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COVID-19: Shrimp Demand & Supply

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Vannamei shrimp farm in India,
Picture credit Ramesh Arji,
Growel Feeds India

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Zuridah Merican

Embracing a culture of innovation

Leaving this Covid-19 pandemic temporarily, it is a good time for reflection on the direction and future of Asian aquaculture. How often have we asked ourselves why the financial community is reluctant to invest in aquaculture in Asia? This includes both capital investment and credit lines for operating expenses. Insurance companies tend to avoid protecting shrimp or fish stock against financial loss as we have no compelling disease mitigation process in place. At TARS 2018 on shrimp aquaculture, Tim Noonan presented 'An investor's perspective on Asia's shrimp industry' and remarked that it was a 'high-risk, high-return' scenario akin to a casino. "For shrimp producers seeking capital, there needs to be a focus on management of disease risks, traceability and consumer-driven demands."

Fast forward to 2020, has there been change? Some may argue the paradigm today is still a large backyard operation pretending to be industrialised. Asian aquaculture needs to move from a highly volatile and disease impacted model to an environment friendly, industrial and predictable model. The past decade of disease impact has provided a lot of data but little of it has been analysed to make cogent operational decisions. The goal would be a data-driven management operation using real-time monitoring and a feedback loop to determine trigger points and drive consistent production.

Innovation is here. Hatch Blue is an accelerator programme that helps aquaculture startups. Their 3rd cohort (2019) can be loosely segmented into artificial intelligence (AI), automation, disease diagnostics, satellite imaging and novel feed ingredients. The first two can be immediate fixes to our problems.

Automation provides real-time monitoring 24/7 and can eliminate human error or mishaps while AI can prove valuable for big-data analyses. The internet of things (IoT) connects the two. With continuous improvement, we can determine trigger points for disease outbreaks. In simple terms, the carrying capacity for any species/density/culture condition can easily be determined and the whole aquaculture operation can be directed from a control room. This is what the investors and insurers look for – risk management.

At Infofish Shrimp 2019, Chelsea Andrews, XpertSea said that "AI can lead the revolution to sustainable production. For example, AI can predict diseases before they happen. AI will not replace farmers but become a key asset in their toolbox." I reiterate - this is an important assurance for technicians and farm owners. With the current movement restrictions, imagine savings in time, costs and grief if some level of AI innovation had been in place.

Indonesia has a dynamic scene with startups – helped by local events such as Digifish. eFishery and JALA lead in the startup ecosystem and in this issue, we feature Sgara (see p24). The pull factor in Indonesia is the new generation of shrimp farmers looking to change the way farming is done, while requiring some level of predictability in farming using AI. India has two award-winning startups in aquaculture: Eruvaka with real-time analytics to track shrimp feeding and pond conditions and Aquaconnect which uses AI to monitor real time farm operations. Eruvaka's Sreeram Raavi had a nice story to tell on how a farmer sought his technology back in 2012. Although Eruvaka ran its first pilot project in India, larger shrimp farms in Ecuador have found a stronger product-market fit! Thailand's Algaeba has an affordable post larvae counting device to ease a hatchery's workflow. It continues to ask the industry in Thailand and the region to test out its technology.

So where is the resistance and why is the industry slow in embracing innovation? Admittedly, these innovations need to be tried and tested, and both the farmers and innovators need to work together to achieve this. Otherwise we will forever be stuck in a 'catch-22' situation. Perhaps it is a question of features and benefits. Traditional farmers continually look for short term cost-savings, not realising that efficiency can provide bigger and better savings. Innovations tend to be costly but prices always come down with economies of scale and competition.

Without doubt, Covid-19 has thrown a spanner in the works for demand, supply and the aquaculture supply chain but it is time to focus on the future. It is time for us to see the forest for the trees.

PS For those startups interested to be featured, please email: zuridah@aquaasiapac.com

OUR MISSION

We strive to be the beacon for the regional aquaculture industry.

We will be the window to the world for Asia-Pacific aquaculture producers and a door to the market for international suppliers.

We strive to be the forum for the development of self-regulation in the Industry.

Innovations and startups making waves

Among the leading shrimp farming countries, it is none other than Indonesia where the conversation is on the adoption of Technology 4.0, which is considered an indispensable tool by industry players. Despite the slowdown with the Covid-19 pandemic, Dr Romi Novriadi, Vice President of the Indonesian Aquaculture Society or MAI, said that it is either staying with the traditional systems or adopt IR4.0 i.e. stay or move into the future. This is the country's strategy to increase production volumes using the existing aquaculture areas. Indonesia has some early startups in aquaculture, such as eFishery, which is making waves in the aquaculture sector.(see page 62).

At the July International Forum of Science and Technology (FOSTECH) MAI webinar series on Smart Aquaculture for Farmers, Agus Somamihardja, Head, Indonesia Shrimp Hatchery Association pushed for scientific shrimp farming and data recording to monitor the pond's water parameters. "Aquaculture is a complex activity, and farmers should view the pond in three dimensions instead of just one," said Agus. "There is a need to have precision and increased accuracy; so that aquaculture can be a predictable activity. This can be achieved by adopting automation and removing the subjective elements in shrimp farming," added Agus. A poll launched at the webinar showed that data recording was done manually on paper (38%), Excel spreadsheet (57%) or using a management system (4%).

BOSCH has entered the Indonesian market with AquaEasy, and Aries Dwiputera, Product Manager said that the goal is to transform shrimp farming from an art to a science. AquaEasy is a comprehensive artificial intelligence (AI) innovation to optimise shrimp culture. The development process began 3 years ago and today it encompasses disease and water quality management, and fills the gaps in the estimation of several parameters. It starts with sensors to get accurate, fast and reliable measurements of multiple water quality parameters for data analysis, and modelling to give insights into biomass estimation and growth anomalies. With cloud connectivity, production information is available in real-time and across all devices. The farmers get to know the crop status, whether it is optimal or below average. The system works on a subscription basis. Sensors can be located permanently in ponds or moved depending on the subscription level.

The World Bank has a series of webinars on the Internet of Things (IoT) for Agriculture . This initiative is supported by the Korea-World Bank Partnership Facility (KWPF), and in collaboration with USAID and Feed the Future, which is the US Government's global hunger and food security initiative. India's Sreeram Raavi, Founder and Managing Director of Eruvaka Technologies was selected to present on "Transforming Aquaculture with IoT". Eruvaka is already established in India, Central America and Ecuador, and has plans to expand into Indonesia, Malaysia and Vietnam with water quality monitoring, automated aerator control and on-demand intelligent feeding with acoustics integrated into a cloud-based software to provide insights on pond performance. Seeram explained the value chain integration– how Eruvaka's data analysis of shrimp growth assesses post larvae batch performance and how this information can be filtered back to the hatchery to reflect on performance of broodstock. In the pond, real time feed consumption data show the health status of the stock and downstream, real time availability of shrimp biomass can be sent to prepare processing plants. The cost element to use these innovations is always a concern among farmers but Seeram pointed out that costs of his subscription-based business model is compensated by the savings in feeds (20%) and energy (~15%). Similar to several startups in shrimp farming, Eruvaka's seamless integration of data contributes to risk mitigation for insurance purposes. Next, Seeram plans to develop intelligent feed trays to assess shrimp growth and health, underwater drones to assess shrimp activity, and image processing-based feeders to access feed consumption by different fish species such as the tilapia. The latter is targeted for farms in Bangladesh, Vietnam and Indonesia.

At the August webinar on "Mariculture: The future of Asian Aquaculture", organised by Infofish and sponsored by Skretting, USSEC's Lan Hsiang-Pin expects that in the future, offshore aquaculture will be the mainstream culture system. Today, feeding is still manually done and new technologies such as image recognition and acoustic driven feeding will dramatically reduce feed conversion ratios. Joyce Leo, Marine Scientist at the Singapore-Japan deep tech startup UMITRON explained that the technology developed is aimed at increasing productivity in marine fish farming. There is the large smart automated feeder with feed management software and a feed silo of 400kg and another, without a feed silo for those farms already equipped with feed barges but is lacking in a centralised feed management software. How to accurately determine biomass in a cage remains a challenge and this is being resolved with underwater cameras measuring fish length. Next will be correlation of length and weight to have a more precise biomass data.

Eruvaka's on-demand feeding of the shrimp based on acoustics, water quality, and growth models. The farmer only needs to fill up the hopper.

Achieving food security with innovation

In Singapore, aquaculture accelerator Hatch Blue organised a webinar series "Aquaculture Innovation Hour". In the first conversation in June, Benedict Tan, Programme Coordinator at Hatch Blue led three panellists on entrepreneurship and innovation in food security. Georg Baunach, Managing Partner and Co-founder said that Hatch has a mission to support early stage startups in aquaculture. The accelerator works on innovations for aquaculture farms and in terms of traits, Georg said that there are two groups of innovators or startups. The first group consists of those who are very strong technically, often university-based but have a very poor understanding of the aquaculture markets. Hatch helps them understand more on the needs of these markets and how their innovation can fit in. The second group consists of those very well versed with their customers' needs. In general, a positive attitude on solving challenges is a prerequisite for startups.

Benedict said that with empty shelves in supermarkets seen with the Covid-19 lockdown, food security has become a greater need as never before in Singapore. Singapore has the '30 by 30' goal, that is, 30% local food production by 2030. This includes production of fish – but what will it take to get there?

Ah Hua Kelong has two farms and runs a seafood delivery business and a restaurant serving 90% locally produced seafood– farmed fish (mainly barramundi and groupers) and seafood from fisheries. For Wong Jing Kai, Managing Director, the opportunity to enter seafood marketing was the gap he saw; farmers are good at producing but have little knowhow on direct sales for their output. He started door to door deliveries of fresh locally produced seafood, selling fresh fish within 12 hours after harvesting.

There are varying perceptions on sustainability and Kai realises that it is here to stay, and he is seeking local certification on good farming practices. Georg complimented Kai's entrepreneurial spirit which has brought him to this level today and mentioned how JALA, a startup in Indonesia, a member of Hatch Blue's first cohort of startups, introduced sensors and software for massive improvements in feed conversion ratios in shrimp farms. He added that Norwegian farmers are highly optimised in salmon production and entrepreneurs in Singapore could also follow these examples to do the same and manage the resources better.

On achieving the '30 by 30' goal, production is possible but Kai questioned whether the local market can absorb this increase in local production. Based on his experience in a shrimp farm in Malaysia, Ronnie Tan, aquaculture consultant, Malaysia, said that the critical factor is knowing the daily carrying capacity of the local market so as not to create a price turmoil in the market. Benedict summarised this conversation as the need to know economics and perception of the consumer, and not just performance and price.

In another Aquaculture Innovation Hour, the discussion was on encouraging a startup culture among the new generation of students. As Singapore's aquaculture ecosystem is rather small for startups in aquaculture, Yeo Keng Joon, Chairman Bharat Luxindo Agrifeeds Pvt Ltd, an aquafeed company in Andhra Pradesh, India, proposed that an ideal option is to be involved in domestic fish production which will help the nation with sustained seafood production instead of dependence on imports. This is by using technologies for intensive systems such as recirculation aquaculture systems (RAS) or multitier farming concepts.

Agri-tech startup sells marine fish locally

Singapore's Aquaculture Centre of Excellence Pte Ltd (ACE®) has begun to revolutionise fish farming with an eco-friendly, cost effective and sustainable method. In May, in a live CNBC Squawk Box interview on his innovation Eco-Ark®, Leow Ban Tat, Founder/CEO outlined his role in Singapore's long term strategy on food security in the aquaculture space. He is using his game-changing technology - a closed containment aquaculture system which is housed on a novel offshore advanced hull system (NOAHS) - as an alternative to open cage farming of marine fish.

ACE's Eco Ark® integrates automated tank cleaning and feeder systems under one roof, creating an optimal environment for the production of healthy fish.

"Technology can help to maximise production and is climate resilient and is not affected by poor quality water or harmful algae blooms. We have a close containment vertical farm; downwards to any ocean depth working with nature. We draw in seawater at very low energy and all other flow downstream is via gravity, thus saving energy, filtering and ozone sterilizing of the inlet water prior to use and treating outflow water before discharge back to the ocean. We add oxygen and create a cyclonic flow to raise fish in better conditions than in the wild. In such conditions the fish eat better, grow faster and have higher survival rates. We produce vaccine- and chemical- and hormone-free Asian seabass." Leow emphasises on how future fish farming needs to evolve for self sustainability with cost efficiency and yet not pollute the sea in Singapore. ACE expects to produce 166 tonnes of fish by 2021, which is 20X more than a coastal fish farm. Today, ACE has a B to C business model and is working with a large supermarket chain and online sales at ace-fishmarket.com. There is a better value in terms of carbon footprint to export this patented technology for aquaculture 4.0 rather than export frozen fish.

Consortium buys Red Lobster Seafood Co.

San Francisco, California-based Golden Gate Capital has agreed to sell its remaining equity stake in Red Lobster Seafood Co. to a consortium comprising existing Red Lobster stakeholder Thai Union, an investor group of experienced global restaurateurs and hospitality industry executives, and members of the Red Lobster management team. Bangkok-based Thai Union is an approximately USD 4 billion publicly traded global seafood supplier. The new investor group, under the name, Seafood Alliance, comprises key shareholders, Paul Kenny and Rit Thirakomen, who together have over 75 years of experience in restaurant industry strategy, operations and brand building. Thirakomen is the chairman, CEO and controlling shareholder of MK Restaurant Group, a leading Thai restaurant chain. The Red Lobster chain has been facing the most challenging time in its more than five decades of existence during this Covid-19 pandemic.

Launch of next-generation RAS in Taiwan

Global leader in land-based aquaculture, Nocera, Inc. announced the introduction of its next-generation of commercially operational recirculating aquaculture systems (RAS) designed to improve productivity and sustainability in commercial aquaculture. The features include an improved oxygenation system, allowing approximately 50% more fish to be raised in the tanks and makes the transport of fish more convenient. Nocera manufactures RAS for saltwater and freshwater species including for the tilapia, perch, bass, crayfish, crab and abalone. Nocera currently has its aquaculture equipment factory in Xing Yi, China and plans to install its next generation tanks in Taiwan. CEO Jeff Cheng said, "Our next generation RAS is larger and improves oxygen utilisation, which means better fish. This represents an environmentally friendly and cost-effective way to bring clean fish to the table, while returning clean water back to the environment."

Salmon farm complex in South Korea

After completing a strategic investment to acquire a minority stake in Norway's Salmon Evolution in July, South Korea's Dongwon Industries has announced that together they will jointly construct and operate a land-based fish farm using Salmon Evolution's RAS technology. Dongwon is a global top-tier seafood company. The KRW 200 billion (USD168.4 million) onshore salmon farming complex of 35,000 pyeong (11.5ha) in Yangyang-gun, Gangwon-do will target a production of 20,000 tonnes in ten years from 2021. Dongwon wants to grow the domestic aquaculture industry to an industrial level using cutting edge RAS technology where only 35% of seawater is replaced and 65% of seawater can be reused through continuous circulation to maintain a constant culture environment. Real time monitoring and control of the entire farm facilities will use IoT, ICT, and big data. It also plans to establish an R&D centre and salmon processing facility. Dongwon imports 20% of South Korea's salmon imports. In 2018, the country imported 38,000 tonnes. The construction of the onshore salmon farming complex is expected to contribute to a revitalisation and creation of 400 new jobs in Yangyang-gun, Gangwon-do and other east coast regions. The government has recently enacted the Aquaculture Industry Development Act allowing large companies to enter the aquaculture of high value fish species including the salmon.

New premium shrimp brand

Charoen Pokphand Foods PCL (CP Foods) has released a new premium brand for shrimp called "CP Pacific" for the Thai market. Dr Sujint Thammasart, COO- Aquaculture Business, said that the company has worked towards sustainable aquaculture, with less environmental impact and more resource optimisation. CP Pacific has been farmed to reflect these commitments; farming without antibiotics in high biosecurity facilities and fed on feed produced from 100% sustainable and traceable ingredients to ensure that it is not from illegal, unreported and unregulated fishing (IUU). CP Foods is applying its "3 Clean" principles and zero water discharge. These have helped to improve survival rate significantly. CP Foods is expected to produce more shrimp than in 2019 due to better disease mitigation. Sujint said that shrimp production in Thailand is predicted to be at 280,000 tonnes, while the global production should reach 3 million tonnes.

Clarification on article "Algal 1,3-β glucan and vitamin C:a synergistic combination", published in issue July/August 2020, p49-51.

Following a query from Michael New, UK, lead author Edward Gnana Jothi George has made the following clarifications.

1.Treatments T1 and T2

In these field trials, we used two ponds to test the efficacy of our product. As there were no differences in the diet treatment, T1 and T2 were actually replicates. But, I termed them as treatments (T1 and T2) based on the fact that these ponds were allocated in different sectors of a corporate farm.

2. Why was there only one control?

At the start of the trial, we were given two ponds as control. However, as we progressed through the trial, the results in the treatment group were good. Impressed the farmer started using the product in one control pond as well. Therefore, we were only left with one control to make comparisons. We also reported that shrimp in this control pond was harvested early because of white gut disease at DOC47. Subsequently, growth was slow post infection which resulted in an unprofitable harvest.

3. Why were there large differences in performance between ponds T1 and T2?

There were significant differences between the performance of the two treatment ponds. T1 pond was an aged pond where post larvae were stocked in the previously cultured water. Organic sludge in the pond bottom eventually led to poor water quality. But the T2 pond was well prepared prior to stocking and we were able to maintain water quality.

Admittedly, we should have ensured pond preparations and pond conditions were equal at the start and throughout the trial. Common with trials in farmer's ponds, we also noticed that the sector technician for pond (T1) increased feeding (reflected by higher feed costs in Table 3) in the pond which led to comparatively higher FCR (1.27). The sector technician of pond T2 had a good control over the feeding regime and the FCR was 1:0 in this pond.

The essentials to minimise costs of vannamei shrimp production

With shrimp prices on the downward trend, being able to control cost of production is fundamental to stay ahead, says Ravikumar Bangarusamy in India.

India has reached the pinnacle as the largest producer of farmed shrimp in 2019 and will continue to do so in 2020. However, with the current fluid situation on international demand for its shrimp and lower prices than in 2019, the concern among farmers, not only limited to those in India, is how to be more cost efficient along the production chain.

"The producer cannot really control the market price; therefore, controlling the cost of production is an urgent need," said **Ravikumar Bangarusamy,** General Manager, Technical of Growel Feeds, India. "In 2019, the average cost of production was reported at INR170/kg (USD 2.42/kg) for size 70/kg. As ex farm prices for size 70/kg shrimp (April to September 2019) was INR248/kg (USD3.5/kg), farmers could secure good profits. However, as the ex-farm prices drop below that in 2019 with lower demand and now to INR225/kg (USD3.21/kg), it is imperative that farmers seek ways to increase profit margins."

