

These can have a long-lasting effect to mitigate the bacteria but dosages and administration times matter.

In a previous article in this magazine, we showed that short administration times with high dosages of immunostimulant can have a strong protective effect against acute hepatopancreatic necrosis disease or AHPND in *Litopenaeus vannamei*. This effect proves to be similar to a lower dosage of the same product but fed for a longer period. The conclusion of that study was that strategies to prevent disease outbreaks could vary and should be adapted according to farm and feed management; feed intake should be monitored carefully for an optimum immune stimulation.

In fish, when reviewing the literature, it is difficult to extract a particular, or standardised protocol to use immunostimulant/prebiotics. For the same species, stages of growth, weights, dosages and administration times vary greatly. Often in these studies, the composition of the immunostimulants is not mentioned, neither is the composition of the feed. Strategies including the use of these immunostimulants are then difficult to put in place.

Yeast parietal fractions rich in mannans and beta glucans are good candidates for disease prevention in tilapia. Previous trials at Phileo Lesaffre Animal Care (Mexico, Thailand, China, internal data) have demonstrated the efficacy of these immunostimulants in the field. Dosages as low as 0.5kg/tonne of feed have consistently been effective against bacterial diseases such as *Streptococcus agalactiae* and *Aeromonas hydrophilia*.

In these previous trials, these low dosages were administrated during the whole trial period (often 3 months). They also included dosages higher than 1kg/tonne and sometimes these higher dosages could lead to a lower growth. In view of previous results obtained in shrimp, it would be interesting to see if shorter administration of these higher dosages could also lead to the same level of protection than low dosages administrated over a longer period.

A trial was designed to administer a low dosage of 0.5g/kg of yeast parietal fraction for a period of more than 7 weeks compared to higher dosages (1, 2, 3g/kg) fed for 3 weeks. The effects on the resistance of *S. agalactiae* infection were observed.

Experimental design

All male sex-reversed tilapia juveniles *(Oreochromis niloticus)* with an initial mean body weight of 0.1g were obtained from a hatchery in Dong Nai Province, Vietnam. Fish juveniles were checked for important infectious diseases including *S. algalactiae, Streptococcus iniae*, and *Aeromonas spp.* using polymerase chain reaction (PCR) and transferred to a bio-secure wet laboratory at the ShrimpVet Laboratory.

Juveniles were acclimatised and grown to reach the suitable size of 20g/fish for the feeding challenge test. They were distributed to experimental tanks (250 cubic litres) 2 days prior to the start of the study. Each tank was fitted with a biofilter and stocked with 30 fish. Sixteen treatment tanks (four treatments with four tanks for each treatment) were setup as shown in Table 1, while the feeding design of the experiment is shown in Table 2. Fish in all the tanks were fed their respective diets to satiation four times per day.

The experiment was set up as a completely randomised design (CRD) where the tanks were randomly designated to treatments. The total period of the trial was 67 days, including 2 days of acclimation, 51 days of pre-challenge, and a 14-day challenge with *S. agalactiae*.

Table 1. Treatment diets and feeding application during the study.

Treatment	Additive and feeding application			Challenge
	Day 0 to Day 21	Day 22 to Day 51	Day 52 to Day 66 (challenge)	
Negative Control (T1)	Control Diet	Control Diet	Control Diet	PBS
Positive Control (T2)	Control Diet	Control Diet	Control Diet	*S. agalactiae*
Treatment T3	Dose 1: 0.5g/kg	Dose 1: 0.5g/kg	Control Diet	*S. agalactiae*
Treatment T4	Dose 2: 1g/kg	Control Diet	Control Diet	*S. agalactiae*
Treatment T5	Dose 3: 2g/kg	Control Diet	Control Diet	*S. agalactiae*
Treatment T6	Dose 4: 3g/kg	Control Diet	Control Diet	*S. agalactiae*

Table 2. Feeding design of the experiment.

Negative and positive control, control feed, 51 days		*S. agalactiae* challenge, monitoring 14 days
Treatment 3: 51 days		
Treatments 4, 5 and 6; 21 days	Control feed, 30 days	

Feeds

The commercial feed used in this study was No.0 fingerling fish feed with very fine particles. The feed additives were mixed with this feed. A binder (CMC – carboxymethyl cellulose) and water were added before being put in a pressurised meat grinder to produce pellets of size 1.5-2mm in length. Yeast parietal fractions (Safmannan®, Phileo Lesaffre Animal Care, France) with a composition of ≥ 20% mannans and ≥ 20% beta glucans were added to the treatment diets as shown in Table 1.

S. agalactiae challenge

A consistently virulent MPA's strain of *S. algalactiae* (NUF18 strain) was inoculated in Tryptic Soy Broth (TSB) sodium chloride and incubated for 24h at 32°C in a shaker-incubator at 140rpm. Bacterial density was measured by optical density absorbance (OD600 nm). A standard volume of bacterial suspension was injected to each challenge fish to achieve a pathogen density of 1.0E+07 CFU/fish to kill 50-60% fish in the positive control within 14 days. After 51 days of feed additive administration, all the fish in treatment T3, T4, T5, T6, and positive control (T2) were subjected to an intraperitoneal injection challenge at LD50. The negative control (T1) was treated with sterile PBS at a dosage 0.3mL/fish. During the challenge period, all treatments and control groups were fed with a control diet without any additive supplementation.

Histological analysis

All moribund fish were sampled for histopathology; they were injected with 10% formalin, processed, and stained with hematoxylin and eosin-phloxine using routine histological methods. The histological sections were analysed by light microscopy for *S. algalactiae* lesions in the hepatopancreas.

Sampling and observation

Fish were monitored daily for 15 days post-challenge and checked for morbidity/mortality and gross clinical signs of disease. Dead and moribund fish were removed and the presence of gross lesions both externally and internally was recorded and then the kidneys were aseptically sampled for *S. algalactiae* using TSA. Moribund fish were fixed in 10% formalin to check for *S. agalactiae* pathology. Samples were taken from the kidney, spleen, eyes, brain, liver, intestine, gills, and heart for bacterial analysis. PCR assays were also performed to confirm the presence of *S. agalactiae* in the samples collected during the challenge period.

Water quality parameters such as dissolved oxygen, pH, and temperature were measured every day. Total ammonia concentration, nitrite, and alkalinity were also measured twice a week. At the termination of the challenge study, all live animals were counted as survivors.

Survival and growth rate

Survival rates of experimental fish after 51 days of feed additive administration showed no significant difference in survival among treatments and with the controls (T1 & T2) ($P > 0.05$). No significant difference was also observed in the fish growth rate.

Cumulative mortality rates

The survival rates of the treated fish at 14 days post-challenge are shown in Figures 1 and 2. We did not observe any clinical signs of *S. algalactiae* infection and any mortality in Treatment T1. Hence, this indicates that the trial set up was acceptable and no cross-contamination happened to the negative control. Mortalities started rapidly in the control group (13% at day 1) up to day 10, whereas in the experimental groups, there was no fish mortality in the treatments up to 15 days post-challenge. The clinical signs of infected fish included, abnormal behaviour, anorexia, eye lesions, skin haemorrhages, lethargy, erratic swimming/spiralling and resting at the bottom of the tank at day two post-exposure. The targeted mortality of 50-60% was observed in the positive control group, within 14 days. Cumulative mortality rates of 22.26 ± 4.50%, 20.94 ± 13.94%, 28.63 ± 7.35%, and 35.34 ± 13.10%, were recorded in Treatment T3, T4, T5, and T6 respectively (Figure 1).

Resistance to *S. agalactiae*

All treatments demonstrated a higher resistance against *S. agalactiae* in *O. niloticus* during this 14-day challenge. This confirmed the beneficial action of yeast parietal action already observed in shrimp (*Aqua Culture Asia Pacific*, Mar-Apr 2015; Jan/Feb, 2017). This action can be due to the binding of pathogens by the mannans present in the yeast fractions, which subsequently lowers the pathogen pressure. On the other hand, the high level of beta-glucans in Safmannan® will trigger a better immune response in tilapia.

The best protection was shown with low levels of yeast fractions at 0.5g/kg administrated during the whole feeding period. We also observed a similar protection with levels of 1g/kg administrated only for 3 weeks, 1 month before the actual challenge took place. Higher levels of products did not show better protection, indeed the trend was to show a lower resistance towards the pathogen. It is possible, as already shown in other species (Japanese sea bass, Yu et al 2014) that a high application of yeast fractions can have a detrimental effect on the immune system. Although it must be said that in that case, we have stopped the administration early to have a significant difference.

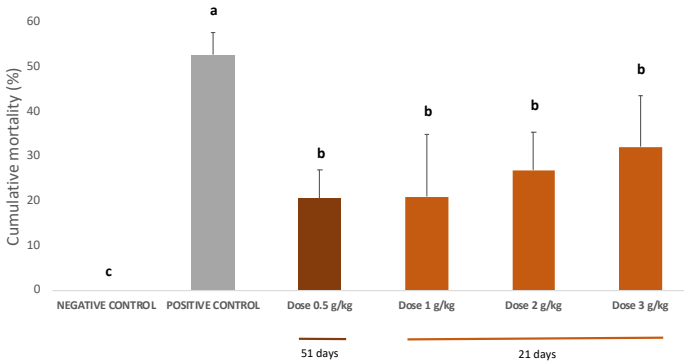

Figure 1. Survival rates of fish in the treatments at day 14 post-challenge (Mean ± SD) of the treatments. Different superscript letters indicate significant differences ($P < 0.05$).

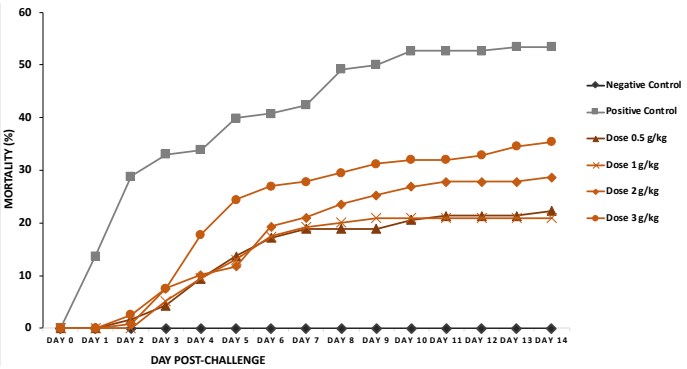

Figure 2. Cumulative percentage daily mortalities in fish in the treatments exposed to *Streptococcus agalactiae* during 14 days.

As we have shown in shrimp, dosages and administration period are crucial factors to the efficient usage of immunostimulants. It is very important to target the right stage with the right dosage. We cannot apply the immune stimulant protocol for one species (e.g. shrimp) to another (e.g. tilapia).

The key finding of this study is that there is a persistent effect of the immunostimulant treatment. The effect can be seen even 30 days after the administration was stopped. We can envisage then that the immune system was "trained" by the yeast parietal fractions. This can prove to be very beneficial in strategies to prevent the outbreak of diseases in farms by applying prevention in advance before the actual stress (pathogen, environment) happens.