At Growel Feeds, under the guidance of the Technical Director, Dr Arul Victor Suresh, Ravikumar conducts R&D in shrimp farms throughout India and uses the findings to advise farmers on best practices. At a recent Infofish Webinar, Ravikumar discussed ways to minimise production cost for sustainable shrimp farming. At TARS 2019, he discussed the role of feed producers in finding solutions for farmers in farm management, from control of diseases with functional feeds to the use of sensors in feed management.

Over the last few years, Ravikumar's target is to find the right balance in production. Acknowledging that lower costs of production comes with managing diseases and improving survival rates, he has been combining his expertise in farm and feed management with the findings of Dr Loc Tran, ShrimpVet Laboratory, Vietnam, to develop standard operation procedures (SOP) to manage shrimp diseases.

In this Q&A article, Ravikumar addresses several important areas of concern for farmers and offers ways to manage them.

Ravikumar Bangarusamy's expertise in the aquaculture industry goes back to over 21 years, having worked around the world. Part of his role in Growel, is to conduct R&D in shrimp farms throughout India and use the findings to advise farmers on best practices. The target is to find the right balance in production.

What are the strategies to minimise cost of production and maximise profits?

Based on the trials conducted, we have shown the possibility of lowering the costs of production. In the production of size 70/kg shrimp, we have achieved a production cost of INR214/kg (USD3.05/kg) at a stocking density of 25 post larvae (PL)/m^2 and feed conversion ratio (FCR) of 1.0 to as low as INR175/kg (USD2.5/kg) at a stocking density of 60 PL/m^2 and FCR of 1.2. Cost was INR181/kg (USD2.6/kg) at a stocking density of 45 PL/m^2 and FCR of 1.1. Consistent results are achieved through a combination of best management practices, use of functional feed and probiotics and using SOPs advocated by Growel.

For the past 3 years, we have been using the same fermentation technology, functional feed and auto feeder for more than seven crops at our demonstration and corporate customers' farms. The stocking density ranged between 35-50 PL/m^2 and the days of culture (DOC) was between DOC 59 and 156. Most of the ponds had a survival rate of about 80% and at very few ponds, shrimp survival was lower than 80%. The FCR was 1.1 because the average body weight was high at 46.28g; even small-sized shrimp had an FCR of just below 1.0.

Based on the typical production cost assessment, feed accounts for almost 50-60% (Figure 1). In 2019. as offer prices declined, farmers reduced stocking densities; the average is now 30-35 PL/m^2 as compared to 40-60 PL/m^2.

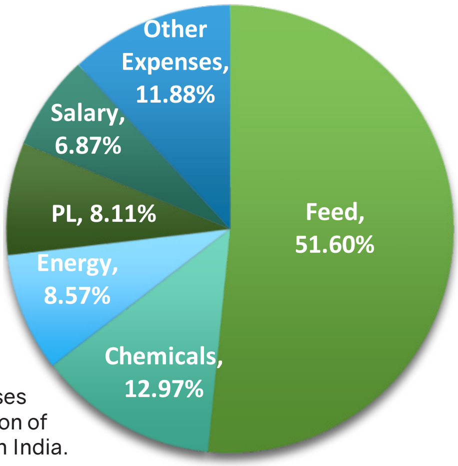


Figure 1. A typical example of expenses (%) in the production of vannamei shrimp in India.

A way to minimise production costs and maximise profits is by strictly implementing best management practices (BMPs) at various stages of farming and develop farm-specific SOPs. It is essential that the farmer selects good quality inputs and validate chemicals and other inputs before use. At TARS 2019, I said that the feed industry can offer shrimp health solutions, but it cannot substitute good farm management.

At the beginning of the cycle, stocking the best quality post larvae will have a significant effect on the production and profitability of a shrimp farm. However, there is the dilemma of hatcheries providing perhaps up to 20-30% more post larvae than the amount purchased. Usually all post larvae are stocked into ponds. Henceforth, how do we estimate numbers in calculating feed amounts and the final survival to derive the actual costs of production? We know that the best feed efficiency comes with knowing the stock in the pond. I recommend estimating and measuring the post-stocking survival rate by installing hapas in the pond.

In India, most farmers are small-scale and we developed SOPs to promote sustainable shrimp farming by having an on-farm nursery phase, either using the earthen pond or lined pond with good biosecurity, to produce better quality juveniles as well as to reduce the cost and culture duration in the grow-out phase. An advantage of having a nursery phase is the elimination of weak animals before transfer to the grow-out phase. For example, in one farm, we stock juveniles of 0.5 to 1.2g each and the grow-out was only over 59 days. The production achieved was 2.7 tonnes at average body weight of 18.9g and survival was 83.5%. FCR was 1.03. There were no disease outbreaks.

Feed and disease management are key factors in the production economics and have an influence on water quality and survival, respectively. Overfeeding can cause farmers to spend more money on water quality management and treatment. For disease management, bacteria loads should be checked, and it is better to understand the balance between the *Vibrios* and probiotic bacteria. The early detection of diseases can be done by training farm staff. The current practice that most farmers adopt are tests for *Vibrios*, viruses, post larvae microscopy and the stress test.

Loc Tran showed that *Vibrios* are the primary agent of white faeces disease (WFD) in laboratory challenge trials. Pre-infection with *Enterocytozoon hepatopenaei* (EHP) may increase the severity of WFD. There are two types of WFD; a treatable one caused by *Vibrios* only and the other untreatable caused by vibriosis and EHP. Therefore, we can manage WFD if we have clean ponds, water and post larvae and microbiota maturation to control *Vibrio* load throughout the crop cycle, waste management, on-farm nursery and use of functional feed. For *Vibrio* loads, we recommend that the green colony should be less than 10^2 CFU/g of post larvae and yellow colony should be 10^3 CFU/g of post larvae before stocking.

> "Every 0.1 improvement in FCR can increase the crop profitability by USD100/tonne of shrimp harvested and that every 0.1 increase in FCR will produce 90kg more organic waste/tonne of shrimp production."
> – Ravikumar

With feed accounting for 50-60% of production costs, what are your thoughts on feed management?

It is important to remember that best practices for feed efficiency start at stocking. One way to look at its importance is that for every 0.1 improvement in FCR the crop profitability can increase by USD100/tonne of shrimp harvested and that every 0.1 increase in FCR will produce 90kg more organic waste/tonne of shrimp production.

There are many high (40% CP) and low protein feeds (25% CP) available in the market. But when using a high CP feed, it is important to have a stringent feed management protocol. An economical feed conversion is essential or else the production cost will go up. I have presented data from our R&D work comparing pelleted feeds versus extruded functional feeds in about 1,000 ponds across India for the past 3 years at various locations, at different salinities and over winter and summer. The results showed better survival rates by 24%, better average daily growth rate by 30% and improved FCR by 21% with extruded functional feeds. Functional feeds increased shrimp growth and profit per unit of feed intake (Figure 2).

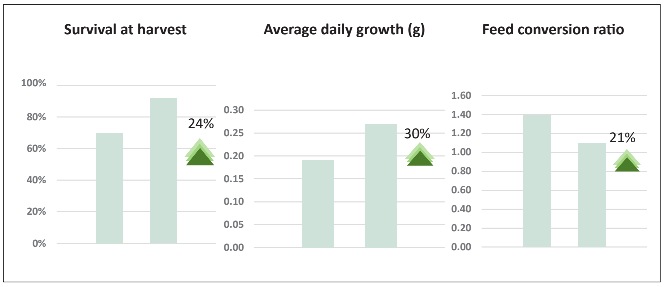
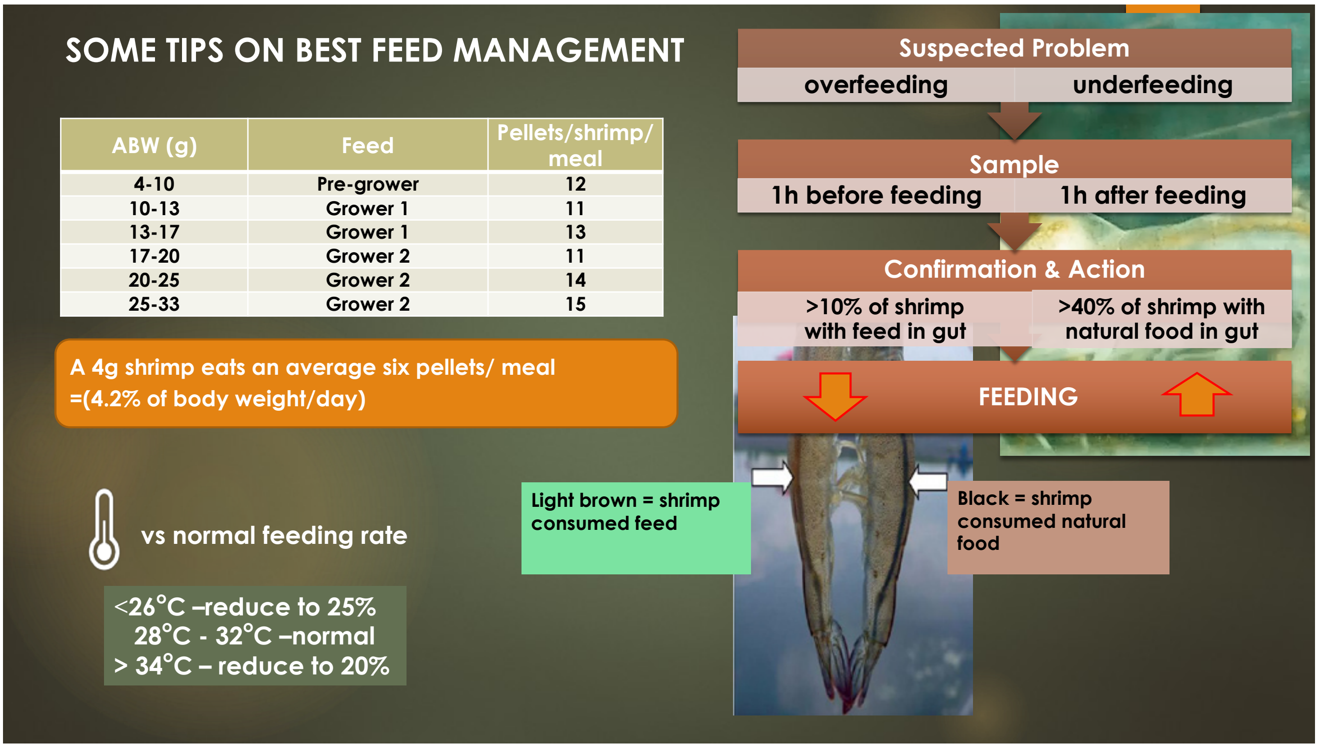


Figure 2. Performance results of shrimp fed Growel extruded functional feed (Nutriva15) as compared to pelleted feed at its demonstration farms over seven crop cycles.

What are your observations on feeding rate and frequency?

I recommend using high-quality feed or functional feed with 6-8 feedings per day during the nursery phase. Feed particle size is important. Shrimp of about 4g size consumes on average six pellets a meal (4.2% of body weight/day). When the feeding frequency increases, the animal's overall growth is much better. Overfeeding at the farm occurs when more than 10% of shrimp gut contains feed an hour before feeding. As for underfeeding, about 40% of shrimp will have natural food in the gut an hour after feeding. We know that feeding should be based on temperature and observing the gut is important for feed management. The feeding rate is temperature dependent. When the temperature increases, the gut transit time is only 45 minutes. Any undigested feed will add to the organic load at the pond bottom, affecting water quality.

Therefore, the daily feeding rate is farm specific. We develop these based on observations and data, using check trays and feeding tables and adjusting daily within the lower and upper limits based on the pond's biomass and carrying capacity. Ideally, we should practise a combination of feeding table, check trays observation and checks on gut colour to adjust the daily feeding rate, control FCR and reduce the cost of production.



How effective are autofeeders in improving feed management?

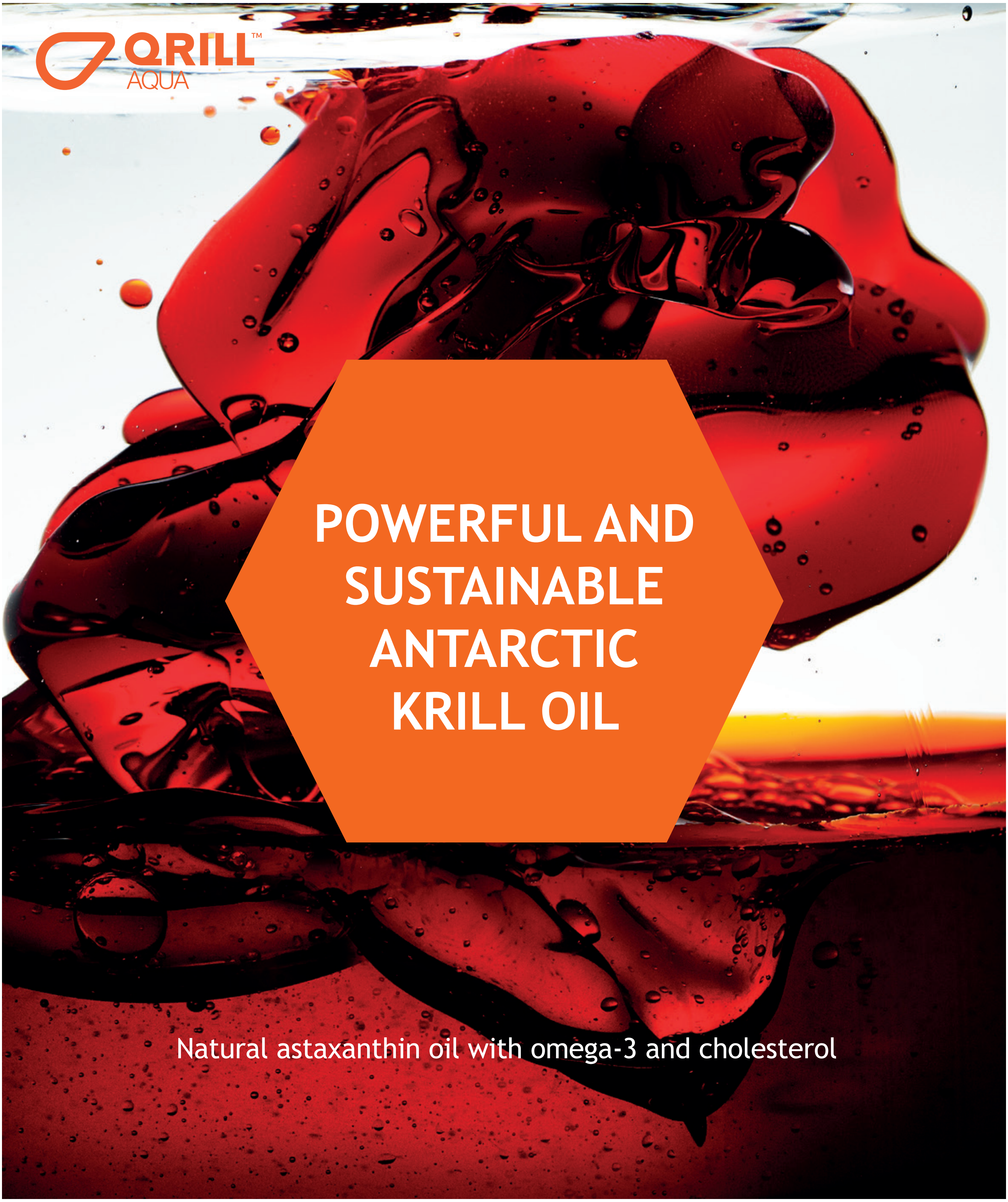
In my opinion, the use of manual labour requires close supervision and the chances of errors are high. Automatic feeders are much better than manual feeding and there are two types of automatic feeders: one has the ration set by the farmer and delivered using a timer; the other is an acoustic feeder where the ration is driven by the shrimp's feeding activity, transmitted to the feeder as sound signals. They can also provide real-time information on water quality parameters (dissolved oxygen, pH, temperature, etc.)

When we started the crop with the acoustic feeder, the farm's FCR was 1.1. In 2 years, the overall farm FCR reached less than 0.9. Farmers will need to depend on automation in the future. But remember one advantage of using autofeeders is that your pond operator will not need to go into the pond. Furthermore, we can say that waste is accumulated only 6-10m away from the autofeeder and as such is easy to remove in between crops.

In your opinion, what are the major disease threats and how can we manage them?

If we look at issues in production in 2019, we had diseases caused by white spot syndrome virus (WSSV), then EHP, vibrosis, WFD and running mortality syndrome (RMS). We had reports on slow growth from most regions because of EHP and WFD. EHP does not directly cause mortality, but the microsporidian can cause severe growth retardation affecting farm production. To be effectively managed, the severity of infection needs to be correlated with growth performance and FCR.

Preliminary tests must be conducted at the farm level to determine the severity of the EHP infection and be classified as Grade 1, 2 and 3. In most cases, Grade 1 infection is reversible after treatment; however, when the infection reaches Grade 3, I recommend to harvest the shrimp crop. A weekly growth rate of 0.7g/week is acceptable. I have advised farmers to calculate growth performance (not to be less than 0.7g/week) and to control FCR to below 1.3 or 1.2. I explained how to sample the hepatopancreas and categorise the severity of EHP infections into grades. If FCR is very high at the end of the cycle, the crop can either be just at break even or incur a loss.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Farm	Pond	Stocking density PL/m²	DOC	Average body weight (g)	Biomass (tonnes)	Survival (%)	FCR
R&D	G3	40	59	18.86	4.8	90	0.95
R&D	G7	35	82	24.40	7.4	87	1.00
R&D	F3	35	67	20.83	8.1	80	0.92
R&D	F4	40	70	21.73	7.1	81	0.87
Demo Farm-1	T1	38	68	26.30	12.1	77	1.05
Demo Farm-2	T1	50	156	38.46	25.2	93	1.13
Demo Farm-2	T2	36	156	45.50	56.9	73	1.09
Demo Farm-3	T2	40	126	31.00	31.4	97	1.03
Demo Farm-4	T1	37	159	26.32	62.3	96	1.07
Demo Farm-5	T2	50	178	46.28	23.4	94	1.21

Table 1. Crop results at Growel's R&D farms and demonstration farms using the combination of fermentation technology, functional feed and auto feeding.

Biosecurity is highly effective in disease management but is also challenging to apply in most practical farming systems. Here in India, 80% of farmers are small-scale with perhaps 2-3 ponds, and it is extremely difficult to implement good biosecurity systems.

What are your approaches on water quality management?