However, more work is required. In particular, we need to see whether a minimum intake of immunostimulant will be able to trigger this training effect, and the maximum duration that this effect can last. It should also be interesting to see the synergy of these yeast fractions in conjunction with vaccination.

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Farming the crayfish in China

By Wang Yao-Hua, Xiao Hai-Dong, Dong Qiu-Fen and Zhang Song

With soaring demand, attention is now on extruded sinking feeds with higher palatability for more efficient molting and higher growth performance in monoculture systems.

Crayfish *Procambarus clarkii*, is known as Xiao Long Xia, 小龙虾 and is translated as small freshwater lobster in China. Taxonomically, it belongs to the subphylum *Crustacea*, order Decapoda, family *Cambaridae* and genus *Procambarus*. Crayfish is endemic to North America and was first introduced to China from Japan in the 1930s. It is now widely cultured in China; five provinces (Hubei, Hunan, Jiangsu, Anhui and Jiangxi) account for 95% of the total crayfish production in China. The species has benefitted from the "explosive growth" of the middle-class population in China. Consumption is booming, and it is a very popular seafood product both in e-commerce and traditional market channels which in turn have greatly stimulated crayfish farming. According to official statistics, in 2017, the annual crayfish production of China was nearly 900,000 tonnes, (compared to 265,000 tonnes in 2007), with a market value of CNY 60 billion (USD 9.5 billion, at the exchange rate of CNY 6.3/USD). Some 5 million farmers and related stakeholders are involved in this industry. The crayfish farming area is around 600,000 ha and is expanding. Crayfish has become a key aquaculture species in China and is set for further expansion.

Breeding

The breeding season of crayfish is from September to October. During natural breeding in ponds, the stocking ratio of female:male is 3:1 and after mating the fertilised eggs are housed in the female's abdominal region. If the water temperature is low, the berried females will dig holes in the pond, and stay there for the fertilised eggs to hatch into larvae. Crayfish larvae stay in the holes, until the next spring when the water temperature rises. Besides natural breeding, artificial breeding has been well developed since 2005. Some commercial crayfish breeding companies can supply enough and good quality post larvae at a size of around 5g/PL.

After mating the fertilized eggs are in female's belly region.

Juvenile crayfish

Farming systems

Paddy-crayfish farming

This is an ecological farming system where the crayfish is farmed simultaneously with paddy. Crayfish production is 50-100kg/mu (750-1,500kg/ha). Although this production is small, it can increase the income of paddy farmers. It is recommended by the government.

Paddy-crayfish farming system. Yield is 750-1,500 kg/ha.

Crayfish-crab polyculture

This is an efficient farming system where crayfish is co-cultured with Chinese mitten crab, *Eriocheir sinensis* in earthen ponds. The average production of crayfish and crab is 100-200kg/mu (1,500-3,000kg/ha). Some farmers with good farming technology can even achieve a production above 200kg/mu (3,000kg/ha). Chinese mitten crab is another important commercially cultured crustacean and is a very popular seafood in China.

Pond monoculture

This is a highly efficient system, with an average crayfish production of 100-200kg/mu (1,500-3,000kg/ha). Waterweed cultivation, mainly *Elodea nuttallii*, is particularly crucial either in monoculture or in polyculture systems, as waterweeds can generate oxygen via photosynthesis. Waterweeds also provide shelters and prevent cannibalism during the crayfish molting phase. They usually cover 60-70% of the pond area. However, if the amount of waterweeds is insufficient, crayfish yield is usually low. Farmers prevent the waterweeds from growing below the water surface to avoid any phytoplankton blooms and crashes as well as bad water quality. Such occurrences will lead to a shortage of waterweeds in the pond and increase farming risks. Farmers need to control the density of waterweeds during the farming period. In addition, crayfish feeding on waterweed indicates a shortage of commercial feed consumption and requires the feed volume to be increased accordingly.

Table 1. Comparison of three farming practices.

Farming practices	Paddy field farming	Crayfish-Crab poly culture	Pond monoculture
Pond depth (m)	0.8-1	1.5-2	
Pond area (ha)	0.6-200	0.3-3.3	
Stocking density (PL /m^2)	4-9		
Stocking size (g/PL)	6-8		
Waterweed	None	*Elodea nuttallii, Hydrilla varticillata*	
Culture duration (months)	3-5	3-7	3-6
Harvest size (g/individual)	20-60		
Yield (kg/ha)	750-1,500	1,500-3,000	1,500-3,000
Net income (USD/ha)	7,143-11,905	7,143-14,286	
Pelleted sinking feed price (30% CP, USD/ tonne)	825-888		
Extruded sinking feed price (30% CP, USD/ tonne)	873-1,032		
Medicines/chemicals	Seldom used	Farm care products & disinfectants	

Waterweeds in monoculture system

Mower to control the waterweed height in water

Harvesting with net cages

Commercial crayfish

Feed technology

Crayfish larvae consume mainly phytoplankton and zooplankton as food. Following molting, the crayfish grow to a body length of 1.5-2.0cm. Post larvae can feed on commercial feed. In the major culture provinces such as Hubei, Hunan, Jiangsu, Zhejiang, Jiangxi and Anhui, there are more than 80 feed mills producing pelleted or extruded sinking feed for crayfish.

Extruded sinking crayfish feed contains crude protein from 26%-32% and prices range from CNY4,500-6,500/tonne (USD 714-1,032 /tonne). Pelleted feed prices range from CNY 4,000-6,000/tonne (USD 635-952/tonne). Different feed brands often differ in quality and farming performance, thus resulting in different pricing and popularity.

Pelleted sinking feed, CP 28% (2.0mm)

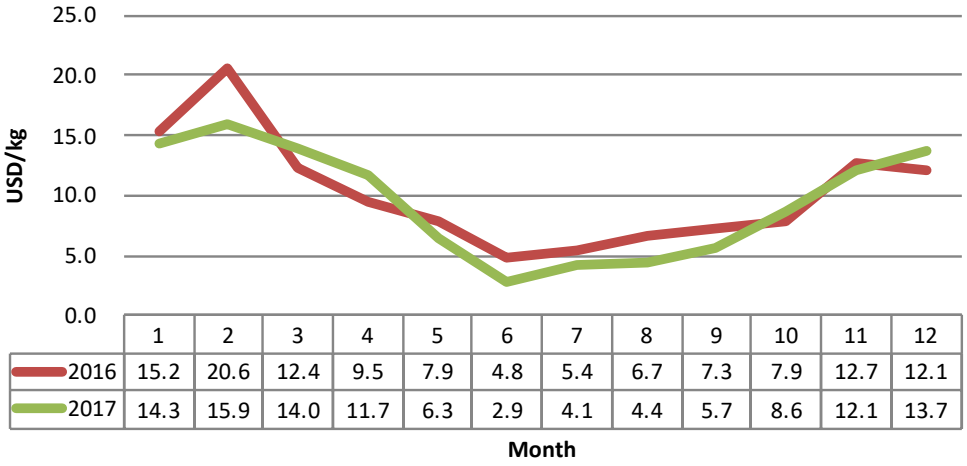
Pelleted sinking feed, CP 28% (3.0mm)

Extruded sinking feed, CP 28% (2.0mm

Extruded sinking feed, CP 28% (3.0mm)

The nutritional requirements of the crayfish are different from other shrimp and prawn species Only some suitable feed ingredients with reasonable costs can be selected and used in its formulation. The crayfish has special feeding habits. Water stability of commercial feed should be a minimum of 3 hours. Extruded feed is always better, with higher water stability and less dust, but 100% sinking is another basic specification of a good crayfish feed. On the other hand, besides balanced nutrients, feed palatability to stimulate crayfish feeding behaviour is a priority. Feed composition should enable the crayfish to go through molting efficiently and successfully as well as show good growth performance. Bad feed palatability and poor molting will lead to high mortality and low production.

To ensure excellent and consistent feed performance, scientific knowledge needs to be applied in raw material selection, optimal feed formulation and finally, feed production. With decades of accumulated expertise in feed nutrition and technology, Guangdong Nutriera Group has a good reputation for supporting many crayfish feed enterprises with specific knowledge in feed formulation, production and technical support.



	1	2	3	4	5	6	7	8	9	10	11	12
2016	15.2	20.6	12.4	9.5	7.9	4.8	5.4	6.7	7.3	7.9	12.7	12.1
2017	14.3	15.9	14.0	11.7	6.3	2.9	4.1	4.4	5.7	8.6	12.1	13.7

Crayfish prices (USD/kg) in Hubei province during 2016-2017.

Consumption

With different cooking styles in different types of restaurants, crayfish is becoming more and more popular among the young generations from eastern and central China to southern China, and even in Myanmar, the Philippines and in Chinese restaurants of Southeast Asia. The Chinese crayfish industry has become a total value chain industry and includes farming, processing, consumption and tourism from "capture + restaurant" model in the past 20 years. Cold-chain logistics and e-commerce have pushed crayfish consumption in different cities in China. Some governmental offices and enterprises are promoting vigorously crayfish brands in different locations, such as Qianjiang Crayfish in Hubei province and Xuyi Crayfish in Zhejiang province. Every year, the authorities in these two cities, Qianjiang and Xuyi, hold crayfish festivals. They invite famous celebrities to endorse and promote crayfish consumption. The Jiangsu Xuyi Crayfish Festival and Hubei Qianjiang Crayfish Festival have been held over 17 consecutive years and 8 years, respectively; they have attracted millions of consumers.

Apart from the mainly domestic consumption, whole crayfish and value-added products like shelled crayfish are also exported to the United States, Russia, European Union, Japan and the Middle East, creating a USD 259 million export industry in 2016. Soaring demand for crayfish and high prices have made crayfish farming a more profitable business.

Crayfish dish on the table (Source: js.ifeng.com)

Strict quality control system of JD E-Commerce

The crayfish shell comprises more than 50% of the whole-body weight and it can be used to produce chitin and astaxanthin products, which are used in the healthcare and chemical industry, such as in the production of artificial skin, and in the cosmetic, and clothing industries.

Prospects

Crayfish has become a popular seafood product and the demand is increasing in China as well as in nearby countries. Production is expected to increase in the coming years. There are also some disease problems in crayfish farms during the hot season with 30~35 °C water temperatures and when temperatures fluctuate with the rains. With strict food safety regulations, the use of antibiotics is not allowed. The production of crayfish free from harmful substances, the use of new technology and sustainable farming systems are important for the future expansion of crayfish farming in China.

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Snail and grouper farming in Vietnam

By Fernando Castro

Together, these are the second most lucrative aquaculture business after intensive shrimp farming.

The two Asian countries with the largest diversity of aquaculture practices are Vietnam and China. In Vietnam in the Cam Ranh area of Central Vietnam, there is the traditional culture of babylonia snails *Nassaruys aerolata* and three families of groupers: giant grouper *Epinephelus lanceolutus*, black grouper *Epinephelus malabaricus* and the hybrid grouper, which is a cross-bred of tiger grouper *Epinephelus fuscoguttatus* and giant grouper.

This area from Cam Ranh airport to Phan Rang city has many bay enclosures, few or no rivers and windy conditions making it the driest area in Vietnam. However, the area has good water quality favourable for snail/grouper and vannamei post larvae shrimp hatchery production.

In Cam Ranh, farmers started culturing monodon shrimp more than 20 years ago. While some have changed over to culturing snails 10 years ago, others moved to farm grouper in ponds. Snail and grouper farming are the second most lucrative business after the intensive vannamei shrimp culture which ranks first in the aquaculture industry.

Snails and groupers are being cultured in a sustainable manner from parent lines and hatcheries supplying baby snails produced in Vietnam. The snail breeding centre is RIA 3 (Research Institute of Aquaculture No 3) which sells eggs to hatcheries located in Phan Rang. Grouper fry are imported from hatcheries in Taiwan and Indonesia. Vietnam also produces some grouper fry but the farms I visited prefer to import fry which give better survival and growth.

The traditional farming method for snails and groupers in Cam Ranh consists of many small farmers, operating 4-8 ponds each. The ponds are 2,500 m^2 in size and have two sluice gates on opposite sides of the ponds for the incoming and discharge of water on both sides depending on wind conditions and daily tides. Snails and groupers are cultured in separate ponds, so most farms have 1 - 2 ponds for snails and 3 - 6 ponds for grouper culture.

Babylonia snail culture

Snail culture ponds are sited at the outer perimeter near the dykes; these ponds are enclosed with a green screen netting to prevent snails from crawling out. Each pond has two paddle wheels and four aeration devices to aerate the pond water over 22 hours.

The production cycle starts with the stocking of 2.2 to 3 million baby snails. Each kilogram of snails contains approximately 39,000 baby snails and cost an average price of USD2/1000 baby snails.

The snails are then reared in the same pond for 6 months to reach the marketable size of 150-170 snails/kg and sold at an average price of USD11.91/kg. Snail culture is very profitable as compared to grouper culture, but has more risks. Snails require more intensive work and more trash fish as feed. The price of baby snails, trash fish and final sale price of snails tend to fluctuate. Snail culture brings profits of 200% to 300% of investment, shorter cycle of 6 months and high production yields.

Snail culture ponds. Notice the green screen netting to contain the snails from crawling out.

Critical stages

The first two months of baby snail culture are the most critical periods. During the first month, they develop the shell and second month the meat. The first 10 days of culture (DOC) is where the highest mortality may occur at 30% to 50%. During the first DOC 60, the amount of trash fish used to feed the snails start from 30kg to 100kg of trash fish. In the remaining 4 months, they will feed on 200 to 400kg of trash fish/day. The feeding is done for 3 days and stopped for 2 days. Some farmers practise a two-phase culture system; after DOC 60, they transfer snails from the nursery pond to grow-out ponds in the next phase.

Pond water management is done based on a 24-hour tidal table to exchange water during high tide; farmers fill water for 2 hours and then hold the level for 8 hours and during the low tide, drain water for 2 hours. There is approximately 30% to 70% water exchange in the ponds/day. The highest pond water level is 1.8 to 2m in depth and a drained pond will have a lower level, down to 0.7 to 1m.

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Snails collected during the daily cleaning of earth pond bottom at 3 months of culture

Cleaning baby snails of macroalgae

Fernando Castro (centre) with two first generation snail - grouper farmers, on the left, Phan Thanh Thuy and on the right, Phan Dinh Kiet

Water exchange is subject to tides during the year and the rainy season. The water quality is best between March to September with no rain and from October to February, the rainy season will be very problematic for snail culture.

Feeding with trash fish

The snails are fed ground trash fish starting from DOC 1 to DOC 10, reaching 40kg in the first month and up to 100kg during the second month to DOC 60. Feeding baby snails is done in the afternoon from 3:30 pm to 4:30 pm when the water temperature is lower, and the pond bottom has been cleaned. The feed conversion for snails is 9 to 10 tonnes of trash fish to 1 tonne of snails harvested after DOC 180. Once the snails have reached a size of 150 to 170 snails/kg or 700 snails/m^2, they are harvested by a machine that collects the snails buried at 15 to 20cm in the earthen pond bottom. The amount of snails harvested/pond can reach 11 tonnes with a survival rate ranging from 50% to 80%. The snails are harvested all at once and are sold locally or to markets in China. Monodon shrimp are also stocked at 1 shrimp/m^2 and harvested together with the snails.

The daily chore in snail farming includes water exchange, feeding and cleaning of the pond bottoms for macro algae and debris to keep the pond bottom clean for snails. Farmers use nets to sweep the bottom of earthen ponds.

Culture of groupers

The three species of groupers are cultured in 2,500 m^2 ponds with a depth ranging from 1.8 to 2.0m^2. The ponds have one paddle wheel that operates for 16 hours/day to increase the dissolved oxygen in the pond water during the afternoon and evening hours.

Black and hybrid groupers are cultured in a two phase system, nursery and grow-out ponds. In the first phase, nursery ponds are stocked with 12,000 to 15,000 imported grouper fry of 7cm long. Each fry cost USD1.13/fry. Nursery ponds are divided into two areas with green netting. During the first 30 days of culture, grouper fry are held in one half of the pond. After 30 days the net is opened to provide more space for the fry to reach the transfer size of 200 to 300g after 90 days of culture. During the first 3 months of culture in the nursery phase the grouper fry mortality rate is highest.

From the nursery pond the groupers are transferred to the grow-out ponds for the remaining 8 to 9 months of culture. Groupers grow to 800g in 7 months and 1kg in 10 months. The black and hybrid groupers are harvested after 11 to 12 months at 1.2 to 2kg/fish or 2,200 to 2,600kg/pond and sold for USD10/kg. Groupers have a more stable price in the market. Grouper survival ranges from 50% to 70% as cannibalism is a big issue.

In the case of the giant grouper, ponds are directly stocked with 500 fish/m^2 into 2,500 m^2 pond and harvested after 36 months, when fish reach 20 kg fish. Groupers move the soil bottom of the ponds to create nests for resting. Groupers are partially harvested on demand and sold live for local consumption.

Water management and feeding

After the nursery phase is the grow-out phase, where groupers usually do well with few problems. Water management with more than 50% exchange is done per day depending on the tide table.

Grouper ponds. In the first phase nursery ponds, fry is reared over DOC 90 to 300 -400 g sizes

In the second phase, fish are kept in grow-out pond for 8 to 9 months until they reach 1.5kg/fish.

Groupers are sold live to local Vietnamese restaurants.

Small trash fish are fed to the grouper starting at the nursery phase with 20kg for the juvenile grouper. Feeding is twice a day at 6:30 am to 7 am and 4:30 pm to 5 pm for the first 3 months and feeding is continued at the grow-out phase every other day at 4 pm to 5 pm reaching up to 200 to 250kg of trash fish/day. Some farmers use dry feed for the first 3 months of culture and then change to trash fish for the remaining 8 to 9 months of culture.

Iced trash fish are bought from local suppliers. The availability and quality vary during the year as well as price. The price for trash fish averages USD0.97/kg and the range is USD0.65 to USD1.39/kg. Commercial dry feed costs USD1.30 USD/kg.

In both cultures after the ponds are harvested the soil bottoms are tilled, chlorinated and dried for 1 month before stocking again. Some probiotics are used during the culture.

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Sexual cycle of the Asian seabass in oceanic salinity and high temperature conditions

By Alain Michel

Oceanic salinity and high temperature conditions open the possibility for mating males and females of the same age instead of a commonly applied one-year age difference.

When an Indonesian farm decided to start a selective breeding program for the Asian seabass *Lates calcarifer* in 2010, it became crucial to obtain information on the environmental conditions encountered all year round and their effects on the sexual cycle of the fish. Near this farm located on Jukung Island, in the Pulau Seribu Archipelago, north of Jakarta, the surrounding waters has a constant temperature of 28-29°C and an oceanic salinity of around 33 ppt all year round. There is no native population of seabass in the area and the founding broodstock originated from South Sumatra.

The Asian seabass or barramundi undergoes sex reversal in the wild. Males of 2.5 years with females of 3.5 years are commonly used for reproduction, as the maturation of males and females in a same batch are not synchronous. In the Java Sea conditions, we observed that at the same age in each cohort, primary females were found developing without going through a male stage at least with regards to gonadal development. This is the first time that primary females were observed in a captive population.

This finding opens a new possibility of running a selective breeding program by mating males and females of a same batch. This results in a gain of 1 year in each captive generation: less than 3 years instead of 4 years. Our observations were based on gonads in samples collected in 2010-2012;

- dead fish after dissection of the gonads
- live fish in onshore tanks or in cages with gonad samples extracted with cannula and microscope observation of smears
- fish at the processing plant, when, after weekly harvesting the fish were gutted and filleted, and the gonads collected for observation,
- random sampling of 400 fish in cohorts of the selective breeding program. Some pieces of gonad were preserved in Bouin Holland for histological studies.

The appearance of maturation was followed by regular checks during a 4-month period, following the first signs of maturation, both in broodstock under culture in onshore tanks and in grow-out cages. The examination of fresh smears was very informative, giving an immediate answer and the results were always confirmed by histology.

Gonadal development

Figure 1 shows that in 30g to around 2kg fish, immature gonads look like a thread on each side of the swim bladder linked with a veil of grease adhering on its surface. At around 24 -28 months the gonads undergo development with cells multiplying inside the thread which is increasing in diameter to reach its final shape of ripe ovaries or fluent sperm gonad (Figure 2). The early development is different for males and females. Primary females start by developing a small inflated area near the anus and then increasing anteriorly. When their gonad is fully developed, they continue to remain as females. Figures 3-6 show the development

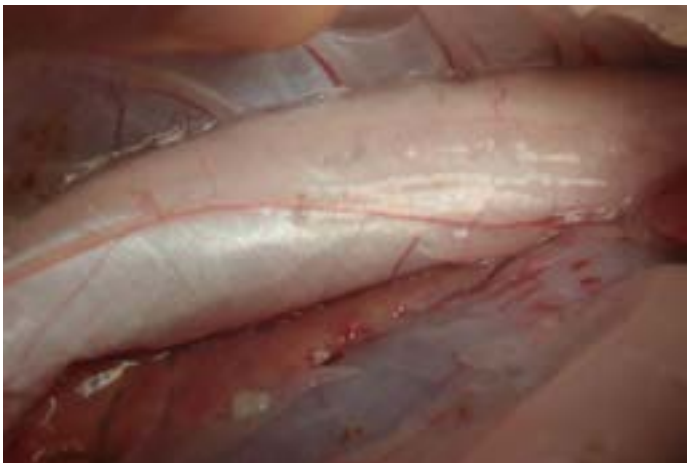


Figure 1. Immature gonad

Figure 2. Male and female gonads

Figure 3. Two immature gonads and one developing.