Vibrios multiply rapidly every 12 minutes after disinfection and farmers stock the ponds when the *Vibrio* load is at its peak. Normally, the farmers then apply probiotics once in a month or once in 2 weeks. They need to apply a good quality probiotic at 3-day intervals and use only 100 to 200g after fermentation.

To control diseases, we recommend fermentation to encourage probiotics to multiply and utilise organic matter. But for this to work, we need sterile freshwater, carbon sources, minerals, probiotics and aeration. We use various carbon sources and all these inputs should be cooked before fermentation. Water is treated by reverse osmosis or chlorinated and then dechlorinated. It is then checked for *Vibrio* loads. In our R&D and the demonstration ponds, we do not have problems with WFD or WSSV; however, we do have issues with RMS when the organic load increases at the end of the crop cycle. My advice is that if the probiotics application is delayed, the *Vibrio* load will increase, and the probiotics becomes ineffective. At an application period of 110 days (100 days growth period + 10 days pond preparation), the product input cost of probiotics is less than USD0.1/crop/ha.

Growel Feeds has invested in a full-fledged R&D Innovation Centre which has been recognised by Government of India's Department of Science & Technology in July.

In summary, walk us through your recommendations to lower production costs.

We need to start with pathogen-free post larvae, count the number and conduct *Vibrio* checks. TCBS plate counts tell a lot about the post larvae quality before going for PCR analysis. Use only the best quality post larvae for stocking and it will have a profound effect on the production and profitability of a shrimp farm.

When it comes to feed, manage it aggressively, avoid overfeeding and use immune-enhancing functional feeds. For pond management, address the problem of EHP during pond preparation and keep a healthy microbiota balance with aerobic and anaerobic fermentation. In the case of probiotics, use the right ones and get validation of products before using them to get the best results and control the cost of production. Finally, the removal of sludge and controlling the organic load in the pond are essential to have a successful crop. Growel is developing a mobile data application that will syncronise farm operations dashboard and provide online solutions for pond problems and predictive analysis. We expect to release this app by the end of this year.

Growel Feeds is unique in India's aquafeed industry. It has been exporting shrimp and fish feed to 11 different countries in the Middle East, Africa, South and Southeast Asia over the last four years.The leadership team, from left, P.S. Narendra (Executive Director), Dr Arul Victor Suresh (Technical Director) and Sandip Ahirrao (Vice President – Sales & Marketing).


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An industrialised vannamei shrimp farming model in China

In Rizhao, Shandong province, light shaded algae ponds model is creating an impact.

By Technical Support Team, Grobest Group Limited

Since 2012, in the northern part of China, the industrialised farming of turbot was badly impacted due to low market price, disease outbreaks and drop in groundwater levels. Later, as farmers shifted to sea cucumber farming, they also suffered the same fate. Consequently, some of these turbot and sea cucumber farmers decided to renovate their concreate ponds and switch over to industrial farming of the white-leg shrimp *Penaeus vannamei*.

After five to eight years of development, two common farming models have emerged; light shaded ponds with algae and dark shaded ponds using probiotics with water exchange. From our observation, such models have greatly contributed to farming success. In this article, we would like to focus on the basic infrastructure of these light shaded algae ponds.

Concrete ponds

Along the coast, south of Qingdao, the concrete ponds around Rizhao, Weifang and their vicinity are 5m x 5m and 6m x 6m square ponds. Going up north, around Haiyang, Zhushang and the vicinity, these ponds are larger at 10m x 10m and 20m x 20m. There are also smaller rectangular ponds of 3m x 6m and 3m x 7m which have been developed following the sea cucumber ponds in Hebei, Tongying, Yingkou and Dalian areas.

Steel frames have been installed above these concrete ponds. In Rizhao and Haiyang areas, clear wrap films are used in two layers or in one layer with vinyl plastic. The overall structure resembles that of shading in a vegetable garden. While in Tongying and Hebei areas, polypropylene sheets are inserted between the steel structures, creating semi-transparent dark shadings.

Heating

Heating of pond water is by various ways: geothermal heat pumps, geothermal wells, gas turbines, biomass boilers as well as aluminum tubes in a central plate and steel with zinc coating. Coal-fired boilers have been phased out as a heating device.

Aeration

These are achieved using root blowers and nanotubes in the smaller ponds and paddlewheel aerators in larger ponds. The target is optimal aeration of 4.0 ppm throughout the culture cycle.

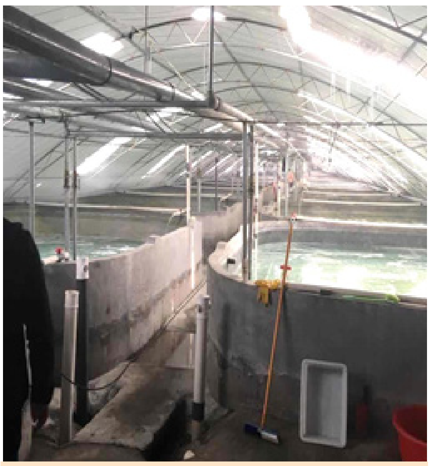
Pond design

Ideally, these should be circular in shape. Otherwise, it would be rectangular externally and circular internally, with a sludge pipe in the centre.

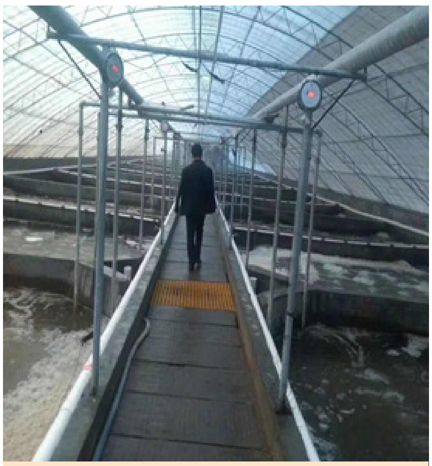
Water conditions

These vary with locations. In Shandong province, farms around Rizhao, Haiyang, Yentai and Weifang areas, use underground water at 10-25ppt salinity. Water is sand-filtered before channeling into the culture ponds. In normal, light shaded farms, the well water is sand filtered prior to use. In order not to disturb the shrimp, the water flow is controlled. Water is only added at 8 am to 3 pm. In the dark shaded ponds, the well water, after sand filtered is directed to boilers and flow into the ponds at 27~28°C.

Around Tongying in Hebei province, sea water is used. Usually there are outdoor disinfectant ponds of various sizes, from 1,300m^2 to 3,300m^2. Water is sand filtered and heated before flowing into the ponds. Since there is no temperature difference, there is no limit on water exchange.



Dark shaded ponds use probiotics with water exchange



These light shaded ponds have algae, diatoms and chlorella.

In the big ponds, paddle wheel aerators oxygenate ponds.

Farming practices

This is divided into phases; nursery and grow-out.

Nursery

In the nursery, we start with post larvae (PL5) stocking at 5,000~10,000/PLm². After 20 to 30 days, when the post larvae size reach 4,000PL/kg, we change ponds. Nursery management includes filling of water up to 60cm. Water is preheated, disinfected and enriched with probiotics before stocking. We only start feeding after the situation is stable.

Grow-out

This starts with water preparation and growing algae, mostly diatoms and chlorella, in light-shaded ponds; these are particularly important steps.

At grow-out, adding water and growing algae - mostly diatoms and chlorella

There are some critical issues. In terms of trace elements, there should be a balanced level of calcium, magnesium, and potassium. This is important during moulting and grow-out stages. Probiotics addition are timed with addition of water treatment products. It is also important to pay attention to the shape, colour, fine foams, stickiness of the water bubbles.

Key performance indicators

In 6m x 6m ponds, stocking 400-600 PL/m^2 and using a water exchange of 30-50% per day, we achieved a survival rate of around 80%. The feed conversion ratio was 1.3. The final production yield was 8kg/m^2. The key points for this super intensive farming model are using a good water source (either direct or through a reservoir) and maintaining optimal dissolved oxygen. An excellent drainage system to remove dead shrimp, faeces, etc. is important. Finally, this comes with optimal management practices throughout the cycle.

Culture management includes controlling water quality

Harvesting shrimp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New studies show microbial solution reduces shrimp mortality from AHPND

A gnotobiotic *Artemia* model system showed that probiotic treatment alleviates *Artemia* mortality after purified PirAB toxin challenge

By Anwar Hasan, Benedict Standen and Jutta Kesselring

Early mortality syndrome (EMS) or acute hepatopancreatic necrosis disease (AHPND), is a penaeid shrimp disease that causes serious economic losses and significant mortality, up to 100%, in cultured shrimp species. Until 2015—in Thailand alone—the AHPND outbreak costs the industry more than USD5 billion (Shinn et al., 2016). Since then, recent publications suggest a further USD1 billion is lost every year across Asia and Latin America. These figures only consider the direct mortality losses, so the real figure is likely to be significantly higher when considering diagnostics, treatment and labour costs as well as potentially damaging consumer perceptions and market access.

The dramatically high mortality rates in infected shrimp are caused by disfunction and destruction of the hepatopancreas (Lightner et al., 2014). There is no inflammatory response to the causative *Vibrio* spp., because AHPND is elicited by a toxin (Han et al., 2015), which is encoded by a plasmid (Yang et al., 2013; Tran et al., 2013). Various *Vibrio* spp., not only *Vibrio parahaemolyticus*, were demonstrated to carry this pathogenic plasmid.

Comparison of genome sequences revealed that the pathogenic plasmid encodes genes homologous with *Photorhabdus* insect related (Pir) toxin genes (Kondo et al., 2014). The Pir toxins act as binary proteins; they are encoded by the PirA and PirB genes and both proteins are necessary for oral toxicity (Blackburn et al., 2006; Ahantarig et al., 2009; Han et al., 2015).

PirB was demonstrated to be a haemagglutinating lectin (Santos et al., 2020). As part of the tetrameric PirAB^{VP} complex it binds to glycosaminoglycans (amino sugars) of the membrane receptors on hepatopancreas epithelia of shrimp to trigger the massive sloughing of these cells in the final stage of the AHPND disease.

Although many reports may document *Vibrio* inhibition, there is still a paucity of information on how to degrade the toxin of AHPND, thus preventing the shrimp from the negative effect of this PirAB^{vp} toxin. One of the few initial studies has recently been reported and is explained below. (For the full article, readers are directed to the original https://www.biomin.net/science-hub/b-subtilis-dsm33018-is-able-to-degrade-pirb-and-alleviates-ahpnd-in-artemia/)

Degrading the AHPND toxin

In *vitro studies* at the Laboratory of Aquaculture and *Artemia* Reference Center, University of Ghent, Belgium, demonstrated that *Bacillus subtilis* DSM 33018 has the capacity to degrade the AHPND-causing PirB toxin, one of the two subunit toxins needed to elicit AHPND in shrimp. *B. subtilis* DSM 33018 is part of the probiotic product range AquaStar® (BIOMIN).

After positive *in vitro* results, the next step was to test if B. subtilis DSM 33018 was able to rescue infected animals from AHPND-related mortality, using a gnotobiotic *Artemia model*. This *B. subtilis* DSM 33018 was tested alongside individual probiotic components and this multi-strain probiotic product, AquaStar, all at 10^7 CFU/mL (Figure 1).

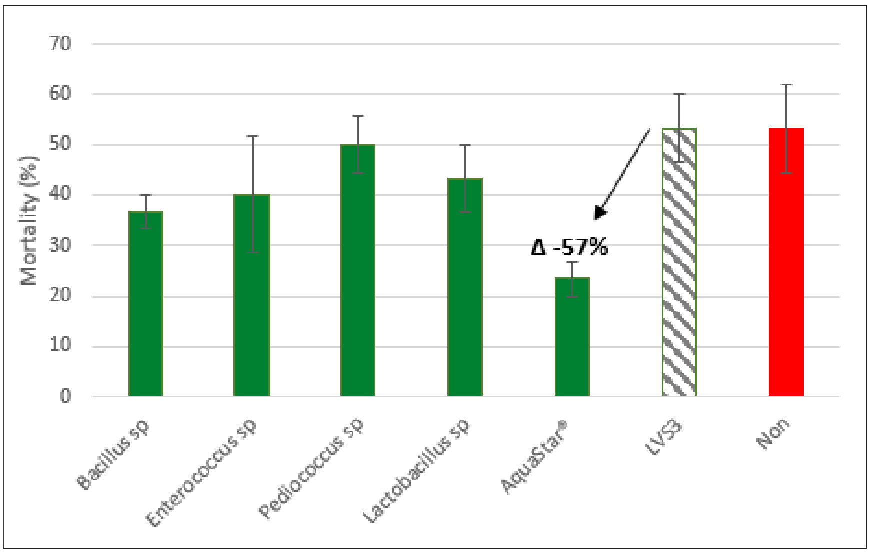

Figure 1. Probiotic treatment alleviated *Artemia* mortality after challenge with purified PirAB toxins at 26µg/mL. Individual probiotic strains and their combination (AquaStar® Growout) were tested at a concentration of 10^7CFU/mL. LVS3 is a heat inactivated *Aeromonas control*, acting as a nutritional support. 'Non' is the control challenge without probiotic treatment nor basic nutritional support

The *Bacillus* treatment resulted in significantly lower mortality rates (37% versus 53% in the control). *Enterococcus* sp., *Lactobacillus* sp. and *Pediococcus* sp. alone were able to reduce mortality after toxin challenge (40%, 43 and 50% mortality, respectively), albeit not significantly. Interestingly, the lowest mortality, and therefore the best protection (23% mortality), was achieved with the mixture of the tested strains (AquaStar). This demonstrates the complementary and synergistic benefits of combining *Bacillus* sp. with lactic acid bacteria. Compared to the control group, this multi-strain probiotic reduced *Artemia* mortality by 57%, in real terms.

Although *Artemia* represent a robust model crustacean species, it remains to be determined if this *B. subtilis* DSM 33018 alone helps to alleviate AHPND in shrimp culture. Having said that, when whiteleg shrimp *(Litopenaeus vannamei)* were challenged with PirAB toxin producing *V. parahaemolyticus* (AHPND-positive), supplementing the multistrain probiotic combination of *Bacillus* sp. plus lactic acid bacteria significantly reduced mortalities. In the first *in vivo* trial, whiteleg shrimp were intra-muscularly injected (IM) with *V. parahaemolyticus* (AHPND-positive; 5 x 10^4 CFU/shrimp) after 12 weeks of probiotic feeding at 3g/kg. The probiotic-supported group showed significantly higher survival rates after the infection had taken its course (Figure 2; Kesselring et al., 2019). This result demonstrates strong immune modulating benefits of this multistrain probiotic, but doubts remained as to the real effect, as IM or intraperitoneal (IP) injection bypasses an important defense mechanism of the animal, the gut. This is particularly true when it comes to probiotics where one of the main modes of action may be competitive exclusion.

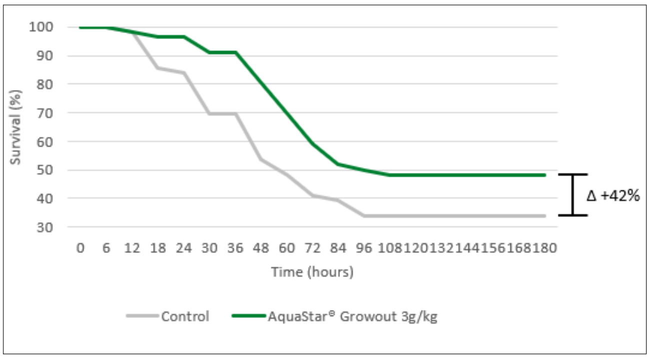

Figure 2. Survival rate of shrimp fed control and AquaStar® Growout 3g/kg diets during a 180-hour *V. parahaemolyticus* (AHPND positive) IM challenge.

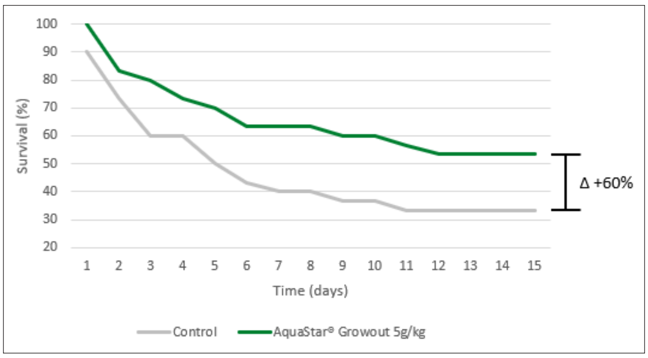

Figure 3. Survival rate of shrimp fed a basal feed, with and without Aqua Star® Growout at 5g/kg for 15 days following *V. parahaemolyticus* (AHPND positive) immersion challenge.

The second *in vivo* trial employed a more natural immersion infection route (one-hour immersion at 1.25 x 10^6 CFU/mL) in whiteleg shrimp with an AHPND-positive *V. parahaemolyticus* strain. Significantly higher survival rates were observed in shrimp receiving the four-species preparation of the probiotic bacteria (AquaStar Growout, 5 g/kg, Figure 3). Survival was 53% in the probiotic treatment group versus 33% in control, a real term improvement of 60%.

Conclusion

Importantly, Gram-positive probiotic organisms, such as those defined in the AquaStar product range are not involved in horizontal gene transfer processes with Gram-negative organisms such as *Vibrio* spp. and are thus unlikely to acquire resistance or virulence genes or plasmids from *Vibrio* species (Moriarty, 1999).

It is strongly argued that AHPND is a management disease, which means there is no silver bullet solution. Some countries, such as Thailand, have demonstrated the benefits that a holistic approach may be able to tackle such pathologies, for example by considering strict biosecurity, shrimp waste and water management, good quality feed, use of additives and clean post larvae to name a few. However, these results clearly demonstrate that probiotics, specifically those relying on multiple genera, have a key role, and are an important tool in a shrimp farmers arsenal in the constant battle against shrimp disease.



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First in Vietnam: Highly concentrated probiotic-coated shrimp feeds

Homogenous application of probiotics in shrimp feeds is a game changer, moving away from top dressing of shrimp feeds at farm site

By Cuong Huynh Tran, Fernando Castro and Sjoerd Bakker

The use of probiotics has become increasingly important in Southeast Asian shrimp farms as culture practices intensify. Farmers and technicians have clearly identified the need to control bacterial populations in both the culture water and the shrimp gut, and probiotics have proven time and time again to be very effective in performing this task. Processors, exporters, and all other downstream stakeholders also benefit from the use of probiotics, which can mitigate the misuse of antibiotics in an industry plagued by diseases. However, the practical application of probiotics is still a subject of debate as opinions from probiotic suppliers, aquaculture technicians and researchers differ greatly, especially when referring to probiotics in feed application.

Feed probiotics are live microorganisms that provide health benefits when consumed by shrimp or fish. The beneficial impacts of feed probiotics on the host can be classified under three categories:

- **Exclusion of pathogens:** through competitive exclusion (competition for the same environment and nutrients) and secretion of antibacterial peptides, probiotic bacteria can control the population of pathogenic bacteria. It has also been proven that a healthy bacterial population reduces incidences and impact of harmful viruses and other pathogens.
- **Improved digestion:** probiotic bacteria, when carefully selected, can secrete digestive enzymes, and adjust the gut pH, thus helping the animal get the most out of the feed.
- **Enhance the health status of the host:** probiotic bacteria improve the general health status of the host by enhancing the barrier function of the gut, secreting antioxidant enzymes and through different immunomodulation activities.

A simplification of the impacts of feed probiotics on the host is shown in Figure 1.

Limitations of on-farm top coating of feeds

Today, the main method of using feed probiotics is by top-coating. Farmers, either manually or with the help of machinery such as a concrete mixer, dress the feed with probiotics mixed with a liquid support. This, when applied at larger farms, has several limitations:

- Low concentration and high cost as most products available in the market have low CFU counts. Highly concentrated products are expensive. Many of the available products have quality variations from batch to batch.
- Lack of homogeneity and precision since the dose measurement when coating at the farm is usually unprecise and there is no effective measurement of homogeneity in the coating.
- Labour intensive especially when reaching the end of the production cycle. Coating large volumes of feed is extremely labourious. Therefore, a majority of farmers only coat the feed once a day, leaving the other feeding times without probiotics.
- Special care in probiotic storage and usage since probiotics are highly sensitive to humidity. Once the pack is open, farmers have to use it up quickly.
- Microbial loss with top-coated feeds which have a high leaching rate, as the liquid and additives are not absorbed by the pellets but remain on the surface of the feed.

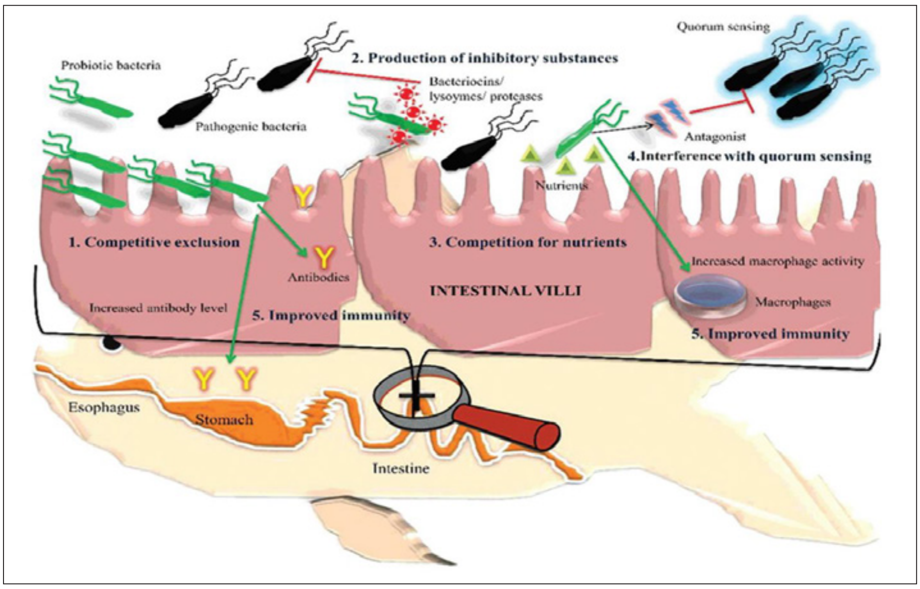

Figure 1. Mode of action of probiotics in the aquatic system (Jamal et al., 2019)

New technology for industrial coating

To solve the above inadequacies, ADM has invested in high-end equipment in its Ocialis shrimp feed plant in Vietnam to coat its shrimp feed (Vanalis Probiotics by Ocialis) with probiotics directly at the end of the manufacturing process. A specific probiotic mixture with higher concentration and quick action has been designed by ADM to provide a higher count of probiotic bacteria on the feed at a lower cost than any top-coating probiotics available in the Vietnamese market today.

The probiotics are fermented, manufactured and imported directly from ADM's plant in the USA to ensure quality and traceability. The fully automated probiotic coating system provides accurate weighing of the probiotic powder before it is mixed with fish oil. The coating is performed at a maximum temperature of 40°C to maintain probiotic viability. The mixture of oil and probiotic is spread evenly on the feed via nozzles.

There are multiple advantages of industrial coating for the shrimp farmer:

- A higher concentration of probiotic bacteria on the feed than with the traditional top-coating method
- A homogeneous coating of the probiotic around the feed with reduced leaching in the water
- A strong natural bacteria culture in the shrimp gut, which suppresses the growth of harmful bacteria such as *Vibrio* sp.
- Increased animal survival and yields
- High animal weight gain and improved feed conversion efficiency resulting in lower FCR.
- Reduced labour and storekeeping at the farm

The coating homogeneity of each batch of Vanalis Probiotics is strictly controlled by ADM's international laboratory. Moreover, viability of the probiotics is controlled up to 3 months in Vietnam, as shown in Figure 2.

Ocialis is proud to be a pioneer in the probiotic complete feed segment in the Vietnam market. After 2 years of development and quality control, Vanalis Probiotics was first launched in June 2020 in Vietnam while the first overseas shipments will reach shrimp farmers across Asia in September 2020.

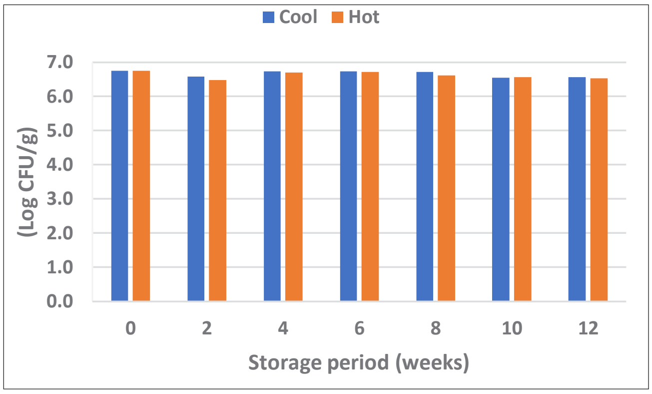

Figure 2. Viability of probiotics during storage in cool conditions and tropical condition

Reference

Jamal, M., Chithambaran, S., Abdulrahman, I., Harbi, M. 2019.. Probiotics as alternative control measures in shrimp aquaculture: A review. Journal of Applied Biology & Biotechnology 2019;7(03):69-77.

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Shrimp farming made easy

A new startup in Indonesia brings modernisation and computerisation to shrimp farming

Indonesia has an active startup ecosystem which today, matches well with the needs of its expanding shrimp farming industry, eager to modernise. A changeover is also happening with farms being managed by a new generation of entrepreneurs or being passed on to the next generation.

The opportunity is there for an aquaculture startup like Sgara which aims to help shrimp farmers increase farm efficiency through data analytics. At the recent "Bandung Startup Pitching Day 2020", held to facilitate access to funding as well give exposure to new startups, Sgara was voted as the most marketable.

Sgara was started in October 2018 by three founders; Arrival Dwi Sentosa, Christopher Jason Sjarif and Rizky Darmawan. It is focused specifically on shrimp farming; helping shrimp farmers increase farm efficiency through data. It has Sgarabook, a mobile and web-based AI-powered shrimp farm management system. The aim is to help farmers prevent diseases by generating optimal plans for the farm's future cycles based on the farm's previous data. As a farming cycle progresses, the system is able to recommend tailored feeding programs and water treatments to ensure an optimal result. The system alerts farmers on unusual water quality parameters and disease predictions in advance to help farmers avoid diseases.

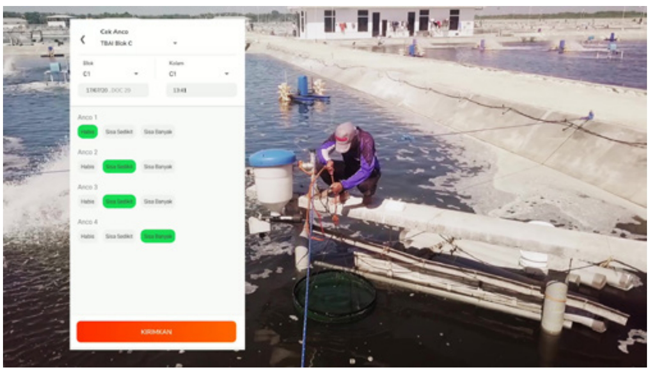
This is the story of Sgara as told by the three founders via email.

"..We asked ourselves, what if we can streamline data reporting, access all our data easily, and present it as such that we can analyse it day by day, anywhere we want, anytime." - Christopher Jason Sjarif

The pull factor

It helped that all three founders are second generation shrimp farmers taking over from their parents and relatives, but keen to modernise the whole industry. Rizky runs a 60-pond intensive shrimp farm on Sumbawa Island; Christopher has a 8-pond intensive farm also located in Sumbawa, and Arrival Dwi had experience in his uncle's traditional shrimp farm located in West Java. In terms of training, none of them were specifically trained as aquaculturists.

Christoper and Arrival Dwi were college mates at the Beijing Institute of Technology, both majoring in computer science. Rizky studied aquatic and fisheries sciences at the University of Washington, Seattle and joined the family farming business in 2014. Rizky also founded the PMI (Penternak Muda Indonesia), a young shrimp farmers association and is currently its chairman. Arrival Dwi is currently enrolled in Bandung Institute of Technology (ITB) graduate school majoring in AI development. Marrying these backgrounds with their hands-on training in farm operations gave them the heads-up in pushing for "factory style farming" with data at hand.



"We were exposed to aquaculture because our parents are shrimp farmers. As we learnt more about this industry, we saw that changes were minimal in the direction of modernisation and computerisation. Daily reports are still handwritten and sent around using chat apps. This made data recollection a nuisance especially if you have many ponds and you need to analyse a specific set of data," said Christopher, CEO. "In the worst case scenario, when farms had a problem, such as a disease outbreak and had managed it well, they had to restart at finding solutions again when the problem reappeared, as data from previous cycles were very disorganised and hence practically unusable.. Because of those reasons, we asked ourselves, what if we can streamline data reporting, access all our data easily, and present it as such that we can analyse it day by day, anywhere we want, anytime. Thus, we founded Sgara and created the app."

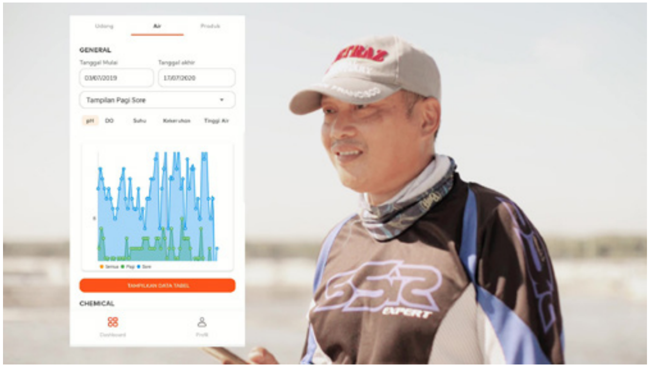
The journey

It started with the team reaching out to multiple farms to better understand aquaculture and possible improvements. "Both Christpher and I had many ideas such as improving the supply chain, finance, marketing, etc. However, they didn't work out for us because aquaculture is a complex business and we did not have enough time nor the resources, " explained Rizky, CMO.

"Finally, we decided to focus on one product that we believe can help farmers the most; we concentrated our efforts in making a more efficient, accessible and traceable data management system. Hence Sgarabook was born."

"While doing our research, we saw some limitations that needed to be addressed if our app will ever be used in the farms. The first obvious problem was that most farms are in rural areas with unreliable internet capability. Secondly, not all farms have computers; the only technology that is almost always available in the farms are mobile phones. Lastly, we saw that most people in this industry are seniors and it will be a challenge since they usually have an established working method and might not want to adopt a new one. For those reasons, we decided that Sgarabook had to have mobile capability and the simplest user interface," added Arrival Dwi, CTO.

> **"However, we were lucky to have early adopters that patiently tested our product, gave feedback, and helped us identify problems." – Arrival Dwi Sentosa**



At its early stages, Arrival Dwi said that the team struggled in developing Sgarabook. "The complex logic needed within the system made bugs and errors a common occurrence. Each data point in the system is attached to a number of other data and calculations. However, we were lucky to have early adopters that patiently tested our product, gave feedback, and helped us identify problems. One of the most prominent features added from the farmer's idea is the synthesise feature."

Nowadays, it is common practice for farmers to ferment feed or add additives. Using the synthesise feature, they can plug in the mixing ingredients to track usage and cost. Finally, after many bug fixes and iterations, Sgarabook was ready to be launched in the market.

Positive feedback from young and old farmers

"When we revealed the final product, Sgarabook received positive feedback from farmers both young and elderly. They even provided us with some new ideas to better cater to their needs. The younger farmers are especially excited since they are more avid with the new technology and efficiency that Sgarabook can enable them to better manage their time," said Rizky.

Some resistance came from farmers worried about the security of their data. Nevertheless, we were able to convince them that the data is secure, encrypted, and will not be exploited; the data that we actually gather will be anonymous and only be used to improve our services."

"We are confident that Sgarabook is better than competing farm management apps on the market because it is by far more comprehensive. Sgarabook can manage all aspects of managing a farm from item usage, water quality, feed trays, shrimp data, and even warehouse stocks. The interface is easy to understand and it is easy to adopt the system through our data import feature. As of now, more than 400 ponds are registered and actively using Sgarabook, new client farms are onboarding our system, and we already formed partnerships with feedmills."

> "By simplifying data analysis and automating tedious calculations, we believe farmers can make better and faster decisions," - Rizky Darmawan

Next is AI and marketplace integration

From here, Sgara has unlimited room to grow. "We have numerous projects lined up to improve and modernise aquaculture. Our next big project is to create an AI that can analyse data and give treatment recommendations based on previous cycles and regional data. When coupled with our marketplace integration, farmers can directly order farm necessities while analysing farm parameters through the app. On top of that our IoT developers are striving to build better, standardised equipment that can make data collection more accurate," said Arrival Dwi.

"Through Sgarabook, we want to help farmers increase their success rate and productivity. By simplifying data analysis and automating tedious calculations, we believe farmers can make better and faster decisions. The farming assistance will also serve as a smarter, data-driven alternative. In addition, we want our product to not just benefit farmers, but also the consumers," said Rizky.

"More importantly, our dream is that data within Sgarabook is shareable by its owner when a customer demands it. This feature enables the farmers to market seafood that is fully traceable and transparent," said Christopher.

The team from left, Arrival Dwi Sentosa, Christopher Jason Sjarif and Rizky Darmawan with Haris Muhtadi, Chairman of the Indonesia Feedmills Association (GPMT-Gabungan Perusahaan Makanan Ternak) and Associate Director at PT CJ Feed and Livestock Indonesia (right).

Changing to deep technology in ocean aquaculture and ecosystem

A startup leverages on its aerospace and software engineering background to dive into smart feeding systems and satellite sensing

Since year 2016, the Singapore and Japan based deeptech startup, UMITRON, has been making waves with a series of developments and solutions to difficult problems to accelerate sustainable mariculture using computerised technology. The first innovation is an IoT based smart feeding system for cage culture. The company followed this with the world's first real-time ocean-based fish appetite detection system, FAI or Fish Appetite Index, an algorithm that automatically evaluates feeding conditions using artificial intelligence (AI). This allows for a more detailed and optimised feeding operation that matches the appetite level of the fish.

Masahiko Yamada (first row, right) and Andy Davison (back row, left) and the team.

In Japan, Co-founder cum Managing Director **Masahiko Yamada** and his team worked closely with the fish farming businesses in the Shikoku and Kyushu regions in applying these devices which can be managed remotely via the cloud through a smartphone. The demand of these farmers producing various fish species – such as red seabream, tuna, rainbow trout, white trevally and longtooth grouper – is to reduce a farm's workload and optimise the feeding process. "Based on the results delivered by these units, we reflected on the feedback and visited the sites to develop a new model of smart aquaculture feeder called Umitron CELL 2," said Masahiko.

Subsequently in Japan, the company worked with a leading seafood producer, Maruha Nichiro in its salmon farming project in Saga prefecture to provide solutions on remote monitoring of fish in pens, automatic accumulation of feed data and detailed and real-time adjustment of feed timing and amount. The aim is to reduce the environmental impact and lessen the burden of labourers in farms. The team has also taken its innovation for fish farmers to Peru. In 2019, it partnered with Asia's leading aquaculture multinational Charoen Pokphand Foods (CPF), to provide solutions such as AI and automation technology to CPF's environment-friendly shrimp farms. This will improve growth efficiency, boost biosecurity and quality of work and reduce feed wastage which would help minimise any environmental

The first units of this smart automated feeder have been installed at farm sites in Ainan City, Ehime, Japan.The device can be managed remotely through use of a smartphone or desktop computer via the cloud.

issues. In 2019, the team participated in the Aquaculture Europe trade show, displaying its innovation to accelerate the growth rate of red sea bream to the industry in Europe (see AAP January/February 2020, p61).

Since then, these millennial entrepreneurs have continued to astonish industry with innovations, the latest being high resolution water quality data monitoring called PULSE. Via email, *AQUA CULTURE Asia Pacific* posed questions to Masahiko and **Andy Davison**, Product Manager, to understand the drive behind their interest in aquaculture and ocean ecosystem.

Why aquaculture? How did the group come together to think of helping this industry?

Masahiko: Our founders originally had experience in both the aerospace industry and software engineering. We were trying to find potential areas or industries where we could leverage our backgrounds to solve important problems. We first thought of industries related to the ocean since it covers 70% of the Earth's surface and that advances in satellite observations and data analytics could potentially have a huge impact in this area. We then identified that aquaculture was a fast growing and exciting industry that was providing healthy protein for billions of people. At the same time, we also noticed that farmers were still largely relying on old technology to operate their farms. After identifying this initial gap, we started to dive into deeper conversations with farmers to really understand their core challenges.

We started at one of Japan's premier aquaculture areas, in Ainan municipality located south of Ehime prefecture. Aquaculture is the core industry of the town, but it is facing changes including an increase in production costs due to soaring prices of feed and labour shortages due to an aging population. Our goal was to reduce the farmer's workload via remote monitoring and control systems that utilise IoT technology, to optimise feeding based on data analysis. We have done research there for 3 years now.

Recently, you announced some profound innovations on biomass measurement, and environmental data monitoring of oceans using satellite data. How do you see this benefitting the aquaculture industry?