Figure 4. Primary female gonad starting to developovocytes inside

Figure 5. Primary ovocytes

Figure 6. Primary ovocytes enlarge with nucleus

of a primary female gonad. In general, after 3 years all fish of more than 2.5kg are females with ripe ovaries. In the case of the male fish, the development is ongoing on the whole thread at the same time and the gonad increases in diameter prior to developing lobules covering and adhering to the swim bladder. After the gonad is fully developed with motile sperm, the sex reversal can be very fast in a matter of less than two weeks.

Onshore tanks

Sex differentiation appeared after 24 months in new broodstock under culture. However, all fish sampled before 24 months in the shallow ponds were immature with the gonad aperture closed. Results varied with different batches. For example, the batch of March 2008 matured in 2010. No male was found; only primary females with gonads of different sizes covering progressively the swim bladder were found. When inflated on the first quarter, there was only primary ovocytes and when covering the three-quarters, secondary ovogenisis was starting. No gonad was in a condition to have reversed from a previous male gonadal stage.

In a processing plant

Table 1. Sampling for new broodstock during a 4-month period after 24 months in ponds.

Date of sampling	Age	Number/weight range	Gonadal status
19 July 2009	10 weeks	90/6g	All immature
23 September 2011	24 months in pond	75/1.5-3kg	All immature
22 October 2011	25 months in pond	68/1.6- 3.2 kg	All immature
22 November 2011	26 months in pond	61/1.8- 3.5 kg	39 females – mean 3 kg; 11 males-2.9 kg; 11- immature
20 December 2011	27 months in pond	50/1.8- 3.6 kg	46 females - 4 males

We looked at internal organs in fish harvested at the end of July 2011. These fish were in cages for 23 months and were 28 months old. The results indicated the following:

- gonads were still undeveloped with just two threads along the swim bladder
- male gonads with fluent sperm
- female gonads with mature ovulae.
- two females with hermaphroditic gonads: mature ovulae and fluent sperm

One gonad probably still under sex reversal, with both mature ovulae and fluent sperm on the outer part of the ovary, a possible sign of hermaphrodism.

Fish in this cage were clearly in the middle of maturation, with all the stages represented. In this harvest, primary females under development were not observed but, according to the age of the fish in the cage, the female gonads found were coming from primary females.

During the following harvest from the same cage, on the harvesting platform, we checked for male sperm by applying abdominal pressure. We found 42 mature males out of 100 fish. These males were transferred on to shore tanks. Five days after the harvest, only five males oozed sperm on application of pressure, while the others did not. Even cannulation was not possible. We killed 10 fish to observe male gonads which had some fluent sperm becoming motile when released in seawater. However, these gonads were of different hardness, indicating probably the start of the normal sex reversal. The changes are occurring over a short period of time which explained the different proportions of males and females.

In general, the quantity of sperm obtained by applying pressure was low, at less than 0.5 mL. Table 2 detailed the results from sampling at a processing plant. The harvest of 18 September 2011 from a younger cage (26 months old fish, i.e. 21 months in the cage) showed that;

- no primary female was found
- all the developing gonads starting from the gonad thread stage were male gonads with a first reddish appearance and with a development along and in close connection with the grease veil on the swim bladder: 6 out of 60.
- some bigger gonads becoming whitish but without fluent sperm: 3 out of 60.
- all the other fish 51 out of 60 were undifferentiated.

It appeared clearly that in this cage, fish were at the starting point of sex differentiation with different male gonadal stages.

Table 2. Results of samples taken at the processing plant from September to November 2011.

Date	Cages No	Fish sampled	Gonadal threads	Gonad developing	Gonadal development
18 September 2011	KJ2 6	60	51 (85 %)	6 (10%)	3 males, 5%
22 September 2011	KJ2 6	60	48 (80%)	10 (16%)	1 male 1 female, 3%
26 September 2011	K9 S	60	11 (18%)	25 (33%)	24 males 4 females, 46%
29 September 2011	K9S	60	17(29%)	18 (30%)	25 males, 42%
3 October 2011	K9S	20	5 (25%)	2 (10%)	11 males 2 females, 65%
6 October 2011	K12 J2	20	12 (60%)	1 (5%)	6 males 1 female, 35%
20 October 2011	K9S	20	9 (45%)	5 (25%)	5 males 1 female, 30%
24 October 2011	K13 J1	20	6 (30%)	2 females 2 males, 20%	8 males 2 females, 50%
27 October 2011	K9S	20	5 (25%)	5 (25%)	9 males 1 female, 50%
30 October 2011		30	13(43%)	6 (20%)	10 males 1 female, 37%
3 November 2011	K13J1-K12J1	30	22 (73%)	8 (27%)	
7 November 2011	K11 J2	30	25(83%)	3 (10 %)	2 males 7%
11 November 2011	K11 J2	30	28 (93%)	2 (7%)	
14 November 2011	K11 J2	30	27 (90%)	3 (10%)	
18 November 2011	K13J1-12J2		25(83%)	5 (17%)	
21 November 2011	K11 J2-		28(93%)	1 female (3.5%)	1 male 3.5%

Sample taken on 24 November 2011 showing primary female and male gonads

The sampling on 24 October 2011 was the most interesting with males and primary females developing all together: 8 males, 2 females, 2 males developing, 2 females developing in the same sample.

Primary females were also found in cages as well as in the oval ponds. The start of maturation can be traced in cages a little less than 2 years which means that the age of fish was around 27 months from the egg stage. In the older cages, among fish more than 2.5 years at sea, the smaller ones, often less than 1kg were mainly functional males with fluent sperm at a moment where all the bigger fish were all females.

Discussion

Surveys in wild populations in different areas of Australia (Northern Territories and Queensland), Thailand and Philippines, have shown a seasonal cycles with one or two periods of spawning year followed by a pause in sexual activity. These spawning periods correspond to the highest temperatures of the year and the pause to the lowest. The juveniles then migrate to freshwater and come back as males of 2-3kg to reproduce in the sea. Some land locked populations in lakes stay as males and never develop into females even at more than 10kg weight. The female gonad development needs oceanic salinity conditions and reproduction is always in saline coastal waters.

A captive population in Tahiti originating from juveniles imported from Southeast Asia and studied by Yann Guiguen (1992) presented a spawning season followed by a sexual rest. All the gonad development occurred in full saline conditions and the reproduction was always successful, demonstrating that the barramundi can achieve its whole cycle without migrating to freshwater.

In the wild, in the Gulf of Carpentaria, Australia, the existence of a population which did not migrate to freshwater, led to the maturation of males and females earlier than the migrating ones. In Jukung Island conditions, with high and constant temperatures and with oceanic salinity, the occurrence of primary females in population of F3 generations was high. Reproduction was achievable, both naturally from November to March but also all year round by hormone inducement. There is no sexual rest which could explain the primary females developing without any signs of a prior male gonad.

These primary females are available around 28 months at the time where males were also developing within the cohorts. In cages, a rapid sex reversal from males to females was observed like that in Tahiti (a two-week period) and after 30 months, only females found. The situation is different with fish kept in indoor maturation tanks, where the males remain as males at least for some extended period. It could be linked with the social and behavioural competition.

A practical point of view indicated that it appears that inside a batch of fish of around 28 months old, we can have both males with fluent sperm and females with ripe ovaries ready to be induced. Male and females are of similar size with some 100g difference in favour of females.

During the following 6 months, we observed that most of the males undergo sex reversal and around 3 years old, all the large fish were females. But there is always in the tail of the cages, smaller fish that were mostly male and remain as males permanently. Most of the males added into the maturation tanks at a small size remained small and male for at least some years. This was also noticeable with a few large males.

It could be that when entering as males in the maturation unit they remained as males under the social pressure of most females or the change in light conditions (all the other parameters remaining constant).

Conclusion

In the Java sea conditions, in a batch from the mass spawning of males and females we found that gonad maturation started around 27 months from the egg stage and after 23 months in cages in fish above 2kg. The primordial gonads were thread-like, but the development was fast. Some fish started as primary females and remained as females for their whole life. Many fish started as primary males at the same time with these possibilities;

- most of them underwent sex reversal quite fast as observed in Tahiti with full salinity conditions.
- some as large as the females could stay as males for many years when in maturation tanks.
- some, often small fish, remained as males on a permanent basis

A seasonal effect was observed with natural spawnings but it appeared there was no sexual rest as by using hormonal injection spawning can be obtained all year round. A potential higher inbreeding could be controlled through genotyping of selected fish.

The frequent occurrence of primary females was the first report for seabass in captivity. It opens the possibility for mating males and females of the same age instead of a one-year difference and thus, shortening the generation time to 3 years instead of 4 years.

References are available on request

Alain Michel is currently a permanent consultant for a new barramundi farm in Sri Lanka. From 1998 until 2014, Alain was scientific adviser to Fega Maricultura, a barramundi farm in Indonesia. Currently, his main interest at the field level is the boosting of the innate immune system to have better control of aquaculture pathogens. Email: alainhenri@aol.com

Continuously innovating shrimp farming

The focus is not only on developing research, but also on improving collaborative services with partners.

The shrimp farming industry continues to grow dynamically in Indonesia. New areas are being cleared for farming, particularly those with good water quality. This is one option to face the increasing challenge with disease which comes with declining water quality. Since disease is the main challenge for Indonesian shrimp farmers, there is a constant need to innovate farming systems to mitigate disease outbreaks.

This focus on diseases is not only by the smaller farmers but also by shrimp production divisions of major companies. One of them is PT Suri Tani Pemuka (STP), a subsidiary of the Japfa Group, a vertically integrated conglomerate with animal feed production and breeding to commercial farming and food processing.

STP has its own production ponds that are already profit-oriented. However, to support product development and collaboration with partners, STP ponds are also used as research ponds. This is important, as the development of a good shrimp culture system is a major focus of STP, as revealed by its Corporate Leader, Ardi Budiono, in a meeting with the Indonesian Young Farmers Association (PMI) in the STP farm located in Banyuwangi, East Java, in July 2018. "We focus on developing a farming system and cooperating with partner farmers," Ardi said.

Farming system upgrade

At this event, STP provided some information on its R&D in shrimp farming. One of them is the technology for super intensive indoor shrimp farming (Shrimp Supra Intensive Indoor -SSII).

According to STP's Head of Aquaculture Technical Development, Itang Hidayat, this technology is expected to be the solution for several problems, such as water quality, disease outbreaks, productivity, and unstable environmental conditions. “This system is for us to have a stable culture environment, especially when we anticipate weather changes. We know that weather changes are very extreme, particularly in the tropics”.

Furthermore, Itang elaborated that this is a system of shrimp ponds in a closed environment to reduce the influence of weather as an external factor. To reduce other external influences, this facility also uses a recirculation aquaculture system (RAS); utilising recycled water throughout the farming cycle up to harvest. This recirculation system is well equipped with physical, chemical and biological filters.