Masahiko: We are always having one on one conversations with farmers to understand the daily challenges they are facing. We also heard from farmers that it was hard to predict and understand how the environment was affecting their operations. We have now developed PULSE which is a web-based software for monitoring key ocean data such as water temperature, salinity, dissolved oxygen, wave height and chlorophyll concentrations. This uses satellite remote sensing data to actively monitor all of the world's oceans. With this, we provide farmers with a tool to monitor the environment and improve their decision making. It helps with all aspects of farm management including feeding, disease and risk management.

Andy: All farmers are dependent on the environment and by focusing on this area we believe it will benefit many farmers in all regions growing all types of fish, shellfish and seaweed. It is the kind of product that can be easily used by everyone.

How have your innovations helped the industry?

Masahiko: With the smart feeder and real-time fish appetite analysis powered by AI, farmers can adjust the amount of feed by remote control according to the fish's appetite. After a year of testing, the results have shown a 0.4kg weight advantage to juvenile seabream fed using the smart feeder. This resulted in growing fish to 1 kg market size 4 months faster than was previously possible (see graph). Feed conversion ratio also improved to 2.06 from 2.62. Users said that they have been adjusting the feeding time and its frequency, and as a result were able to speed up production.

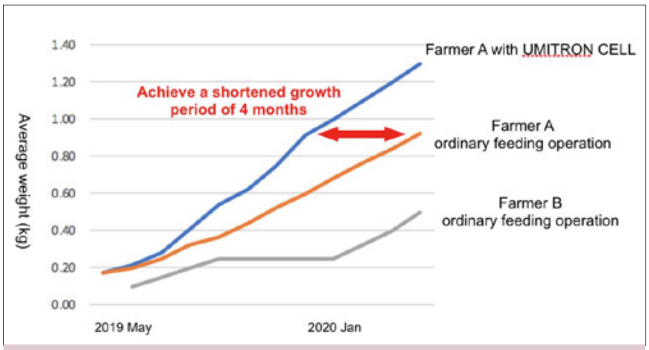
Andy: We will continue to develop and enhance feed optimisation for aqua farmers following the achievement of these positive results. We have expanded the feeder capacity by 100% from 200kg to 400kg to facilitate less frequent boat trips for feed replenishment and a reduction in fuel costs.

Masahiko: In the case of PULSE, farmers now have a reliable way to check the water quality near their farms and by zooming out they can also see trends in a larger area around their farms. This kind of high-resolution water quality data is useful for aqua farmers. It gives them more information to decide the best timing for harvesting, planting and feeding. It also helps new farmers find great locations for farms. Identifying locations with optimal water quality conditions both near shore and offshore will be key to continuing to grow the industry in a sustainable way.

Will the innovations change current aquaculture models? Do you see a paradigm shift?

Masahiko: In the case of PULSE, a lot of this information we are providing was either unavailable, difficult to access, or of very low resolution. One alternative for farmers was to operate their own sensors but these are difficult to maintain and they only provide data from a single location. PULSE makes it a lot easier to access ocean water quality data. It is also the first of its kind to offer forecast information which is something that traditional sensors were not able to do. We hope that having easy access to this kind of information changes how farmers make decisions and that it reduces some of their risks.

Andy: We hope deep technology in general will move aquaculture into the 21st century. One way we can do this is by giving farmers more useful information that can improve their decision making.



Results showed a 0.4kg weight advantage with juvenile seabream and this encouraged farmers to fully automate feeding with Umitron CELL.

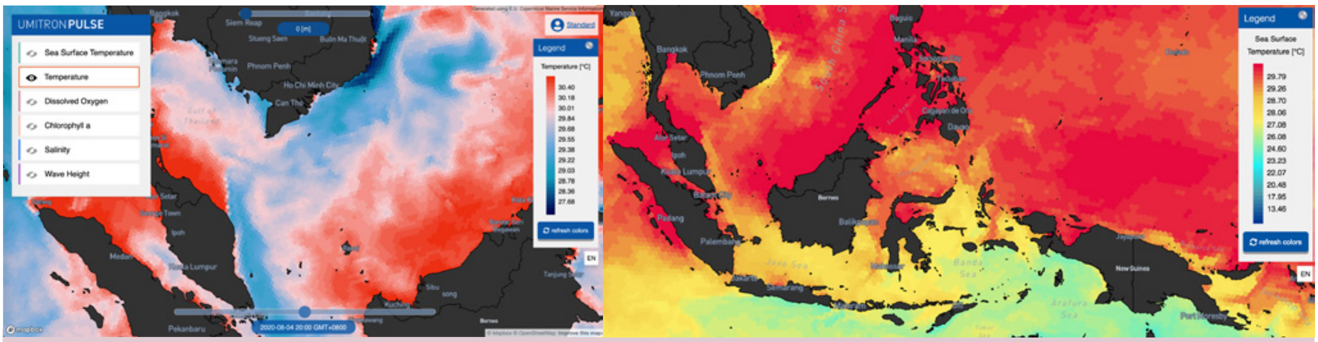
What changes in the market will create a pull effect for you?

Masahiko: Growing awareness with farmers in how new software and hardware technology developments can improve their operations and make their jobs easier will be important. This is especially true for smaller farmers in many regions of Asia who have traditionally not been able to access the latest technology. Now with widely available software all farmers can access this kind of technology. Almost everyone now has access to a smart phone; this is a powerful tool that makes it easy to spread new technology to a lot of people.

Moving forward, what are the next steps?

Masahiko: For us the next steps are to keep talking to farmers to identify key challenges and then develop great products that provide outsized value. We are now working on a mobile version of PULSE and we hope to sign up more users and hear their feedback. We hope to reach more farmers in more areas.

Andy: We are excited to release a product that provides utility to a wide range of farmers; allowing them access to additional information about the environment they are working in every day.



High resolution map of oceans in Indonesia and Southeast Asia. PULSE uses high resolution satellite remote sensing data to monitor ocean environmental data. This web-based service utilises satellite remote sensing technology to provide accurate, near real time measurements. There is an intuitive and user friendly interface that allows farmers to quickly zoom in and out to see both local and large scale trends. The high-resolution map view can display a range of water quality parameters which are updated daily. PULSE gives farmers an easy way to regularly monitor changing water conditions; farmers can check water temperature, salinity, dissolved oxygen, chlorophyll concentrations and wave height. In addition to real time data, the service also provides a 48-hour forecast that predicts how the water quality will change in the near future. This allows them to make key decisions on when to feed, stock or harvest their crops as well as manage risks such as high water temperatures or harmful algae blooms.

Bringing the Akasaka story to the restaurant table

A story of cooperation success swirling brightly amidst the dark difficulties of Covid-19 pandemic.

“We know that this Covid -19 pandemic is a difficult time for farmers. We wanted to help Akasaka Fisheries, a sea bream producer, to have a stable supply of sustainably grown fish direct to consumers. Through crowdfunding we raised JPY 3,000,000 (USD 28,300) from 182 supporters within 1 month. The company is also improving their workers daily jobs by embracing new technologies. The money was for the installation of our latest autofeeder model as well as contributing towards stocking and producing fish. As a reward, supporters received a sea bream called ‘Hakujyu-Madai’ which is one of Akasaka Fisheries’ speciality brands, as well as an opportunity to visit the farm site to see how the fish is grown,” said Andy.

“Many restaurants have been suffering from a lack of customers and revenue. An additional JPY 1 million (USD9,400) was raised with the help of two restaurants in Tokyo and another two in Ehime prefecture. This helped restaurants to serve ‘Hakujyu-Madai’. The additional money raised from the campaign was given to the restaurants in advance to help them tide over this period of low-income. Supporters received meal vouchers for future dining at restaurants serving the dish.

“To reach out to consumers our sustainability story, we provided restaurants with tablets with UMITRON’s pre-installed application after the installation of the smart feeder at Akasaka Fisheries. While eating, diners could access video data from the fish cages and learn about the environmental efforts that our technology together with Akasaka Fisheries are undertaking”.

Hakujyu-Madai

Reflections on Indian shrimp in Covid-19 dominated 2020

By Willem van der Pijl

India is one of the countries most affected by Covid-19: almost 1.5 million cases have been confirmed, more than 32,000 people have died and almost 50,000 new cases are registered every day. For the shrimp industry, the consequences were at their most severe when the country went into full lockdown for 21 days at the end of March – farmers had to stress-harvest their ponds; hatcheries could not import new broodstock; and factories did not have sufficient workers to operate at decent capacity. But with most of the shrimp value chain being permitted to continue activities to some extent during lockdown and activities quickly resuming in the immediate aftermath, hatcheries were able to import new broodstock, some farmers were able to stock their ponds, and factories quickly resumed operations – some factories even maintained operations at 50% capacity during lockdown.

In this article from my blog post, I want to look at how the first seven months of 2020 have unfolded for Indian shrimp, especially the months surrounding the global outbreak of Covid-19. I will also share the view of one of India's biggest hatchery operators and will provide my own prognosis on what the remainder of 2020 might look like for Indian shrimp.

Shrimp exports down 11% in value and around 20% in volume

The data available from India's Ministry of Commerce (MOC) covers export volumes until April and export values until June. Export value data for May and June, although still provisional, show some interesting insights into what happened after lockdown was lifted.

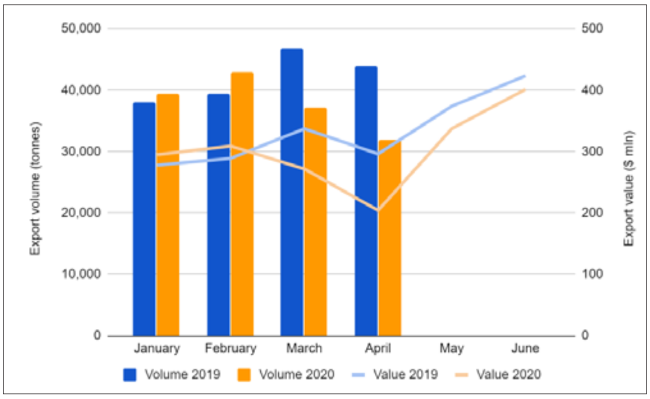


Figure 1. India's shrimp exports in 2020 vs. 2019. (Source: Ministry of Commerce, India)

Concerning export volumes, MOC data show that by April 2020, the year total export volume was 10% behind that of 2019. This is interesting to observe and indicates the impact of the lockdown. As in January 2020, India's export volume was 3% ahead of January 2019, and February 2020 data shows a similar trend with the export volume being 9% higher than that of February 2019. But these volumes plummeted to −21% and −28% in March and April of 2020 respectively: in March 2020, India exported 37,182 tonnes while in March 2019 it exported 46,835 tonnes. However, in April 2020 this downward trend continued and India exported a total of just over 31,800 tonnes compared with April 2019 when it exported 43,918 tonnes.

April 2020's year-to-date export value was 10% behind 2019's April year-to-date total. The export value data for May and June 2020 provide some further insights, most importantly that exports in May and June improved considerably. Although export values for 2020 were 19% behind March 2019 and 31% behind April 2019 respectively, export values in May and June 2020 were only 10% and 5% behind those of 2019.

This showed some significant recovery in the immediate aftermath of lockdown: while exports certainly suffered considerably during lockdown in March and April, Indian exporters managed to get back on track quickly. Despite shortages of labour, exporters seem to have been able to ship considerable amounts of product since then. When looking at export value alone, by June 2020 the year-to-date total exports were only 9% behind those of 2020.

What happened with exports in July is uncertain. Reportedly, exports of Indian shrimp to China came to a halt as Chinese customs delayed the influx of containers. As a result of this development, prices for smaller shrimp (normally purchased by China) fell considerably. With demand from the US being slow as well, prices for bigger sizes dropped even more. This drop in export prices has had an impact on farm gate prices, which have also fallen rapidly in recent weeks.

Broodstock imports are now on a par with 2019

Broodstock imports can be seen as a parameter that allows us to predict post larvae (PL) and eventually farmed shrimp production: everything came to a standstill in April, things recovered quickly by June, and now they're looking promising as the year progresses past the "peak" of the Covid-19 crisis. India was well on track with its broodstock imports in the first three months of 2020. While it was 15% behind the import level of 2018, with 63,430 broodstock during the same period in 2020, imports were well ahead (+35%) of 2019's first quarter import levels. And then the Covid-19 pandemic happened.

We all know about the devastating impacts this has had on global business, economy and industry - and the shrimp sector did not go unscathed. In India and specific to broodstock, from 22 March hatcheries had to close down their operations for over a month. As the Aquaculture Quarantine Facility (AQF) also closed down, broodstock imports stopped entirely for 50 days.

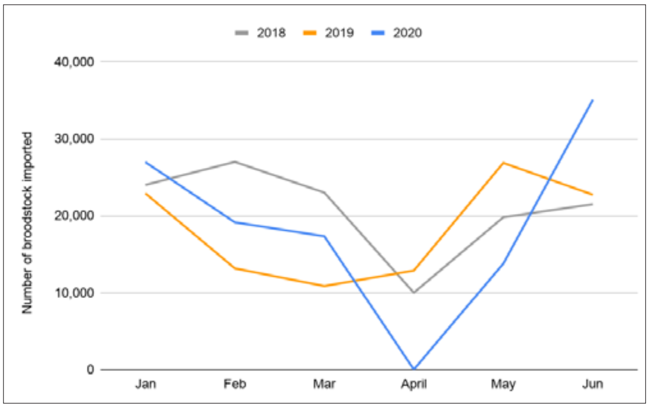


Figure 2. India's broodstock imports January-June 2018, 2019 and 2020 (Source: Aquaculture Spectrum)

When chatting with Ravi Kumar Yellanki, owner of Vaisakhi Bio-Marine, one of India's largest hatcheries, he told me that at least part of the broodstock that was imported in January, February and March went to waste. According to Yellanki, hatcheries were caught by surprise and as demand from farmers dropped and road transport stopped, hatcheries had to dispose of a lot of the PL they had already produced. Although in principle the hatcheries could continue to produce PL with the broodstock that had been imported before lockdown, this was complicated by the lack of availability of live feed for which logistics were also disrupted.

Although the government of Andhra Pradesh and some other states relieved hatcheries and other segments of the supply chain by declaring fisheries and aquaculture as an essential activity, logistics, such as the scarcity of domestic flights, remained troublesome for the industry.

Due to the low stocking levels and the shortage of shrimp harvests in April, farm gate prices went up and farmers became eager to stock their ponds in May and June. However, PL was at that time only scarcely available. According to Yellanki, April-June PL production was almost 50% below the level of 2020. Luckily, after 50 days, the AQF opened again and in May 2020, the first imports of broodstock arrived: 13,786 broodstock were shipped to India from Florida and Hawaii. Shrimp Improvement Systems (SIS) accounted for more than 70% of May's supplies. Other suppliers included Kona Bay (1,536 broodstock), Blue Genetics (1,200 broodstock) and American Penaeid Inc. (600 broodstock). SyAqua USA, for the first time since it was approved to export broodstock to India, shipped 1,200 broodstock in May.

In June, Kona Bay started to increase its exports to India. Indian hatcheries and Kona Bay chartered several flights to enable shipments from Hawaii to India. According to *Aquaculture Spectrum*, Kona Bay shipped 14,300 broodstock to India in June. That same month, SIS exported 19,550 and Sea Products Development (SPD) imported 1,200 broodstock. Together, June supplies of Kona Bay, SIS and SPD already amount to 35,550, well above the import volumes in June 2018 and 2019.

As the hatcheries needed roughly one month to produce PL with the new broodstock, it was only by the end of June that PL become more readily available again. When we look at May and June's broodstock import numbers, it is clear that hatcheries were ready to supply farmers PL to stock their ponds in July for a new crop to be harvested in September and October 2020. Yellanki agrees that since early July sufficient, high-quality PL is available again. However, he does worry that the hatcheries may experience some bad luck and that due to the recent decline of prices, farmers may once again be hesitant to stock their ponds. Stocking may therefore remain behind 2019 levels.

Harvesting shrimp. Photo credit; Aditya Dash, Ram's Assorted Cold Storage Limited.

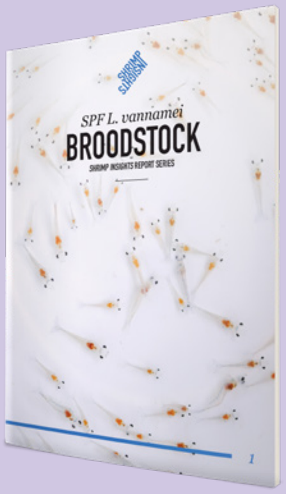
My predictions for the rest of the year

Although the Indian shrimp industry suffered in March and April – as did many industries in India but also globally in this time of crisis – looking at shrimp exports and broodstock imports, it seems that the shrimp industry recovered rapidly in May and June.

Despite the current low farm gate prices, the fact that hatcheries have PL readily available combined with the news that feed suppliers are offering discounts on feed might result in Indian shrimp farms having reasonable stocking levels. Although some people believe that the current cash crunch among shrimp farmers, and the unwillingness of input suppliers to pre-finance feed, will disable some farmers to stock their ponds at full scale, it is likely that a considerable new crop is still underway. The largest part of this new crop will be harvested in September and October.

Chatting to Yellanki reveals that he is hopeful that prices will recover around September when the buying season usually starts. My own worry is that the opposite will happen. I am thinking of a scenario in which even if September and October's harvests are only 70-80% of last year's second crop, it is doubtful whether demand from the US, China and India's other markets can sustain a higher price level. I therefore expect farm gate prices to take a hit once harvests start to peak in September. Although Indian processors may take the opportunity to build new inventories, the farmers may struggle to break even.

Litopenaeus vannamei Broodstock



After several months of hard work, in September I will publish the first publication of the *Shrimp Insights Report Series*, aimed at providing you with a deeper understanding of the shrimp industry. As I want these reports to be accessible for a broad audience – everyone benefits from more transparency in the industry – they can be downloaded for free at www.shrimpinsights.com

Depending on how familiar you are with the sector already, after reading this report you will have a better idea of the production, trade, use and current trends in the world's SPF *L. vannamei* broodstock market. Normally focusing more on downstream parts of the shrimp industry, broodstock was never really on my radar. However, when thinking about a research topic for my first publication, the choice for broodstock was quickly made.

The report will consist of (among others):

- A short history of SPF *L. vannamei* broodstock
- Global export and import statistics for SPF *L. vannamei* broodstock
- 8 country profiles with detailed broodstock export and import analysis
- *Shrimp Insights* 2019 company survey results presentation
- 15 company profiles of the world's leading SPF *L. vannamei* broodstock producers

The report is publicly available. This publication is sponsored by Skretting and American Penaeid Inc. (Platinum Sponsors), Zeigler and Inve (Gold Sponsors), I&V Bio and DSM (Silver Sponsors) and Grobest, Adisseo and Vaisakhi Bio-Marine (Bronze Sponsors).

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An initial assessment on farmed shrimp supply 2020

Up to mid-August, the supply situation indicates a downward trend, as producers are pinned by lower prices amidst the second wave of the Covid-19 pandemic.