Rizki Darmawan (left) with STP's Corporate Ardi Budiono, in a meeting with the Indonesian Young Farmers Association (PMI)

According to Itang's research, this indoor recirculation farming system has not been widely applied by shrimp farmers. "Only one or two farmers are trying to implement RAS in shrimp ponds," said Itang.

Innovation for closed system farming

To develop this SSII system, Itang adopted ideas from a farming system for marine fish that has been applied in Norway and Canada for the salmon. As there are behavioural differences between shrimp and finfish, Itang did some modifications to match the requirements for shrimp. His modification is mainly in the arrangement of water flow which can affect the molting activity of shrimp.

The main objective of the SSII system, added Itang, is certainly to improve land productivity. By using this new high-tech system, STP tries to increase its productivity through increasing shrimp stocking density. This is also an effort to answer the challenge of reducing farming area. “Although it is difficult, but we try because with a small space we can produce larger volumes, " said Itang.

STP itself has several cultivation systems used in the Bomo 1 pond area, Banyuwangi. These systems use stocking densities ranging from 150-170 post larvae (PL)/m^3, 600 PL/m^3 and 1,250 PL/m^3 for the test SSII systems being developed. In its collaboration with partner farmers, STP will then use these as reference systems to apply in the farmer's ponds.

STP's management team with PMI members

Tanks at STP's super intensive indoor shrimp farming (Shrimp Supra Intensive Indoor -SSII) centre in Banyuwangi, West Java which Head of Aquaculture Technical Development, Itang Hidayat, says is the solution for several problems, such as water quality, disease outbreaks, productivity, and unstable environmental conditions in shrimp farming

Collaborating with farmers

STP is not only driving farming research in shrimp, but it is developing aquafeed and hatchery units, to increase cooperation with partners. STP focuses on providing various services for customers throughout Indonesia. "We do not only sell feed but also provide technical assistance as needed by farmers," said Sarwana, STP's Head of Shrimp Techinal Service and Training Center (STT), at the same event.

According to Sarwana, his team has two types of cooperation with farmers; technical assistance and technical cooperation. Technical assistance is an approach of the technical team to farmers who need partners to discuss farm related issues. However, the farmers themselves have the choice on the farming system to use in their ponds.

Meanwhile, technical cooperation involves the placement of a technician in the customer's farmto manage the production process at the partner farm. Thus, the standard operational procedure (SOP) used comes from STP.

"Before starting our program there is discussion. Then we will tell them in this location which farming system will be applied. We determine the steps together, " said Sarwana. In the collaboration, the STT-STP team focuses on disease management and production efficiency.

STT has a Shrimp Health department that specifically monitors the health status of shrimp farms. As for the efficiency program, STP wants the farmers to only use the required farm infrastructure, both in terms of types and numbers. Therefore, STT also has a surveillance team tasked with seeing the potential of a farming area. In case of an area with a bad record, such as the spread of disease, Sarwana and the team can anticipate through the creation of a farming concept that can mitigate the disease. "For example, in case of an area with a white spot syndrome virus (WSSV), the farming concept and reservoirs are adjusted to anticipate a white spot problem."

Itang Hidayat presenting to the young generation STP's R&D in shrimp farming.

Other production services offered include measuring water quality parameters in open waters around the farm area. According to Sarwana, currently his team has done this for approximately 6 months. They have found a relationship between the quality of open waters around the pond and the conditions of shrimp farming. "We look at many emerging diseases. It turned out that at that time the sea conditions were also changing."

From the analysis of various parameters of water sources, Sarwana can also give recommendations when the incoming water must be treated in full or partially. If the water quality is to adequate, the water treatment can be minimised. In addition, when water quality is good, farmers can also increase stocking density to optimise production. Conversely, vice versa, farmers should reduce stocking density if water conditions are less adequate. "The target is efficiency," Sarwana concluded.

Ease for farmers

The team members of STT-STP constantly improve their capabilities so that they continue to be ahead of growing farm problems. "We update knowledge every 4 months," said Sarwana. "We do this in various ways including collaboration with universities with fisheries study programs and focusing research on shrimp farming."

Ardi summarised, "The farming system which is continuously being developed by the STT-STP team is none other than to provide the best for its partner farmers in carrying out farming. It is especially so for beginner farmers with low farming hours." Ardi also expressed hope that the young farmers who visited the farms can benefit from the farming system implemented by STP. "Hopefully, the results of the visit are useful and we can expect future collaboration."

The young farmers welcomed this presentation from the STP team. The PMI Chairperson, Rizki Darmawan, representing his community, expressed his gratitude to the STP management for giving them the opportunity to visit the production ponds as well as learn the development of the latest farming system in Bomo 1 pond. "We are very grateful for this exchange of information by the STP staff to update our information on innovations in shrimp farming, "said Rizky.

The article was prepared by Asep Bulkini, TROBOS Aqua

Sponsor at TARS 2018 on shrimp aquaculture

Multinational feed additives producer **Nutriad**, pioneer in species specific additive solutions in aquaculture, once again sponsored The Roundtable Aquaculture Series (TARS) which was held in August in Chiang Mai, Thailand. The theme of TARS 2018 was Shrimp Aquaculture: Need for Change and Nutriad specialists presented views on the use of novel feed ingredients and additives to improve nutrition and health in shrimp production across the world.

With over 250 attendees, TARS 2018 attracted international and regional aqua feed mills, including Cargill, CPF, Thai Union, Thai Union, TRF, Gold Coin, DeHeus, BioMar, as well as farm owners and major suppliers in the region to share updates and experiences and explore workable solutions towards increasing efficiency in shrimp farming. "Low Shrimp pricing is the main issue producers are facing this year, but we believe that we can still manage feed cost through innovative nutritional approaches," said Dr Fai (Poonmanee) Kanjanaworakul, Technical and Commercial Manager Aquaculture, Nutriad Asia Ltd (Thailand).

"In the past few years, farmers have managed to offset increasing production costs with strong global shrimp prices. At TARS, the industry sector advocated for an aggressive Need for Change towards more efficient production to sustain profitability of shrimp production," says Allen Wu, Aquaculture Manager APAC for Nutriad.

Dr Waldo Nuez, Nutriad´s Aquaculture Lead Scientist, shared his views on the potential of novel feed ingredients and functional feed additives to upgrade the current nutritional and functional value of shrimp feeds. His presentation received special attention and questions from participants, particularly feed producers, aiming to secure production efficiency and good health of shrimp by improving their formulations. "Traditional plant ingredients, novel oils and protein sources will improve the inputs of some but not all essential nutrients, so functional feed additives aiming to maximise the efficiency of absorption and utilisation will be key to extract more nutritional value of each kilogram of feed," said Nuez.

Dr Waldo Nuez, presenting at TARS 2018

Nutriad delivers products and services to over 80 countries through a network of own sales offices and distributors. Supported by 4 application laboratories and 5 manufacturing facilities on 3 continents. www.nutriad.com

Collaboration on feeding systems

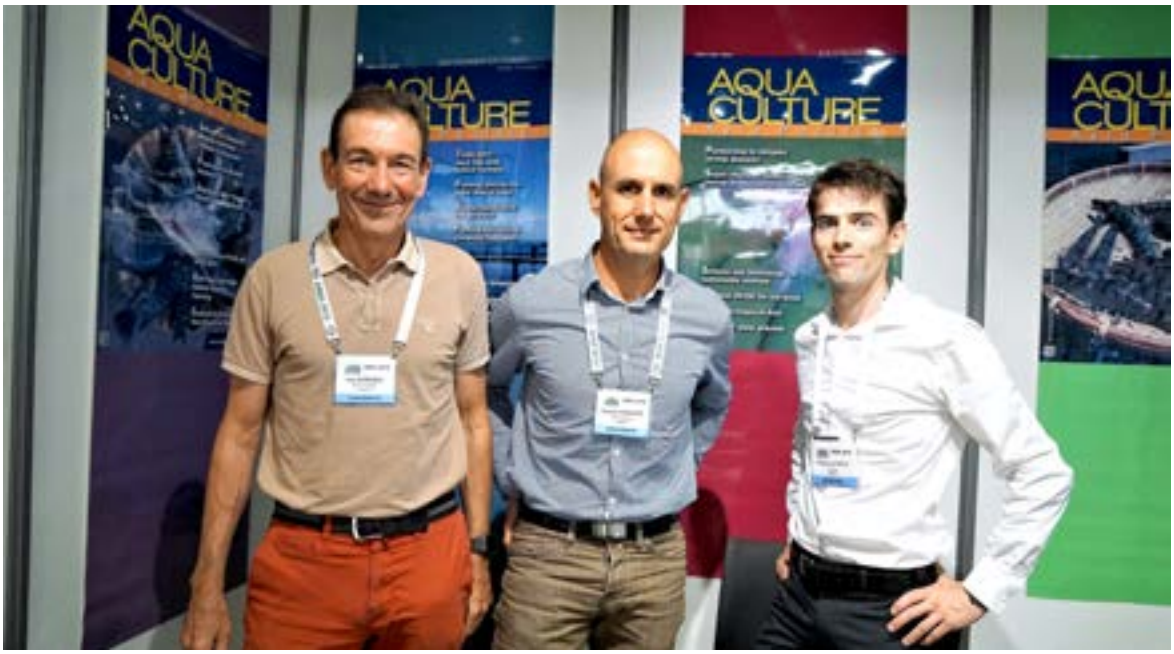
Hatchery Feeding Systems (HFS) manufacturer, **Nutrakol**, has nominated **Fish Farm Feeder (FFF)** as its European distributor. The nomination was announced during the Aqua2018 trade show in Montpellier France, in August.

The collaboration between Nutrakol (Australia) and FFF (Spain) enables the companies to cover all stages of feeding and all sizes of facilities. The HFS is aimed at the small to medium hatcheries, as well as research centres. The HFS provides a solution for all hatchery feeds, liquid and dry. The FFF systems are aimed at larger hatcheries and grow-out facilities, both land-based and off-shore.

"Having all the feeding solutions for any aquaculture facility and organism, from the smallest to the largest, under one roof will enable us to optimise the systems to the client needs," said Miguel Arostegui, Managing Director of FFF. www.hatcheryfeedingsystems.com / www.fishfarmfeeder.com

Dr Sagiv Kolkovski, Director, Nutrakol (left) with Miguel Arostegui at their booth.

Natural free amino acids mixes for aquafeeds



From left, Joël Duperray, Pierrick Kersanté and Aquaculture Nutrition Consultant, Guillaume Le Reste at Aqua 2018.

BCF Life Sciences is based in Brittany, France and produces natural mixes of free-L form amino acids, extracted from a sustainable protein source, poultry keratin. The production is through 25 steps of an extensive and proprietary keratin hydrolysis process technology. This ensures a very stable and standardised product. Kera-Aqua®, the food grade product being marketed for aquafeed formulations has 92% amino acids in the free form and there are 17 amino acids. L-proline, L-serine, L-glutamine acids, L-glycine, L-valine and L-leucine are present at higher levels.

BCF was established in 1986 and specialises in the extraction of natural amino acids (L-cystine and L-tyrosine) and their derivatives of 100% traceable origin for the pharmaceutical and health care industries. It also has a range of highly soluble and highly bioavailable free amino acid mixes with very low molecular weights for industrial applications in human, animal and plant nutrition. It is present in 38 countries, mainly in the pharmaceutical and pet food segments. In Japan, it markets pure cystine, tyrosine, carbocisteine, specific for the pharmaceutical industry. It is now fast entering the aqua feed sector and has set up an office in Thailand 5 years ago. Luxsanawadee Soonngam is the Business Developer for Aqua Southeast Asia Markets.

"The amino acids mixes are already popular as an attractant in carp fishing and now we see its potential to increase palatability and potentially reduce fish meal. We just started in the aqua feed industry 3 years ago. We believe our Kera Aqua range is an interesting candidate for the aqua feed industry. Our standardised process followed by rigid quality control means that feed millers will not need to upload formulation matrix with each delivery. Kera-Aqua® is a low molecular weight feed ingredient (100% less than 800 Dalton and 92% less than 250 Dalton) which facilitates high assimilation rates," said Joël Duperray, Scientific Support and Application Manager, at the Aqua 2018 trade show in Montpellier, France.

BCF has a dedicated range for fish and shrimp feeds. These are presented as liquid or powder forms. Both Kera-Cal49 and Kera-Boost55 are concentrated liquids and Kera-Stim50 is a powder. All three are recommended for feeds for the grow-out cycle. The inclusion rate will depend on the production and ranges from 2.5 to 20 kg/tonne of feed. Kera-Start88 and Kera-Start90 are powders for the inclusion at 2.5 to 50kg/tonne of feed for larvae and early stages. The products are EFSA (European Food Safety Authority) approved as well as certified with GMP+.

"We have already conducted trials at Neovia's research centre in Nha Be, Vietnam and at the Faculty of Fisheries, Kasetsart University in Thailand on the use of the KeraAqua® in feed formulations for the white shrimp *Litopenaeus vannamei*. This unique mix of L-amino acids has a clear potential to improve shrimp feed palatability. In the case of Kera-Stim®50 we have demonstrated that feed intake increased by 11.3%, feed conversion ratio is better and that the dosage of 0.50% significantly improves the feed intake, daily weight gain, specific growth rate and feed conversion ratio," added Pierrick Kersanté, R&D Aquaculture Project Manager.

"The very high invivo digestibility (96.8%) of the Kera-Aqua® range relative to fish meal 70 (91.6%) also makes it a potential candidate as a protein source in early larval nutrition when the digestive tract is still developing. We will be pursuing this and will soon start some trials in Ecuador to see the effects and performance of shrimp larval feed with Kera-Start," said Joël Duperray. www.bcf-lifesciences.com

A new vision on fish health in Southeast Asia

Roberto Cascione (second left) is pictured here with the Ictyogroup team. From right, Francis Courault, Business Export Manager; Lauke Labrie, Chief Scientific Officer & Co-Founder; Cedric Komar, Chief Executive Officer and Laurent Dupuis, Adjuvant Technology Manager, at the recent Aqua 2018 held in Montpellier, France from August 26-29.

Tilapia aquaculture is growing rapidly worldwide and particularly in Southeast Asia with more and more intensive culture systems, resulting in an increased and more complex disease situation. In contrast, today, there are still only very few prophylactic solutions available against major diseases for tilapia aquaculture.

A few reasons may explain why there is a lack of available vaccines in the market for tilapia.

- Over the past decade, the disease situation has become more complex and dynamic. This evolution went from a very clear epidemiological situation to a much more multifaceted one. Five to ten years ago, it was possible to associate a pathogenic agent such as Streptococcus serotype 1b with a particular zone or country. This is often not the case anymore. Indeed, it has become common to find several *Streptococcus agalactiae* serotypes in the same farm while these pathogens were found on different continents a decade ago. In addition, new pathogens like *Streptococcus dysgalactiae*, *Lactococcus garviea* and *Francisella asiatica* are emerging.
- Consequently, classical vaccine solutions such as a registered vaccine which has taken 5 years to develop and 1-2 years to register are no longer an adapted solution for this rapidly evolving epidemiological situation. Quickly, registered vaccines become incomplete, obsolete and/or ineffective once proposed to the market 7 years after they have been designed based on an epidemiological situation.
- In addition, large pharmaceutical companies have little interest for this type of market in comparison with salmonids or terrestrial animals as in comparison it remains a small and complicated market. Consequently, little R&D efforts are being deployed towards developing a tilapia vaccine.

Ictyogroup is a small and dynamic French based pharmaceutical company specialised in the development of tilapia vaccines worldwide. The company vision is to develop tailor-made vaccines that are tested for safety and efficacy and are GMP produced. "We can offer products to the market in 6 months to 1 year. We are also working hand in hand with local governments in Southeast Asia to increase awareness that a regulatory adaptation is needed to allow for a new approach to bring vaccines to the tilapia aquaculture," said, Roberto Cascione, Technical Director for Southeast Asia. "Indeed, rapid time to market is key to respond to actual farmers' needs and rapidly evolving disease situations."

To be closer to farms, since February 2018, Ictyogroup has set-up a new office in Kuala Lumpur, Malaysia, to start activities in South East Asia. www.ictyogroup.com

Targeting fish immunity and natural defences through nutrition

Lallemand Animal Nutrition revealed new results through five different presentations at AQUA 2018, the joint EAS/WAS conference organised by the European Aquaculture Society and the World Aquaculture Society.

These studies contribute to advancing the understanding of functional aquafeed ingredients to support fish health, performance and welfare. Functional feeds are becoming an essential component of modern aquafeed to support a responsible and high-performing aquaculture industry. The studies focused on the fish mucosal surfaces, which constitute an effective line of defence but also are constantly exposed to a vast number of potential pathogens and non-infectious disrupting factors, such as physical transfer or chemical exposure during production. Specific functional ingredients can be selectively applied to support the physical, immunological, and microbial components of the fish mucosal barriers.

First, an innovative analysis approach to immunomodulation studies in Atlantic salmon was developed in partnership with the University of Plymouth, UK. A high throughput real-time qPCR assay technique was specifically developed to follow the expression of 62 targeted genes implicated in mucosal responses, cell mediated immunity, stress and humoral immunity. This unique genomic technology was designed to better understand the immunomodulatory effects and downstream signaling cascades activated at the mucosal level with selected functional feed ingredients such as multi-strain yeast fractions and probiotics. Lallemand's multi-strain yeast fraction formulation has already been proven to provide positive effects on bacteria binding, immune modulation and skin mucous secretion in several aquatic species (WO2017/005936).

A separate salmon study presented at the conference showed Lallemand's single-strain yeast fraction product has a positive effect on the skin mucosal barrier, resulting in lower susceptibility to an ectoparasite with no or positive effect on salmon growth. This highlights the potential of a natural dietary solution as a practical tool against sea-lice.

Studies also were conducted in other fish species with a multi-strain yeast fraction described for its positive effects on bacteria binding, immune modulation and fish skin mucous secretion. In rainbow trout, a trial carried out at the University of Plymouth, UK revealed the supplement had a positive effect on mucosal barrier protection at the gut and skin level. Skin mucus level was around 30% higher with the yeast derivative. Moreover, gene expression analysis revealed a broad and balanced activation of the fish's gut innate and adaptive immune responses improving the understanding of the specific immunomodulatory properties of the multi-strain yeast fraction tested.

A trial on juvenile gilthead seabream using a multi-strain yeast fraction product showed a strong positive effect on skin mucus quantity and quality associated with a significant up-regulation of selected mucin genes involved in physical integrity and protection against potential pathogens at the mucosal level. This study indicates the potential of this functional ingredient at mitigating pathogens and/or physical insults during challenging rearing or transfer periods.

The final presentation looked at different kinds of functional feed ingredients, specifically a primary antioxidant source in the form of melon pulp concentrate naturally rich in the antioxidant enzyme superoxide dismutase (SOD). This ingredient was tested to determine if it enhanced the capacity of mucosal tissues to fight against oxidative stress in salmon.

Wine tasting with Lallemand's enzymes at Aqua 2018, from left; Stephane Ralite, Product Manager; Angeline Rayssac, Marketing Coordinator – Aquaculture & Swine Solutions and Sylvie Roquefeuil, Communications and PR Manager.

In Atlantic salmon, H_2O_2 baths are a common treatment against sea lice and amoebic gill disease. However, H_2O_2 is a powerful oxidizer documented to induce oxidative stress and associated mucosal damages. Following seven weeks of supplementation with SOD-rich melon pulp concentrate, endogenous expression of SOD enzymes was elevated in the salmon skin, indicating enhanced antioxidant defences and confirming previous findings in other animal species. Following exposure to a standard H_2O_2 challenge, salmon skin SOD levels were higher when supplemented with the melon pulp concentrate. This new antioxidant source appears to have the potential to support the antioxidant defences of Atlantic salmon not only under normal rearing conditions, but also when subjected to H_2O_2 treatment.

Abstracts and posters are available on request. Email: sralite@lallemand.com (Stéphane Ralite, Product Manager)/ sroquefeuil@lallemand.com (Sylvie Roquefeuil, Communications and PR Manager); www.lallemandanimalnutrition.com

Scientific communications presented at AQUA 2018

Development of a high throughput real-time qPCR assay technique for the targeted gene expression analysis of Atlantic salmon *Salmo salar* mucosal tissue responses. Nicola Pontefract, Mark Rawling, John Tinsley, Elizabeth Aasum, Mathieu Castex, Daniel Merrifield (Oral presentation).

Effect of a single-strain yeast fraction on Atlantic salmon *Salmo salar* skin mucosal barrier and susceptibility to sea lice. Nicola Pontefract Eric Leclercq, Mark Rawling, Victoria Valdenegro, Mathieu Castex, Daniel Merrifield (Oral presentation).

The effects of feeding a novel multi-strains yeast fraction on the mucosal immune responses of rainbow trout *Oncorhynchus mykiss*. Mark Rawling, Eric Leclercq, Andrew Foey, Daniel Merrifield, Mathieu Castex (Oral presentation).

The effects of feeding a novel multi-strains yeast fraction on the mucosal responses of juvenile gilthead Seabream *Sparus aurata*. Mark Rawling, Arkadios Dimitroglou, Eric Leclercq, Daniel Merrifield, Dimitri Barkas, Mathieu Castex (poster).

Stimulation of superoxide dismutase expression in the skin of Atlantic salmon *Salmo salar* receiving a SOD-rich melon pulp concentrate dietary supplement. Florence Barbé, Eric Leclercq, Julie Carillon, Kiron Viswanath, Mathieu Castex (poster).