By Soraphat Panakorn

Today, the global economic situation is not normal and is filled with uncertainties. As far as the shrimp farming industry is aware, we could have ridden on the wave of demand as each country opens up and plans to increase supply. However, key factors are the demand and supply balance, which determines shrimp price and consumption. At the moment, price and demand do not favour shrimp producers. In this article, with the support from my network of industry colleagues in several countries, I will provide a field report on shrimp production and supply. With regards to demand, in the three key markets, China is likely to be good, Europe should be better soon and for USA still unpredictable.

Production: Inputs pushing up costs

Along the entire supply chain, we witness significant increases in production costs. Most hatcheries in Asia depend on imports of broodstock. Hatcheries reported higher cargo costs of 2.5 times the rate in 2019. On top of higher prices for broodstock, costs of broodstock feeds and live feeds (polychaetes) have also increased. There is also the difficulty in getting new batches of broodstock resulting in the reuse of existing ones, and the sale of poorer quality post larvae, which are more susceptible to disease and slower growth. On the other hand, broodstock suppliers are also suffering from lower demand. Despite being burdened with higher costs of production, hatcheries, at least those in Thailand, are absorbing the additional cost. While they worry about losing customers, they also indicated that they may no longer be able to cap prices, and will need to pass on the higher costs to customers soon.

Similarly, prices have increased for pond and health care products, feeds, equipment, tools and many other essentials for farming. Most suppliers are absorbing the additional costs but most likely will increase prices at the beginning of 2021. Aside from being more costly than before the pandemic, these inputs have become more difficult to procure. There are also "fake versions" or those of lower quality.

Unchanged since 2019 are serious disease outbreaks and managing them amidst lockdown is even harder. Imagine seeking diagnostic services during these difficult times. The processing segment found it hard to run a full operation due to the lack of manpower together with the need to follow SOP and social distancing. So, the cost saving by economies of scale will not work anymore. There is also the additional cost such as coronavirus screenings in many parts of the processing line. We estimate the increase in overall production costs to be around USD0.3/kg.

China

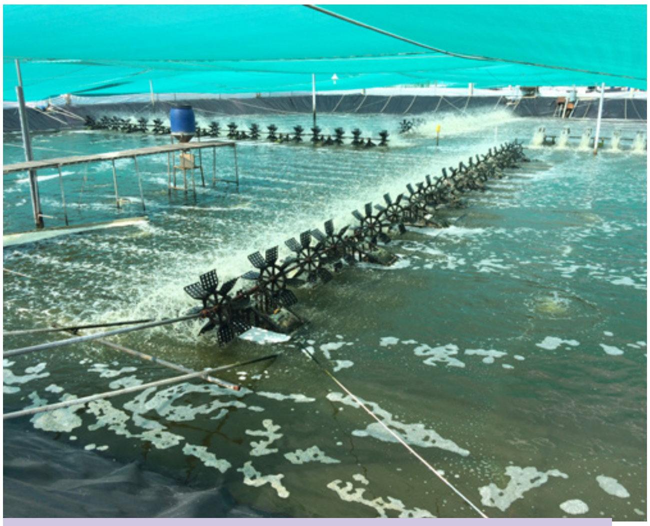
In the hatchery sector, around 60% are operating. Stocking in some areas have just completed at the end of July. Some 70% of the farmers completing the first crop are starting the second crop but they have encountered poor post larvae quality, diseases and adverse weather conditions. In China, post larvae prices vary from USD1 to USD4 per 1,000 post larvae, depending on the supply source. We divided China into four shrimp farming areas.

South China, a key shrimp farming area consisting of Guanxi, Guangzhou and Fujian contributes to >50% of China's annual shrimp production. Normally the first crop will start with the spring season in March and end somewhere in July and August, to avoid the monsoon season. But this year due to the Covid-19 shut down, this crop started late by about 2 months. Therefore, the middle of the crop cycle entered into the monsoon season in July, with heavy flooding and storms occurring in many areas. It is not easy to handle shrimp farming during the rainy season (July-September). Combined with poor post larvae quality due to the rush to produce post larvae after the end of the Covid-19 lockdown, the crop success rate is expected to be lower than usual. For the second crop, farmers will need to wait until September, when the monsoon season is over but some farmers have already started stocking.

East China, comprising Shandong, Jiangsu and Zhejiang provinces contributes roughly 25% of China's annual production, and farms are running well. The second crop is ongoing in August in almost all areas. North China which includes the coastal areas from Shandong to Liaoning until the border with North Korea contributes 10-15% of production. Farming in greenhouses is in full swing.

Shrimp farming at 0ppt salinity is scattered around lakes and rivers in many provinces. Normally the contribution is 10% of production. However, due to floods, the pandemic and issues with post larvae supply and quality, most farms are not operating. For example, the airfreight of post larvae from the coastal hatcheries, such as from Hainan to Wuhan, may take 2.5 times longer, resulting in poor post larvae quality. Farmers have instead shifted to culturing fish.

Today, we expect all production to end up in the domestic market only but less shrimp consumption is expected due to shrinking incomes. Additionally, the discovery of the Covid-19 virus in frozen seafood affected imports. We estimate that shrimp production will be at only 50% of that in 2019.



In Vietnam, recent successes in production are also due to small size covered ponds in the Mekong Delta.

Vietnam

Industry in Vietnam has two advantages - good support from the government and the country did very well in controlling the first wave of the pandemic. Vietnam may be the only shrimp country in Asia where the entire supply chain still flows normally.

Recently, Vietnam's shrimp farming is doing well; at 50 days of culture, it is possible to harvest size 60/kg of vannamei shrimp with feed conversion ratios of 1-1.2. Ex farm prices for August were good at USD3.97/kg. The success rate is higher with multiphase culture in covered small size ponds in the Mekong Delta.

Local consumption rides on the love of eating shrimp. A large domestic market of up to 150,000 tonnes/year helps to support local shrimp prices, combined with a shrimp industry which is very capable on marketing and product development for the export market.

We expect the 2020 production to be less by 20% or 550,000 tonnes only. Because of the pandemic, local consumption is expected to shrink to <50,000 tonnes due to 63,000 shops and restaurants closing and the lower arrivals of tourists compared to 2019. More shrimp will be available for export, at almost the same level as 2019.

This farm in Liaoning province, north China, cultures vannamei shrimp at low temperatures.

India

Although almost all hatcheries are back in operation, production is just about 20% of its maximum capacity because of lower demand. An internal survey revealed that in the last two months, shrimp were stocked only in 30% of farming areas. As the country is entering the monsoon season, disease outbreaks are high, along with low ex farm prices at INR244/kg or USD3.26/kg for shrimp smaller than size 70/kg. Farmers were discouraged; they have decided to wait and see instead of starting the second crop for the year which usually starts in August. Therefore, the industry estimates that Indian shrimp production in 2020 will be as low as 50% of the 2019 production.

There is an active cooperation between the private sector and government. Some support has been launched but supply of workers is facing a bottleneck and is becoming serious. The pandemic is a big blow to India's shrimp farming industry. The industry is supported by large processing plants. Today, prices of farm inputs have gone up 5-10% and some procurements are hard to come by. Export potential remains stagnant and there are price fluctuations. All in all, we can expect production to be down by >35% as compared with that in 2019.

Industry in India is targeting the domestic market, but during the current situation it might not be easy to increase domestic demand . High demand from its key markets pushed production in 2019, but this may not happen this year.

Indonesia

Almost all hatcheries are in operation, but farmers reported that post larvae from some hatcheries were of poor quality and susceptible to disease. This led to high failure rates. Supply of some high quality post larvae had problems with air cargo services, thus limiting supply. The government is helping with reductions in taxes for small businesses. Indonesia's production is helped by a stable market channel. Ex farm shrimp prices are good because of low shrimp supply. (USD4.92/kg for size 60/kg). However, the 2020 production forecast will be lower than in 2019, possibly less by 20-25% or around 220,000 tonnes.

> **"Thai farmers are very focused on production cost management, since there is a clear awareness that in future, shrimp prices may continue to come down."**

Thailand

Only 70% of hatcheries are operating at a capacity of 70%. Since Thailand was in lockdown for 2-3 months, the industry faced the same difficulties like those in other countries. Even though ex farm prices are considered good, overall we expect 2020 production to be less by 20% to 220,000 tonnes compared to 2019.

Thai farmers are very focused on production cost management, since there is a clear awareness that in future, shrimp prices may continue to come down. A cost of production of THB110/kg (USD3.48/kg) for size 70/kg may be acceptable at the current ex farm price such as THB135/kg or USD4.27/kg in August. Industry thinks that lowering costs to as low as THB72/kg (USD2.27/kg) is possible by overcoming one problem at a time. A positive development is the E-APD or Electronic Aquatic Purchasing Document launched by the Department of Fisheries. This document records the origin of the shrimp, from the hatchery until exported as a finished product. This is full traceability helping all stakeholders manage their production effectively with statistical and exact information along the entire supply chain.

An intensive shrimp pond in Rayong province, Thailand. The launch of the E-APD by the Department of Fisheries provides full traceability, helping all stakeholders manage their production effectively with statistical and exact information along the entire supply chain.

Malaysia

While its annual production has been stable for several years at around 50,000 tonnes, the 2020 production is expected to drop by 10-20% only. Ex-farm prices are relatively stable as over 50% of the production is sold domestically. Small price fluctuations for the vannamei shrimp occur because of cross border trade with Thailand. But still, vannamei shrimp prices (MYR22/kg or USD5.26/kg for size 70/kg) are better than for monodon shrimp (MYR27/kg or USD5.90/kg for size 30/kg). Farming of the monodon shrimp has been badly affected by low prices because of reduced sales of live shrimp to restaurants and loss of export markets in China and Singapore amidst the Covid-19 pandemic. Farmers resorted to e-commerce to push sales of live shrimp to local consumers. Some monodon shrimp farmers have shifted either to farm vannamei shrimp or culture the Asian sea bass. Industry expects growth to remain slow for the rest of the year.

Ecuador

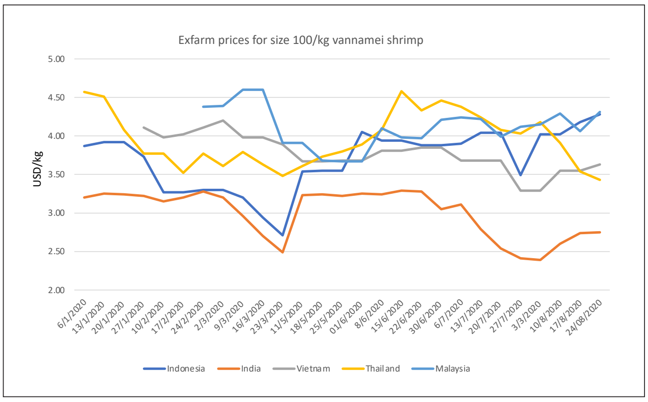
Initially, there was no problem in production; it has its own broodstock supply and high-quality feed. The bottleneck occurred when processing plants were affected by shortage of workers. Industry did not face any problem on the farming side but high volumes of harvested material and high stocks, led to price dumping. A major issue is that producers are dependent on the Chinese market. The imbalance of bargaining power reverted back to ex farm prices, the lowest in 20 years and even lower at 10-20% than production cost at USD2.25/kg for size 80/kg.

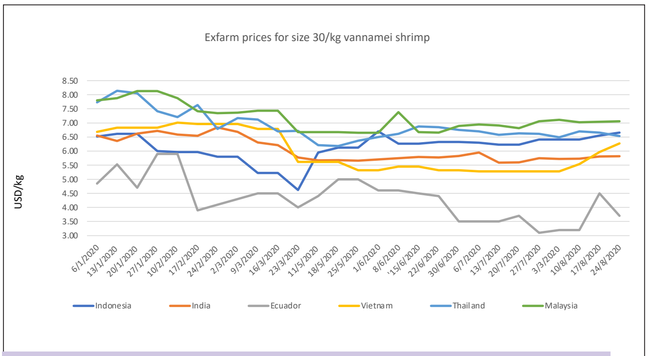
Farms opted for several actions: wait for better prices, skip a crop or revert to super extensive culture with 4PL/m^2 with no feed for least 1 month, a practice common some 30 years ago. Some have decided to stop farming due to poor cash flow. On selling shrimp, they were paid 50% of the amount in 48 hours and the rest only in 2 weeks. When prices are better, within half a year, Ecuador's shrimp industry can be back in operation faster and at higher volumes than any other shrimp producing country. We expect production in 2020 to be around 20% lower than in 2019, or around 550,000 tonnes, if Covid-19 persists.

Expect lower supply and price war in 2020

Finally, we expect global shrimp supply to decline by 1.4 million tonnes. The contribution to this loss in tonnes will come from the following: China 300,000; Thailand 100,000; Indonesia 100,000; India 350,000; Ecuador 150,000 and Vietnam 150,000 and 250,000 tonnes from other players (Philippines, Malaysia, Iran, Saudi Arabia, Peru, Mexico, etc). A price war is also possible due to pending stocks from large producers which will only end somewhere towards the end of 2020. We also predict a demand-supply balance at the beginning of 2021 or perhaps a supply shortage with higher demand in the first quarter of 2021. Current shrimp prices may remain but the chances of lower prices are high.

We also expect that 20-30% of farmers will quit the shrimp farming business because of this crisis. Industry survivors will be the professionals, and stakeholders who will cooperate to ride this crisis together and be able to modify and innovate. Key will be managing costs of production.





Ex farm price trends for vannamei shrimp over the January to August 2020 period.

Notes and acknowledgements

All these predictions have been made as of the August 2020. I thank my network of 17 friends in 8 countries who have shared their experiences and information with me during this Covid-19 pandemic, and updated the shrimp situation in their countries regularly.

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Hydrolyzed yeast as a source of nucleotides

A natural solution to face challenges encountered in Nile tilapia reproduction and progeny performance

By Liliana Borges and Melina Bonato

According to the Food and Agriculture Organization - FAO report (2020), the total global fish production is expected to expand from 179 million tonnes in 2018 to 204 million tonnes in 2030, and the share of fish production destined for human consumption is expected to continue to grow, reaching 89% by 2030. Rising incomes and urbanization, changes in dietary trends, and fish production improvements are the main factors behind this increase. Therefore, to meet the growing demand for fish, fish nutrition and health will play increasingly important roles in aquaculture to ensure optimal food production from this sector.

Nile tilapia *(Oreochromis niloticus)* ranked as the second highest most-produced freshwater fish cultured in the world in 2016 (FAO, 2018). Intensive production is naturally susceptible to bacterial, fungal, and parasitic infections, particularly during times of stress. Because of this, the use of functional nutrients/additives has grown. This is due not only to the need to replace growth-promoting antibiotics but with new concepts being increasingly studied, understood, and accepted. It is known that feed additives derived from *Saccharomyces cerevisiae*, such as hydrolyzed yeast, promote intestinal health benefits, control pathogens, and improve the efficiency of the innate immune response. They have positive impacts on performance and can control mycotoxin infections through their main components, nucleotides, mannan-oligosaccharides (MOS) and β-glucans.

Dietary nucleotide supplementation

Nucleotide supplementation through diet has been studied in several species, and they are not considered essential nutrients. However, they play an essential role in several metabolic processes, and in particular, in some body tissues and animal life stages. There is strong evidence that dietary supplementation of nucleotides acts on the intestinal tract, particularly in physiological functions, in the morphological profile and the microbiota (Li and Gatlin III, 2006). In addition to improving performance and immune responses, the benefits of nucleotides include improving larvae quality by strengthening the reproductive system (Ringø et al., 2012) and they also have anti-stress capacity.

Free nucleotides and nucleosides can be immediately absorbed by enterocytes in the gut. They are especially important in tissues of rapid cell multiplication because of their limited capacity for synthesis by via the *de novo* pathway (main nucleotide production pathway). These tissues include intestinal epithelial cells, blood cells, hepatocytes and cells of the immune system. They are then used by the salvage pathway, where the body can synthesize nucleotides with less energy expenditure. They will recycle their bases and nucleotides from metabolic degradation of the nucleic acid of dead cells or the diet. However, when endogenous delivery is insufficient, nucleotides from exogenous sources become semi-essential or "conditionally essential" nutrients (Carver and Walker, 1995). This occurs especially in animals in rapid growth stages (early stages), reproduction, stress and when faced with challenges.

Hilyses® is derived from *S. cerevisiae* yeast that is used in the fermentation of sugarcane to obtain ethanol, where it undergoes cell autolysis and intracellular content hydrolysis. This final product is highly digestible because it contains free nucleotides and nucleosides, amino acids, peptides and polypeptides, and glutamine. There is also the presence of MOS and high levels of β-glucans. This hydrolyzed yeast is highly recommended for animal nutrition (Figure 1).

MOS is known for its ability to agglutinate pathogens. It prevents pathogen colonization in the gut by offering a binding site to harmful bacteria that possess type 1 *fimbriae* present in the intestinal tract and is excreted together with the fecal material. β-glucans are known as immune system modulators or stimulants since they come into contact with phagocytes, which recognise the β-1,3 and 1,6 compounds. Then, the phagocytes are stimulated and produce cytokines, which will start a chain reaction inducing immunomodulation and improving the response capacity of the innate immune system.

This type of response is especially important in animals in the initial growth phases, reproductive phases, stress periods, and environmental challenges; β-glucans act as prophylactic agents, increasing an animal's resistance and minimizing further damage (such as a drop in performance or high mortality rates). Intensive animal production takes place in a highly challenging environment. Thus, the strengthening of the immunological system can be one of the key steps towards higher productivity.

A recent study was conducted at the Faculty of Veterinary Medicine, Cairo University, Egypt, by Abu Elala et al. (2020, unpublished data), with the objective to evaluate the effect of Hilyses supplementation on the performance and productivity of the Nile tilapia broodstock. This study was carried out in two phases; the first phase was performed on the broodstock, and the second was done with their progeny in the laboratory.

Broodstock phase

In the first phase of this study, broodstock was divided into two groups. In the treatment group, broodstock was fed a 0.4% Hilyses supplemented diet and in the control group, it was fed a basal diet. Each pond (3x8m^2) was stocked with 40 females (average body weight, 250g) and 16 males (average body weight, 400g). The male and female broodstock were stocked together for natural spawning for 11 days. On day 12, they were collected and transferred to earthen ponds for 3 weeks of rest, feeding, and preparation for the second-month production. At the same time, tilapia fry were collected, counted, and transferred to the nursery ponds. The experimental period was 6 months, from March until August, 2020. There was a significant effect in female production during March, June, July, and August (Figure 2), which was particularly important during the high temperature season; where a decrease in production is expected.