PCR-DNA chromatography to diagnose four shrimp diseases simultaneously

The SURE Marketing, Philippines team was at the 10th Philippine Shrimp Congress held in Bacolod in November 2017. From left; Jerome Tabayoyong, Agnes Cruz, Jhosh Rodriguez, Jing Tabayoyong and Jommel Tabayoyong.

In shrimp farming, fast and simple methods for the detection of diseases, particularly, for the early mortality syndrome/ acute hepatopancreatic necrosis or EMS/AHPND (*Vibrio parahaemolyticus*), IHHNV (infectious hypodermal and haematopoietic necrosis virus), WSSV (white spot syndrome virus) and EHP *(Enterocytozoon hepatopenaei*) have become essential tools. At the 10th Philippine Shrimp Congress held in Bacolod in November 2017, Bienvenido "Jing" B. Tabayoyong, General Manager of **Sure Marketing Company**, Inc., presented on the company's diagnostic services and products.

"Using the conventional method, pathogens for these diseases are checked individually which takes a long time and need special techniques," said Tabayoyong. "We have started to introduce the GenePasQ shrimp pathogen DNA detection kits. It is capable of detecting pathogens causing the above 4 DNA diseases simultaneously. A GenePasQ RNA virus kit that could detect IMNV (infectious myonecrosis virus), TSV (taura syndrome virus) and YHV (yellow head virus genotype 1) at the same time is also commercially available. After PCR, the farm technician can visually judge the existence of the target genes with the PASIDNA chromatography method. The kit is manufactured in Japan and uses Printed Array-Strip (PAS), with a patent licensed by NGK Insulators, Ltd., Japan. Sure Marketing, with offices in Vietnam and Indonesia aside from the headquarters in Makati City, Philippines, is the exclusive distributor worldwide for non-clinical markets. The company has been working with government institutions in Indonesia and Thailand to bring diagnostic tools to the attention of shrimp farmers in the region. Some customers in the Philippines have already begun using the GenePasQ kits on a regular basis.

"The results in each tube are compared on a GenePasQ Data sheet. The C-PAS DNA chromatography strips are pasted on to this Sheet which gives the results, in comparison to a healthy shrimp as control," added Tabayoyong. "This uses the single-stranded tag hybridization (STH) method, a newly patented genetic testing method to determine the presence of the targeted DNA in a sample. The advantages of this is that the preparation does not require a heat denaturation process, is simpler than the lateral flow assay, and does not require gel electrophoresis after the PCR step."

This rapid method of simultaneously diagnosing up to 4 shrimp diseases using this multiplex PCR-PAS DNA chromatography was developed in 2017 by Japanese researchers at TBA (Tohoku Bio-Array) Co., Ltd. (Japan) in collaboration with the Laboratory of Genome Science, Tokyo University of Marine Science and Technology (TUMSAT) and with Songkhla Animal Health Research Centre, Department of Fisheries, Thailand.

In the Journal of Fish Diseases, Keiichiro Koiwai et al (2018) said that using portable chromatography strip is ideal for field testing and eliminates the need for electrophoresis equipment for viewing PCR results. In their method, the PCR products rise by capillary action in a thin chromatography strips to a point determined and hybridised by a tag linker, stained with streptavidin-coated blue latex which is visible to the naked eye. For detecting 4 shrimp pathogens at the same time, the process takes less than 60 minutes (30-40 minutes for the multiplex PCR and 10 minutes for the DNA chromatography strip). In comparison, a conventional PCR would take 90-120 minutes and that is without visualisation via gel electrophoresis and just for a single shrimp disease only.

The researchers also reported that they could detect IHHNV in DNA samples of boiled shrimp, WSSV in samples from a crab, and AHPND from soil samples. One caveat is detection may give a false positive for IHHNV as some IHHNV sequences are integrated into the shrimp genome. (Koiwai, K., Kodera, T., Thawonsuwan, J., Kawase, M., Kondo, H and Hirono, I. 2017. A rapid method for simultaneously diagnosing four shrimp diseases using PCR-DNA chromatography method. J. Fish Dis. 2018:41:395-399). www.sure-bio.com

A strategic partnership to improve fish health in Vietnam

Signing the agreement, Truong Thi Le Khanh (left) and Morten Nordstad

In August, **PHARMAQ**, a business of the leading global animal health company Zoetis, announced a long-term strategic partnership agreement with Vinh Hoan, the world's leading producer and exporter of pangasius. The agreement was signed during the Vietfish Exhibition in Ho Chi Minh City by Truong Thi Le Khanh, Chairwoman of Vinh Hoan, and Morten Nordstad, President of Pharmaq. The ceremony was attended by Vũ Văn Tám, Deputy Minister of the Ministry of Agriculture and Rural Development in Vietnam.'

The collaboration involves large scale vaccination of pangasius with ALPHA JECT Panga 2, a Pharmaq vaccine which protects against disease caused by the bacteria *Edwardsiella ictaluri* and *Aeromonas hydrophila*. The company will also provide Vinh Hoan with fish health services, diagnostic testing, and the introduction of new technologies and R&D activities.

"Pharmaq has been present in Vietnam for more than ten years, and we see this agreement as an important milestone for the introduction of fish vaccines in Asian aquaculture," said Nordstad. "Vaccines are important tools for the prevention of fish disease, and they help increase the sustainability of fish farming. In order to develop good fish health solutions, we work closely with visionary and professional farming companies like Vinh Hoan. We highly appreciate the close cooperation we have had with Vinh Hoan since we established ourselves in Vietnam, and we look forward to continue and expand our partnership in the years to come."

The large-scale adoption of vaccines is a major milestone for the Vietnamese pangasius industry. As already proven in salmonid farming, use of efficacious vaccines can reduce or replace the use of antibiotics in treatment of disease, ensure food safety, and improve sustainability and profitability for fish farmers. Treating the fish prophylactically to prevent disease is also advantageous from an animal welfare perspective. "Our goal is to offer healthy and safe food without environmental and economic trade-offs, and the use of vaccines is essential to reach this objective," said Vi Tam, CEO of Vinh Hoan. www.www.pharmaq.com

Leading position in the use of bioactive compounds

Over the last years the Swiss Feed Additives manufacturer **Pancosma** has invested in natural solutions aiming at supporting aquaculture efficiency and sustainability. In a global context of expansion, both fish farming and shrimp productions are facing new challenges where animal health and immunity support have become of major interest. Bioactive compounds are at the forefront of the different tested strategies!

Pancosma's latest XTRACT® innovation includes a microencapsulated additive based on an active ingredient inspired from nature: garlic. Garlic has been used for ages in shrimp production but what makes Pancosma's active compound unique is the fact that the product is stabilised and standardised, unlike the typical allicin based-additive traditionally found in the market.

Pancosma's new product has confirmed its efficacy to support shrimp performance when infected with white feces disease (WFD). This multifactorial disease, known to severely affect shrimp intestinal epithelium and digestive organs, creates substantial decrease in growth rate (BWG), feed intake and an increase in feed conversion ratio (FCR).

In a recent trial performed in Ho Chi Minh City, Vietnam, shrimp infected and receiving feed supplemented with XTRACT® showed a significant reduction of the disease signs. Improvements in performance (BWG & FCR) and higher survival rate (+ 10%) testified that XTRACT® has a protective effect against this infection. www.pancosma.com

Investments to combat disease in the shrimp market

Nutreco announced that it has invested in an Israeli startup ViAqua as part of its focus in combatting disease in the aquaculture industry. ViAqua is developing the first orally-administered treatment for shrimp that improves resistance to viral diseases, including white spot syndrome Virus (WSSV), and prevents viral epidemics. Nutreco has taken a meaningful minority share that will conditionally grow over time.

The solution offered by ViAqua, which was founded in 2014, uses a proprietary particle to disable viral infections. In the future, ViAqua intends to expand to include more species, like other shellfish such as lobster and crab, and small fish. The investment is in line with Nutreco's mission of 'feeding the future'; the company's ambition to contribute to producing enough nutritious and high-quality food for a growing population in a sustainable way.

Nutreco CEO Knut Nesse said, "Preventing and treating disease, particularly viral infections, is one of the biggest challenges facing the aquaculture industry today. In shrimp farming alone, diseases cause 10-20% losses. Working together with Viaqua, we will be able to offer targeted solutions to reduce and prevent disease."

Viggo Halseth, Chief Innovation Officer at Nutreco and head of NuFrontiers, the company's startup investment arm, added, "The solution that ViAqua has developed is a unique and highly innovative way of combatting disease in shrimp. This is a very relevant technology to handle a significant health challenge and has convincing proof-of-concept. ViAqua is exactly the kind of innovative and technological partner we want to be working with in future."

Nutreco's aquaculture division Skretting will work directly with ViAqua to effectively deliver the solution to the market. CEO of Skretting Therese Log Bergjord said, "This investment fits well with our strategy to strengthen our activities in providing health solutions to farmers. ViAqua's knowledge of how to combat health challenges in shrimp coupled with our expertise on application through feed and our reach in shrimp markets around the world mean that together we can really begin to have an impact on aquaculture health."

CEO and Co-Founder of ViAqua Shai Ufaz commented, "We are excited to have strategic investors of the caliber of Nutreco aboard and the strength of the joint agreement with Skretting. Nutreco and Skretting's combined resources and rich knowledge of the aquafeed industry will provide ViAqua with an outstanding opportunity to develop technologies with the right fit for the market. We look forward to collaborating, learning, and contributing our knowledge and expertise, to the common benefit of ViAqua, Nutreco and Skretting." www.nutreco.com

Appointment

Reinforcing the global aquaculture team

François Cellier

Khuong Duy Nguyen

Lallemand Animal Nutrition has two new aquaculture experts joining the team to support a rapidly growing market. **François Cellier** and **Khuong Duy Nguyen** have both been appointed as Aquaculture Technical Support Managers, based in France and Vietnam, respectively.

Cellier holds a MEA in aquaculture from CNAM/INTECHMER in Montpellier, France. Prior to this he obtained a professional license in Quimper and Sète, France, in aquaculture technology and farm management. He has practical experience in aquaculture production and using testing technologies across species including shrimp, fish and shellfish in Asia, Europe and Oceania. He will provide technical and marketing support on tropical aquaculture globally.

Nguyen holds a master's degree in aquaculture majoring in aquaculture health management from the Laboratory for Aquaculture and Artemia Reference Center, Faculty of Bio-Engineering, Ghent University, Belgium. He has studied aquatic pathobiology at Can Tho University in Vietnam. Nguyen brings valuable experience in shrimp farming research, especially in bioremediation and health management. He will oversee shrimp research and development trials and contribute to developing the Lallemand Animal Nutrition aquaculture business in Vietnam.