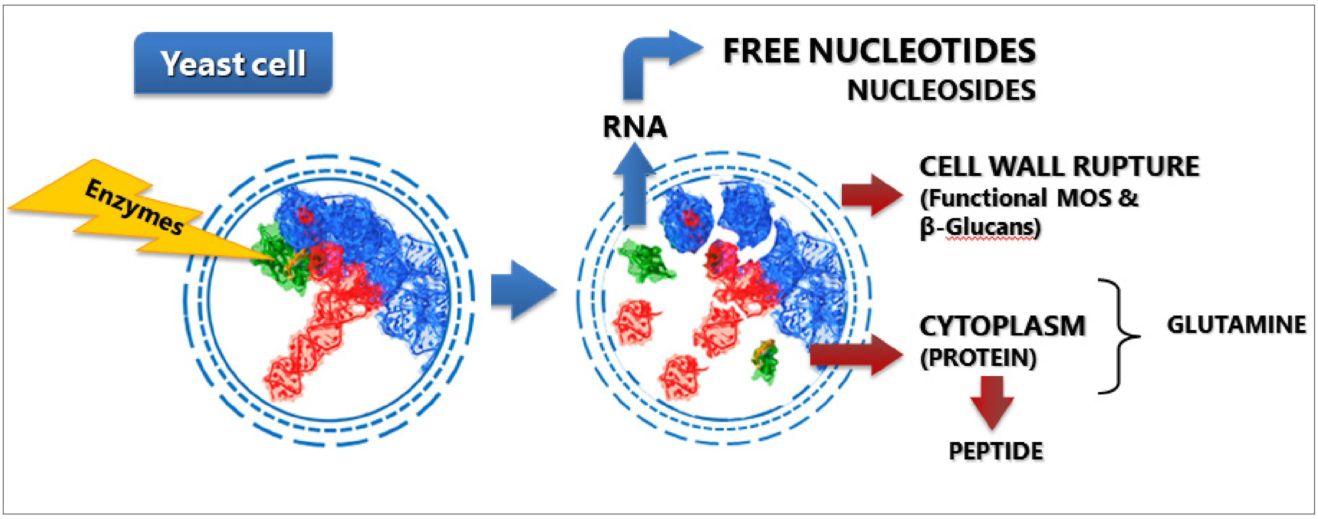

Figure 1. RNA hydrolysis from *Saccharomyces cerevisiae* yeast.

Progeny fry phase

In the second phase, tilapia fry obtained from the two broodstock groups (treatment and control), with an average body weight of 118.75±1.3mg, were subjected to a 2×2 factorial design i.e. broodstock fed the basal diet (control) and Hilyses at 0.4% or fries supplemented or not with Hilyses at same dosage. The treatments were allocated in 12 aquaria (30x40x100 cm) in triplicate.

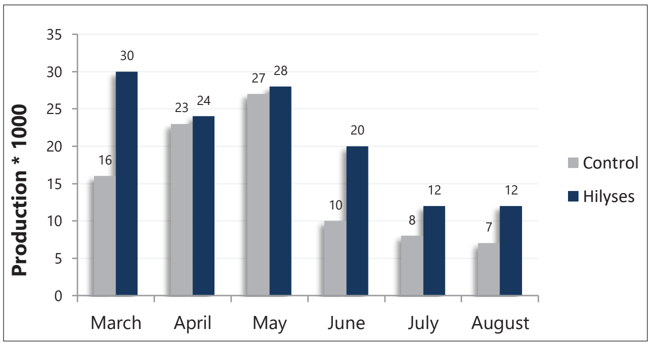

Figure 2. Production of female tilapia fed on diets supplemented with Hilyses® and the basal diet during the spawning season from March to August. *The pond area was 3x8 m² stocked with 40 females/16 males in each pond, temperature was 30°C and pH 8.7. Results were statistically analysed by paired- samples T-test, expressed as mean ± S.E. (n=11 ponds) * Statistically significant (P<0.05), ** statistically highly significant (P < 0.01) when compared to control group. yeast.

A decrease in mortality was observed in tilapia fry after the nursery period (21 days) in the hatchery from March to August (Figure 3) when the broodstock or fry were fed diets supplemented with Hilyses.

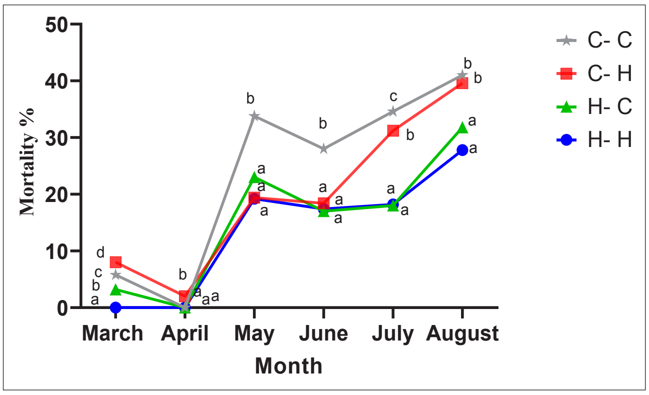

Figure 3. Mortality (%) of tilapia fry after the nursery period (21 days) in the hatchery from March to August. *The pond area was 3x8m², Temperature was 30°C and pH 8.7. Data were statistically analyzed by one-way ANOVA, represented as mean ± S.E. (n=5 ponds); the different letters indicate statistically significant differences in treatments (P < 0.05).

Results showed that there was a positive effect of Hilyses supplementation on fry performance considering broodstock or fry supplementation factors (Table 1); there was also an interaction between these factors (Table 2).

Results showed that fries fed supplemented diets improved significantly FI, BW, BWG, FCR, protein efficiency ratio, and specific growth rate at 3 months. Supplementing the broodstock showed a carry-over effect in fries improving by 33% in BWG and 8% in FCR. In the fry phase it was observed an improvement of 27.2% in BWG and 9.4% in FCR. Nucleotides are naturally present in all feed ingredients of animal and plant origin as free nucleotides and nucleic acids (Li and Gatlin III, 2006). However, many diets in aquaculture use exogenous sources of nucleotides to meet the needs for health maintenance requirements and growth.

Treatments	FI (g)	BW (g) at 3 months	BWG (g)	FCR	PER	SGR
Supplementation in broodstock feed						
Control	22.71^{b}	18.35^{b}	18.23^{b}	1.25^{a}	2.67^{b}	5.60^{b}
Hilyes	26.69^{a}	24.38^{a}	24.23^{a}	1.15^{b}	2.92^{a}	5.91^{a}
Supplementation in fry feed						
Control	22.88^{b}	18.10^{b}	17.99^{b}	1.28^{a}	2.67^{b}	5.60^{b}
Hilyes	26.36^{a}	22.99^{a}	22.88^{a}	1.16^{b}	2.89^{a}	5.84^{a}

^{a,b,c}Means within a column with different superscripts are significantly different (*P*<0.05). SEM: standard error of the mean. Protein efficiency ratio = weight gain (g)/protein intake (g). Specific growth rate = (Ln. Final body weight – Ln. Initial body weight) × 100/experimental period.

Table 1. Feed intake (FI), body weight (BW), body weight gain (BWG), feed conversion ratio (FCR), protein efficiency ratio (PER) and specific growth rate (SGR) of Nile tilapia fed with or without Hilyses®

Treatments C-control H-Hilyses		Parameters						
Broodstock	Tilapia fry	FI (g)	BW (g) at 3 months	Total BWG (g)	FCR	PER	SGR
C	C	20.52^{d}	15.39^{c}	15.28^{c}	1.34^{a}	2.48^{c}	5.41^{c}
C	H	23.81^{c}	19.83^{b}	19.71^{b}	1.21^{b}	25.76^{b}	55.69^{b}
H	C	25.24^{b}	20.85^{b}	20.73^{b}	1.21^{b}	2.73^{b}	5.74^{b}
H	H	28.91^{a}	26.17^{a}	26.04^{a}	1.11^{c}	3.00^{a}	6.00^{a}
P-value Hilyses x broodstock		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

^{a,b,c}Means within a column with different superscripts are significantly different (P<0.05). SEM: standard error of the mean. Protein efficiency ratio = weight gain (g)/protein intake (g). Specific growth rate = (Ln. Final body weight – Ln. Initial body weight) × 100/ experimental period.

C: control group, diets supplemented with 0.0% of the hydrolyzed yeast. H: treatment group, diets supplemented with 0.4% of the hydrolyzed yeast.

Table 2. Feed intake (FI), body weight (BW), body weight gain (BWG), feed conversion ratio (FCR), protein efficiency ratio (PER) and specific growth rate (SGR) of broodstock and fry of Nile tilapia fed with or without Hilyses®

In Table 2, the group of fish fed with Hilyses® in the broodstock and their progeny (fry), presented superior performance results compared to the other groups, proving that nucleotides strengthen reproduction and improve larvae quality.

There is an improvement (P<0.05) in performance parameters when the broodstock, fries or both are supplemented with Hilyses® in diets compared to control group. However, the best results (P<0.05) in performance were when both Nile tilapia broostock and fries are supplemented at 0.4% of Hilyses.

Aquaculture is naturally susceptible to infections, especially in times of stress, and consequently reduces performance. Providing additives that strengthen the immune system may be one of the keys to increase productivity.

Nucleotides are essential for the maintenance of cells and tissues that require rapid multiplication, such as periods of reproduction, early stages of growth, and stress. In intensive systems, it becomes an essential component for obtaining a better performance, guaranteeing animal health. Therefore, this hydrolyzed yeast, Hilyses can be used as a strategy for improving health and passive immunity, decreasing pathogen contamination in the gut, and providing nutrients with high digestibility and nucleotides.

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Partial substitution of fish meal with novel fermented soybean meal enhances tolerance against AHPND

Inclusion levels 10% to 30% enhanced tolerance of whiteleg shrimp against AHPND in challenge trials conducted in Vietnam

By Sergio F. Nates

A challenge trial was conducted to determine the effectiveness of diets containing a novel fermented soybean meal in mitigating the severity and impact of the early mortality syndrome/acute hepatopancreatic necrosis disease (EMS/AHPND) in the whiteleg shrimp *Litopenaeus vannamei*. The 33-day trial which began on January 16, 2020 was conducted at the ShrimpVet Laboratory in Ho Chi Minh City, Vietnam. It included a 1-day adaptation period, 21 days of feeding, a day of challenge and 10 days of post-challenge.

Tanks and water

Trials were carried out in 120L plastic tanks. All tanks were outfitted with an activated coral biological filter and aerator. They were covered with a plastic cap to reduce the risk of cross contamination. Brackish water of 20 ppt salinity was used in each trial. Water quality parameters such as dissolved oxygen (DO), pH, and temperature were measured daily. Total ammonia nitrogen (TAN), nitrite, and alkalinity were measured twice a week.

Shrimp

The specific pathogen free (SPF) shrimp *L. vannamei* used in this trial were progenies from broodstock originally from Hawaii. They were checked for disease pathogens. PCR analyses included pathogens for *Enterocytozoon hepatopenaei* (EHP), white spot syndrome virus (WSSV), Taura syndrome virus (TSV), infectious myonecrosis virus (IMNV) and EMS/AHPND. Nauplii and post larvae were reared in a strict biosecurity facility. Post larvae were also checked again with PCR for important pathogens including EHP, WSSV, TSV, IMNV, and EMS/AHPND. One day prior to the start of the study, shrimp were group weighed to determine initial weight. The initial average shrimp weight was 0.56 ± 0.04g.

Test diets

The trial had five groups; test diets in groups D1-D3 contained the novel fermented soybean meal, ME-PRO® (Prairie Aquatech, USA) at three inclusion levels, 10% (D1), 20% (D2) and 30% (D3). There was a positive control (D4) as well as a negative control (D5). There were four replicates per group.

All feeds were formulated using a commercial feed formulation software and manufactured using commercial extrusion methods. Chemical analysis (proximate analysis and mineral composition) of feeds were analysed using third party laboratories (Midwest Laboratories, Omaha, NE). Shrimp were fed *ad libitum* with their respective diets with four meals per day during the trial. Feed consumption was recorded during the trial. Feeding amount was adjusted depending on the biomass and actual feed consumption.

Challenge method

An immersion challenge method was used in this trial. There was a total of 28 tanks used as treatment and positive controls tanks. Tryptic soy broth+2% sodium chloride (TSB+) inoculated with a consistently virulent strain of *Vibrio parahaemolyticus*, was incubated for 24 hours. The bacterial suspension was added into tanks to achieve the bacterial density measured by optical density absorbance (OD_{600} nm); this density was expected to kill 90% in the positive control (LD_{90}) within 10 days. Negative control (four tanks) was treated with sterile TSB+ added directly to the tanks. The challenge dosage was 3.25×10^5 CFU/mL which was 90% of the lethal dose (LD_{90}). Standard histopathology and H&F stain were applied for shrimp tissues.

Molecular and histological analyses

Five days before the start of the trial, two shrimp samples were sacrificed to check for WSSV, TSV, EMS/AHPND, EHP and IMNV and confirm the animal's health status. During the challenge trial, two-representative moribund shrimp per treatment were collected for histological analysis. Samples were collected within 120 hours of post-challenge. PCR results showed that experimental shrimp were not infected with the above pathogens before the trial started.

Gross signs of EMS/AHPND in infected shrimp included a pale-to-white hepatopancreas (HP), significant atrophy of the HP, soft shell and gut with discontinuous or no contents. In addition, the HP will not squash easily between the thumb and forefinger. This may probably be due to increased fibrous connective tissue and haemocytes (Figures 3-6).

Statistical analysis

Water quality parameters (temperature, DO, pH, TAN, nitrite, and alkalinity) and survival of shrimp were analysed by one-way analysis of variance (ANOVA), followed by Duncan test to determine differences among treatments. All tests were performed at 5% significance level ($P<0.05$). Survival data was arcsine-transformed for analysis but only the original values were presented. Results were presented as mean ± standard deviation. Data were analysed using the SPSS software version 22.

Water quality parameters

Throughout 33 days of the trial, water quality parameters were recorded and are presented in Table 1.

	Treatments with ME-PRO®			Control Treatments	
Treatment	D1 10%	D2 20%	D3 30%	D4 Positive	D5 Negative
Temp (°C)	27.53 ± 0.54[a]	27.38 ± 0.49[a]	27.49 ± 0.50[a]	27.39 ± 0.51[a]	27.45 ± 0.46[a]
DO (mg/L)	6.19 ± 0.06[a]	6.19 ± 0.06[a]	6.19 ± 0.06[a]	6.20 ± 0.06[a]	6.18 ± 0.05[a]
pH	7.78 ± 0.05[a]	7.79 ± 0.05[a]	7.78 ± 0.05[a]	7.79 ± 0.05[a]	7.79 ± 0.06[a]
Alkalinity (ppm)	124.44 ± 5.27[a]	125.56 ± 5.27[a]	124.44 ± 5.27[a]	124.44 ± 7.26[a]	124.44 ± 5.27[a]
TAN (ppm)	0.28 ± 0.26[a]	0.22 ± 0.26[a]	0.11 ± 0.22[a]	0.22 ± 0.26[a]	0.22 ± 0.26[a]
Nitrite (ppm)	3.50 ± 2.26[a]	3.61 ± 2.15[a]	3.61 ± 2.15[a]	3.61 ± 2.15[a]	3.61 ± 2.15[a]
Salinity (ppt)	20.00 ± 0.00[a]	20.00 ± 0.00[a]	20.00 ± 0.00[a]	20.00 ± 0.00[a]	20.00 ± 0.00[a]

Values are presented as mean ± sd. The same letters on the same row were not significantly different (P < 0.05).

Table 1. Water quality parameters during the trial.

Survival rate

During the trial, shrimp were counted daily to assess the estimated survival rate. After 21 days of pre-challenge, there was no statistically significant difference in terms of survival rate among treatments (P>0.05) (Figure 1). Survival rates of treatments D1, D2, D3, D4, and D5 were 85.00 ± 2.00%, 87.00 ± 2.00%, 86.00 ± 2.31%, 87.00 ± 2.00%, and 87.00 ± 2.00%, respectively.

During the challenge and post-challenge, shrimp in the negative control did not show any clinical signs of EMS/AHPND and final survival rate was significantly higher than other treatments (88.53 ± 2.51%). This indicated that the trial set up was acceptable and no cross-contamination happened to the negative control.

After 10 days of post-challenge, survival rate of the positive control was 8.12 ± 7.00%. Survival rates of treatments D1, D2, and D3 were 9.36 ± 5.32%, 17.32 ± 7.13%, and 35.17 ± 21.60% respectively. The results showed that the survival rate of shrimp in treatment D3 (35.17 ± 21.60%) was significantly higher than the positive control (8.12 ± 7.00%) (P<0.05) (Figure 2).

While the survival of shrimp in the D1 and D2 treatments appears to be not statistically different from the positive control, there is a definitive trend of higher survival concomitant with the inclusion levels of ME-PRO in the diet. This clearly indicates that this ingredient clearly enhances tolerance against AHPND in *L. vannamei* juveniles and the inclusion rate of 30% has positive effects compared with the positive control in improving survival rate of the challenged shrimp.

Discussion

Recent studies on the development of practical diets for shrimp production systems using a microbial enhanced protein, ME-PRO, have shown to be a promising solution to produce eco-friendly aquafeeds. Besides having over 70% crude protein content and highly available phosphorus content, it presents numerous physical characteristics including high viscosity, which can improve faecal material stability, low dust and small particle size, both of which can improve water quality.