Lallemand Animal Nutrition aquaculture activities have taken off in 2009 with the first and only probiotic authorized by the EU as a feed additive in fish and shrimp feeding. Over the past decade, the company has grown its technical expertise and commercial presence around Europe, Asia, Middle East and Americas with strong R&D commitments. Lallemand aquaculture solutions include functional ingredients such as probiotics and yeast derivatives as well as bioremediation solutions for ponds www.lallemand.com

A new start for fish larvae and fry

© Dr. Bernd Ueberschär, Sea bream larva

The reliable production of high quality offspring is paramount for successful aquaculture. This is true for both a shift from quantity to quality in established species as well as for closing the lifecycle of new candidate species. High mortality rates can occur in hatcheries if abiotic and biotic conditions are not within tightly framed optima, which is a consequence of the reproductive strategy of many teleost fish species.

The farming of many species still relies on the provision of live feed in the early stages. In fact, the discovery and extensive use of rotifers and *Artemia* may have been the main driving force behind the tremendous growth in aquaculture production so far. Nevertheless, the tremendous efforts in research for manufactured diets in the recent years has substituted live feeds to a large extent.

Aller Aqua has increased its efforts to supply fish in the early life-stages with optimal and tailored feeds. Some fish species benefit from more energy-rich feeds such as fry of rainbow trout, whereas other fish species thrive on feeds with less energy. A series of trials at Aller Aqua Research in Buesum, Germany have shown significantly higher growth, lower feed conversion rate (FCR) and improved nutrient retention in fry of rainbow trout when fed a more energy-rich feed. Consequently, Aller Aqua relaunches its successful ALLER FUTURA EX GR with a higher fat and energy content, fully dedicated to the nutritional requirements of rainbow trout and other salmonids. At the same time, Aller Aqua launches ALLER THALASSA EX GR with a balanced protein to fat ratio, more suited to larvae and fry of marine species as well as species with lesser energy requirements.

For the most delicate early stages Aller Aqua introduces its new premium starter diet for fish larvae and early fry, ALLER INFA EX GR, assembling only premium ingredients, including high levels of krill meal, and the highest standards in production technology. With particle sizes down to 0.1 mm, ALLER INFA EX GR (INFA short for Latin “infant”) acknowledges the immature and delicate stages of fish larvae and early fry in the best possible manner to support healthy development, fast growth and high survival rates.

The larvae of many fish species are not fully developed at the time they start feeding, some lack a fully developed stomach with the complete range in digestive enzymes, and the digestion of feed particles as well as the nutrient uptake is of highest importance to match the high potential for growth.

To aid the developing fish in their digestive processes and organ development, ALLER FUTURA EX GR, ALLER THALASSA EX GR and ALLER INFA EX GR are naturally enhanced to support organ development and health of the liver and the gallbladder. Consecutively, this leads to an enhanced secretion of digestive enzymes, improved nutrient uptake as well as improved growth and health of larvae and fry. www.aller-aqua.com/ rt@aller-aqua.com

Article was written by Dr Robert Tillner, Product Manager.

Feed Size		0.1-0.4 mm	0.5-2mm	1.3-1.5 mm	2 mm
SPECIES	Trout and other salmonids	ALLER INFA EX GR	ALLER FUTURA EX GR	ALLER FUTURA EX	ALLER FUTURA
			ALLER ORGANIC EX GR	ALLER PERFORMA / EX	ALLER PERFORMA / EX
	Marine species and species with less energy requirements	ALLER INFA EX GR	ALLER THALASSA EX GR		ALLER THALASSA EX
	Freshwater species, cyptinids and cichlids	ALLER INFA EX GR	ALLER FUTURA EX GR	ALLER FUTURA EX	ALLER FUTURA
			ALLER THALASSA EX GR		
			ALLER PARVO EX GR		

GR = Granulate

At Aqua 2018 in Montpellier, France, Dr Robert Tillner, Product Manager, Aller Aqua Group was responsible for the launch of the new fry feed range. From left to right: Stefano de Dominis, Country Manager for Italy, Dorota Juchniewics-Pasquier, COO in Aller Aqua Poland, Kristina Petersen, Marketing Project Manager, Aller Aqua Group and Dr Robert Tillner.

Innovative and sustainable nutrition

LSAqua is part of Lambers Seghers SME, which has roots in the Belgium agriculture with more than 100 years of experience in animal feeding and personal service. The company is focused on innovative and sustainable aquaculture nutrition. To achieve this purpose, two product lines were created:

- Fishless Feed (FL) which is aquafeed without fishmeal and fish oil,
- Sustainable Feed (SF) which is an aquafeed based on recovered-by-products from fisheries and fish farming industry.

During Aqua 2018, it held a cocktail meeting to introduce its product lines to conference delegates, exhibitors and tradeshow visitors. The event was a complete success with around 40 invitees from the conference and trade show enjoying the pleasant atmosphere.

LSAqua has developed its own single cell protein to eliminate the use of fishmeal, with better technical results in its FL and SF feeds. LSAqua also formulates fish meal replacing concentrate; a balanced blend of high quality vegetable proteins, single cell proteins and heterotrophic algae with health promoting effects. Tailor-made formulas are specially designed with local ingredients for several species including; trout, sea bass, sea bream, turbot and shrimp, thanks our expert team.

The LSAqua team, from left, Paula Sole-Jiménez, Zahra Geraylou, Danny Van Mullem. "We came to to share knowledge and create a community link in aquaculture. In turn, we successfully participated in the event; meeting lots of people and attending several presentations.

LSAqua is involved in many research projects for sustainable fish – feed production. Fishmeal replacers were tested in Ugent (Belgium) and RIA2 (Vietnam). Results indicated considerable improvement in growth and resistance to diseases in several fish and shrimp species under laboratory and farm conditions. LSAqua is already available in the Belgian market, and proud to be the primary feed supplier of Belgian Omegabaars (AQUA4C), one of the first and biggest sustainable fish farming projects in Europe. www.lsaqua.be

International Conference of Aquaculture Indonesia (ICAI 2018)

Yogyakarta, 25-27 October 2018

This is the annual conference and tradeshow organised by the Masyarakat Akuakultur Indonesia (MAI) or Indonesian Aquaculture Society (IAS). It will be held at Grand Dafam Rohan Hotel, Yogyakarta, Indonesia. Plenary speakers will be as follows:

Prof. Rokhmin Dahuri, President, Indonesian Aquaculture Society
Status and current issues of aquaculture development in Indonesia.

Dr. Rohana Subasinghe, President Elect of WAS-APC 2018-2020
Current trends of sustainable aquaculture development globally and aquatic animal health management.

Prof. Joergen Schlundt, Director, Nanyang Technological University, Food Technology Centre , Singapore
Risk assessment and management in aquaculture based on biotechnology

Prof. Jeong-Dae Kim, Kangwon National University, Chuncheon, South Korea
Overview on the development of aquaculture and aquafeed production of Korea

Dr Nyan Taw, FAO Projects Consultant in Vietnam, Saudi Arabia and Myanmar
Current development of biofloc system for sustainable shrimp farming

Prof. Allen Davis, Auburn University, USA
The development and improvement of commercial feeds and feed management strategies in shrimp farming

Dr Fabio Soller, DIANA Aqua, Bangkok, Thailand
Hydrolysates as an alternative protein source to fish meal in aquafeed

The 2-day conference program will consist of parallel sessions covering the following topics:

Aquaculture Management and Technology; Aquaculture Disease and Environment; Genetic and Breeding; Aquaculture Feed and Nutrition and Social, Economy & Business (Marine culture Group). There will be a shrimp farm day.

More information: www.icai.aquaculture-mai.org

Aqua Culture Asia Pacific in 2019

Volume 15 2019						
Number	**1 – January/ February**	**2 – March/April**	**3 – May/June**	**4 – July/August**	**5 – September/ October**	**6 – November/ December**
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	***Asian Pacific Aquaculture 2019** June 19-22, Chennai, India	***The Aquaculture RoundTable Series, (TARS 2019)** August 14-15, TBA **Vietfish 2019** (TBA) Ho Chi Minh City, Vietnam	**Aquaculture Europe 2019** October 8-10 Berlin, Germany	

Aquaculture 2019

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New Show Dates March 7-11

March 7 - 11, 2019

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Global Aquaculture Alliance
International Association of Aquaculture Economics and Management
Latin America & Caribbean Chapter WAS
US Shrimp Farming Association
US Trout Farmers Association
World Aquatic Veterinary Medical Association
Zebrafish Husbandry Association

For More Information Contact:

Conference Manager
P.O. Box 2302 | Valley Center, CA 92082 USA
Tel: +1.760.751.5005 | Fax: +1.760.751.5003
Email: worldaqua@was.org | www.was.org

Asian Aquaculture 2018

3-6 December 2018, Asian Institute of Technology Conference Center (AITCC) Hotel, Pathum Thani, Bangkok, Thailand

The Conference will bring together world's leading experts in innovative aquaculture, and present emerging technological advancements for better husbandry and feeding practices to stem the disease tides in aquaculture and set the goal for a sustainable enhancement of output from aquaculture, relevant to the Asia Pacific region. The event is designed to benefit participants by generating a wealth of information on innovative management practices and apply them to improve the production and profits from aquaculture enterprises.

Asian Aquaculture 2018 provides an opportunity for entrepreneurs, academia, governments and administrators in the global industry to witness the success stories in Asian aquaculture and progress in sustainable intensification of aquaculture for enhanced product quality and safety.

There will be a 3-day trade show featuring the latest technology and products in aquaculture. On 6 December 2018, there will be a field trip to an integrated shrimp farm in Nakhon Nayok, Thailand.

The conference organisers have announced the following pre conference workshops.

Management of Parasitic Diseases in Aquaculture
26 - 30 November 2018
Resource persons: Dr Kua Beng Chu, Malaysia; Dr Supranee Chinabut, Thailand

Integrated Multi-trophic Aquaculture (IMTA)
1 - 2 December 2018
Resource persons: Prof. Thierry B. Chopin, University of New Brunswick, Canada; Prof. Jianguang Fang, Yellow Sea Fisheries Research Institute, Qingdao, China

Limited seats are available available for these workshops. Those interested are advised to register early.

With a tremendous response from both researchers and entrepreneurs and request of participants, the final extension for early bird rates is **September 30**. All presenters are required to register to secure presentation slots.

More information: info@asianaquaculture.org/ www.asianaquaculture.org

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**

October 1-4
AquaSG'18
Singapore
www.aquasg.com

October 17-19
High Energy Mariculture Conference 2018
Corfu, Greece
www.offshoremariculture.com/europe

October 17-19
VIETSTOCK 2018
Ho Chi Minh City, Vietnam
www.vietstock.org

October 18-20
Future Fish Eurasia 2018
Izmir, Turkey
www.future-fish.com

October 23-26
LACQUA 2018
Bogotá, Colombia
www.was.org

October 25-27
The 8th International Conference of Aquaculture Indonesia (ICAI 2018)
Yogyakarta
www.icai.aquaculture-mai.org

November 7-9
China Fisheries and Seafood Expo
Qingdao
www.chinaseafoodexpo.com

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 23-25
Brackishwater Aquaculture (BRAQCON 2019)
Chennai, India
Email:cibabraqcon2019@gmail.com

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

VIV ASIA 2019

BANGKOK THAILAND
13-15 MARCH

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