The protein is processed at a state-of-the-art plant using non-GMO (genetically modified organism) soybean

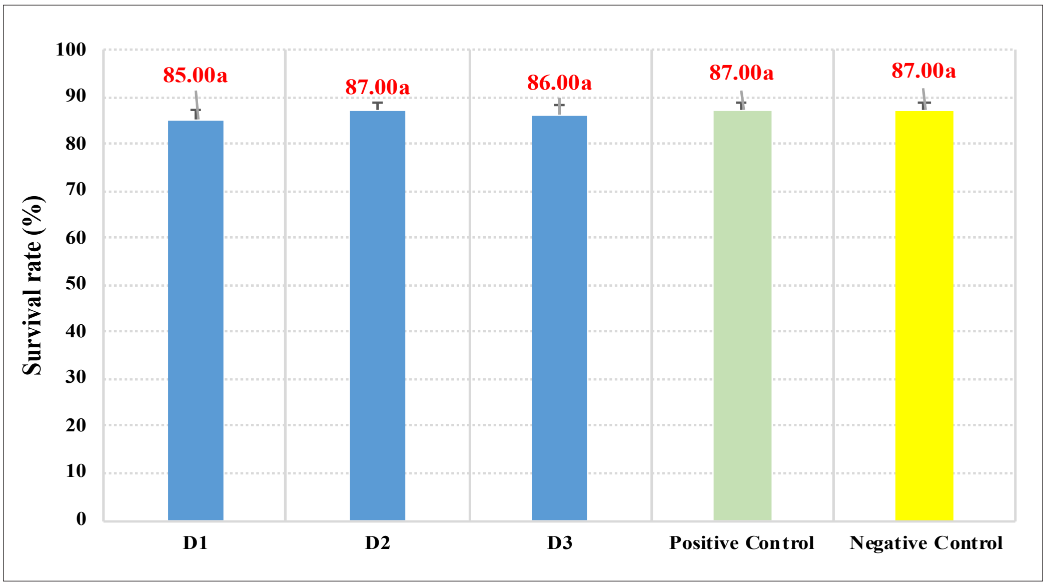

Figure 1. Survival rate at day 21 of the pre-challenge. (Values are presented as mean ± sd; n=5; P < 0.05)

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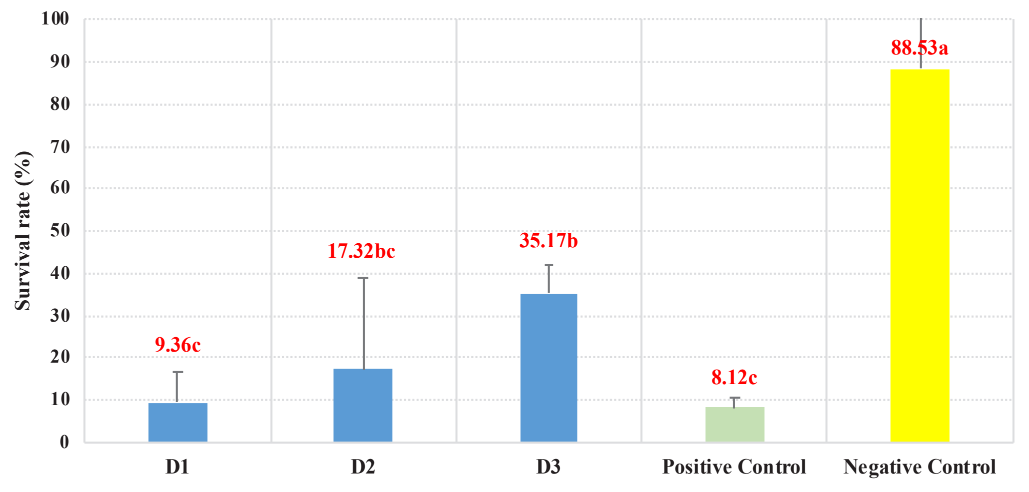
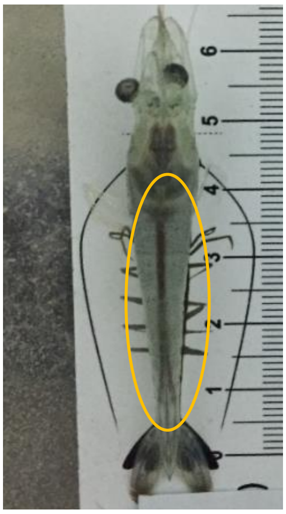
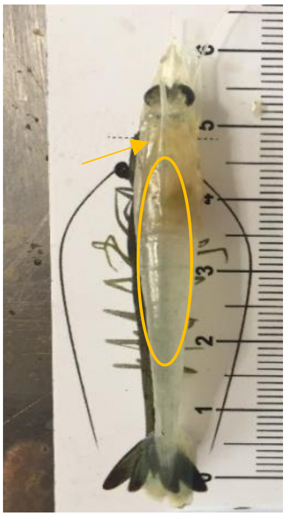


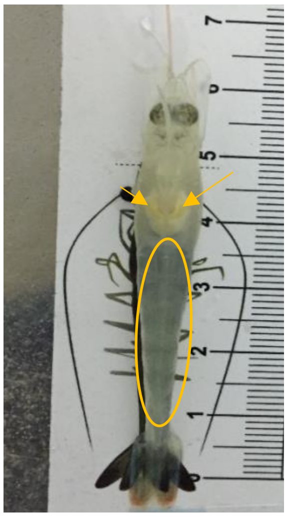
Figure 2. Survival rate at the end of the trial (Day 10 of post-challenge) (Values are presented as mean ± sd; n=5; P < 0.05)



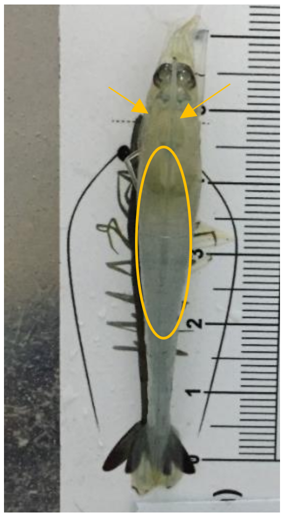
Figures 3. Healthy shrimp in negative control (brownish HP, full stomach and gut)



Figures 4. EMS-infected shrimp in positive control (pale HP and empty gut)



Figures 5. EMS-infected shrimp in a treatment (pale HP, empty stomach and gut)



Figures 6. Gross signs of EMS in shrimp hepatopancreas (pale and shrunken HP, empty stomach and gut)

meal and a natural occurring, non-toxigenic, fungi, *Aureobasidium pullulans*. The fermented co-product also offers significant amounts of short-chain peptides and free amino acids that confer excellent attractability and palatability properties. The presence of biologically active factors can increase gut microbiota, reduce intestinal inflammation, and boost metabolic processes for which lead to improved animal health which makes it a perfect match for the Asian aquaculture industry.

Results from numerous feeding trials has demonstrated that ME-PRO can sustain shrimp health, high-performance growth, and feed efficiency with inclusion levels as high as 50% of the total amount of ingredients in the diet. The results obtained in this study suggest that its inclusion levels in formulated feeds can have a positive effect on improving the survival rate of EMS/AHPND infected shrimp. This ingredient can also be considered a functional ingredient in disease prevention, used when formulating sustainable, practical and economical feeds for the shrimp aquaculture industry.

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Local feed ingredients for Asian seabass diets in Cambodia

Replacing trash fish with local compound feeds requires firstly an evaluation on availability and nutritional composition of potential feed ingredients.

By Khum Sros, Mak Chankakada, Oem Ramana, Hoeun Phearum, Asda Laining, Usman, Michael A. Rimmer, Thay Somony and Hav Viseth

A major concern for the future expansion of marine finfish aquaculture is the increasing demand for low-value or trash fish which is commonly used as the main feed source in Asia. In Cambodia, farming of Asian seabass *(Lates calcarifer)* is expanding rapidly and the Cambodian mariculture industry faces increasing prices for trash fish as well as declining availability.

An Asian seabass sea cage farm at Chong Preak commune, Stoeng Hav district, Preah Sihanouk province.

Trash fish is the main feed source used in farming Asian seabass in Cambodia (Mak et al., 2020; Sen et al., 2018). However, availability of marine trash fish in Cambodia is seasonal, and farmers may face shortages due to weather-restricted fishing. These shortages are compounded by lack of large-scale cold storage facilities for trash fish, which may lead to spoilage and nutritional degradation of the feed. In addition, the price of trash fish used for Asian seabass farming has been rising steadily over the last few years (Mak et al., 2020). Trash fish is also widely regarded as a likely source of pathogens that are transmitted to the cultured fish (Sim et al., 2005).

Some Asian seabass farmers in Cambodia use commercial pellet feed imported from neighbouring countries but usually only for juvenile fish. Despite the advantages of using pellet feed, the cost of purchase is a constraint for small-scale farms that have limited operating budgets. As an alternative, or intermediate option, we are evaluating the use of locally made feeds for Asian seabass farming. The first step in developing locally made feeds was to evaluate the availability and nutritional composition of potential feed ingredients in Cambodia.

Feed ingredient availability

A survey of potential feed ingredients was undertaken in Preah Sihanouk province in October 2018. Local market sellers and retailers were interviewed to obtain information on ingredient availability and samples for future analysis. We collected samples of wheat flour, cassava flour, copra (dried coconut) meal, *Leucaena (Leucaena leucocephala)* leaf, *Moringa (Moringa sp.)* leaf, rice bran, corn, soybean and squid meal at Psar Leu market in Preah Sihanouk province. Information on fish meal and brewery yeast were collected from the Ngoun Hout fish meal factory and Angkor Beer factory, respectively. Samples of each ingredient were placed in labelled ziplock plastic bags and brought to the Marine Aquaculture Research and Development Centre (MARDeC) laboratory where they were cleaned, dried and then stored in a refrigerator until analysis.

Fish meal, an important ingredient in diets for carnivorous marine fish, is available from a seafood processing factory in Stoeng Hav district. In the period of peak catches (April – May), maximum availability is 216 tonnes per month (Table 1). The lowest availability was about 180 tonnes/month from August to November when fish catches decline during the rainy season. The availability of squid meal followed a similar pattern with peak catches in April and minimum availability in October (Table 1).

Another potential feed ingredient identified in this survey was fermented brewery yeast, a by-product of the Angkor beer factory in Preah Sihanouk province. Maximum availability of fermented brewery yeast was in April (Table 1), which is associated with increased demand for beer for Khmer New Year celebrations. Other potential feed ingredients identified from the study were: wheat flour, cassava flour, copra meal, soybean meal and rice bran as well as *Leucaena* and *Moringa* leaves. Mineral and vitamin premixes were available from the animal feed supply retailer in Psar Leu market.

Ingredient nutritional composition

In order to evaluate the nutritional composition of the ingredients, proximate analyses were conducted at the Laboratory of Fish Nutrition and Feed Technology at the Research Institute for Coastal Aquaculture and Fisheries Extension, Maros, Indonesia. Proximate analyses were carried out according to AOAC (1999) methods. Briefly, moisture was analysed after oven drying the samples at 105°C for 16 hours (Memmert, Germany). Crude protein was determined according to micro-Kjeldahl procedure and lipid was extracted with petroleum benzene using Soxtherm apparatus. Ash was analysed using muffle furnace at 550°C (Barnstead Thermolyne, CA, USA).

Month	Ingredient (tonnes)											
	Animal source		Plant source									Premix[2]
	Fish meal[1]	Squid meal[2]	Wheat flour[2]	Cassava flour[2]	Copra meal[2]	Leucaena leaf[2]	Moringa leaf[2]	Brewery yeast[3]	Rice bran[2]	Corn[2]	Soybean[2]	
January	200	0.9	1.8	3.0	2.1	3.6	3.0	10.0	3.6	2.7	3.0	0.15
February	205	1.1	1.7	2.7	2.0	3.9	2.9	11.0	3.3	2.6	2.9	0.16
March	210	1.2	1.7	2.4	1.8	3.8	2.7	12.0	3.0	2.4	2.7	0.16
April	216	1.5	1.5	2.1	1.5	4.2	2.4	13.0	2.3	2.3	2.6	0.17
May	216	1.4	1.4	2.0	1.7	4.5	3.9	12.0	2.7	2.4	2.7	0.17
June	200	1.2	1.8	2.4	1.8	5.1	4.2	10.0	3.3	2.6	2.9	0.18
July	190	1.1	2.0	2.7	2.4	5.4	4.5	10.0	3.9	2.7	3.0	0.19
August	180	0.9	2.1	3.3	3.0	5.6	4.8	9.0	4.2	2.9	3.2	0.19
September	175	0.8	2.4	3.6	2.7	5.7	5.0	9.0	4.4	3.0	3	0.20
October	180	0.6	2.7	4.5	2.6	6.0	5.1	10.0	4.8	3.6	3.9	0.20
November	180	0.8	2.3	3.9	2.4	5.4	4.8	11.0	4.2	3.3	3.6	0.19
December	190	0.8	2.0	3.3	2.4	5.1	4.5	12.0	3.9	3.0	3.0	0.18

Sources: 1. Ngoun Hout fish meal factory. Mouy village, Kam Penh commune, Stoeng Hav district. Preah Sihanouk province.
2. Psar Leu market. Mouy village, Mitapheap commune, Preah Sihanouk city, Preah Sihanouk province.
3. Angkor Beer factory. Bey village, Mouy commune, Preah Sihanouk city. Preah Sihanouk province.

Table 1. Monthly quantities (tonnes) of potential feed ingredients available in coastal areas of Cambodia.

Due to budget constraints, we analysed 8 of the feed ingredients identified in the survey. The local fish meal contained 61% crude protein, the highest protein content among the ingredients analysed. Fish meal is an excellent source of essential amino acids and chemo-attractant properties in feed for carnivorous fish species (Hertrampf and Piedad-Pascual, 2000), including Asian seabass. Based on our survey, it is likely that fish meal can be utilised as a major protein source for aquafeed development including for Asian seabass, due to its availability in Cambodia. The other animal-origin feed ingredient identified during the survey was squid meal. Squid is also available in Cambodia coastal regions but at low quantities. Squid meal is generally utilised in maturation diets or as an attractant in shrimp and carnivorous fish feeds, including those for seabass (Nunes et al. 2006).

Ingredient	Protein (%)	Lipid (%)	Carbohydrate (%)	Ash (%)	Moisture (%)
Fishmeal	61.10 ± 0.79	5.16 ± 0.05	1.32 ± 0.74	20.97 ± 0.07	11.45 ± 0.07
Soybean meal	39.03 ± 0.04	14.63 ± 0.27	37.58 ± 0.60	5.12 ± 0.40	3.64 ± 0.43
Brewery yeast	43.22 ± 0.69	0.22 ± 0.10	47.60 ± 1.08	5.31 ± 0.39	3.65 ± 0.10
Leucaena leaf	24.55 ± 0.48	6.71 ± 0.39	51.93 ± 0.16	10.97 ± 0.18	5.84 ± 0.25
Moringa leaf	24.26 ± 0.35	8.14 ± 0.91	51.64 ± 2.41	9.54 ± 1.63	6.41 ± 0.22
Copra meal	8.58 ± 0.70	64.80 ± 0.20	20.64 ± 0.47	2.66 ± 0.06	3.31 ± 0.02
Rice bran	12.92 ± 0.83	13.24 ± 0.65	57.64 ± 2.03	7.66 ± 0.21	8.53 ± 0.34

Table 2. Proximate composition (mean ± SD) of selected feed ingredients from Cambodia.

Brewery yeast waste, from the Angkor Beer factory, Sihanoukville, is potentially an alternative protein source to fish meal in Asian seabass diets.

Fish meal is available from the Ngoun Hout fish meal factory. Stoeng Hav district. Preah Sihanouk province.

The brewery yeast sampled had a relatively high protein content of 43%, which indicates that brewery yeast could partially replace fish meal as a protein source in Asian seabass feeds. Brewery yeast typically also contains several micronutrients such as vitamins, selenium and chromium as well as immune-stimulatory properties by virtue of their complex carbohydrate components (Tacon 2012). However, brewery yeast has several limiting factors, in particular low levels of the amino acids methionine and cysteine (Huige, 2006). Brewery yeast has been evaluated for use in feeds for European seabass *Dicentrarchus labrax* (Oliva-Teles and Goncalves, 2001) as well as in Asian seabass (Sorphea et al. 2019).

Soybean meal has become an important alternative protein source for fish diets, and our samples had a moderate protein content of around 39% (Table 2). Soybean meal has a good essential amino acid profile, although it is low in methionine and contains several antinutritional compounds (Hertrampf and Piedad-Pascual, 2000). In Indonesia, soybean meal, in particular defatted soybean meal, and fish meal are the major protein sources used by commercial feed companies (Laining and Kristanto, 2015).

Other ingredients of plant origin analysed were leaves of two legumes, *Leucaena* and *Moringa*, as well as copra meal and rice bran. These plant ingredients are generally utilised as carbohydrate and energy sources in fish feeds. Although carnivorous species like seabass do not require as much carbohydrate as omnivorous and herbivorous species, the amount of carbohydrate and lipid that are balanced with the protein content in diet will increase protein and feed efficiency due to protein sparing effects (Enes et al., 2011). Besides macronutrient content, *Moringa* leaves are also rich in vitamins A, C, E, carotenoids, polyphenols, phenolic acids, flavonoids, alkaloids, and glucosinolates which have been reported to have various biological functions including anti-inflammatory effects and protection against oxidative stress (Vergara-Jimenez et al., 2017).

Copra meal had a relatively high lipid content of around 65% and was high in crude fibre (16%) but low in protein (9%). Copra cake meal, a by-product of coconut oil processing, has a higher protein content (20–22%) and low lipid content (9–12%) (Hertrampf and Piedad-Pascual, 2000; Laining et al., 2017). Its nutritive value as a feed ingredient can be improved via fermentation using *Rhizopus* spp. to increase the protein content up to 29% and to reduce the fat content below 1% and reduce the rate of rancidity (Laining et al., 2017).

Implications for Cambodian mariculture

Production of Asian seabass from mariculture in Cambodia reportedly ranges from about 260 to 1400 tonnes/year (Cambodian Fisheries Administration data). Assuming an average food conversion ratio of 1.5:1 and a utilisation of 50% fish meal, about 1,000 tonnes/year of fish meal would be required to support this production. The quantities of fish meal available in Cambodia (Table 1) are sufficient to support this, or even at a higher level of Asian seabass production.

Our future research will focus on developing compounded diets for Asian seabass to reduce the current reliance on trash fish as a feed in commercial mariculture in Cambodia. The evaluation of the composition of local feed ingredients described here is an essential first step to developing feed formulations using locally available ingredients. As part of this research, we are also planning to evaluate the inclusion of brewery by-product in feeds for Asian seabass to reduce the inclusion level of fish meal. Through this research, we hope to see compound feeds used instead of trash fish to feed the Asian seabass in Cambodia in the near future.

Acknowledgments

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A virtual experience for 2020 ONE

Improving fish gut health and feed efficiency via genetic selection, dynamic nutritional modelling and trace mineral nutrition

Each May, the flagship event, ONE: The Alltech Ideas Conference typically attracts more than 3,500 attendees from more than 70 countries to Lexington, Kentucky, USA. This year, it went virtual over 5 days in May, providing on-demand focus sessions, streaming keynote presentations as well as daily and real-time Q&A chats with selected speakers. In his welcome address, Dr Mark Lyons, President and CEO of Alltech, said, “This is a journey of discovery and renewal. For the first time in the 36-year history of our conference, we are connecting virtually. This is an opportunity to shape the future of agrifood – together.”

In the aquaculture segment, **Alex Tsappis,** Alltech’s US Aquaculture Business Manager said that in these extraordinary times, medical professionals have made it clear that being in good general health is vital to mitigate the dangers of Covid-19 coronavirus, as underlying health problems, such as diabetes and heart disease, increase our risk. He examined the vital role seafood plays in maintaining a healthy diet as well as the importance of the aquaculture industry in relation to consumer health and welfare. In describing the progress with its insect meal production, **Kees Aarts,** Founder and CEO, Protix discussed the use of insect meal as a sustainable source of marine protein in aquafeeds.

Genetic selection for efficient gut health

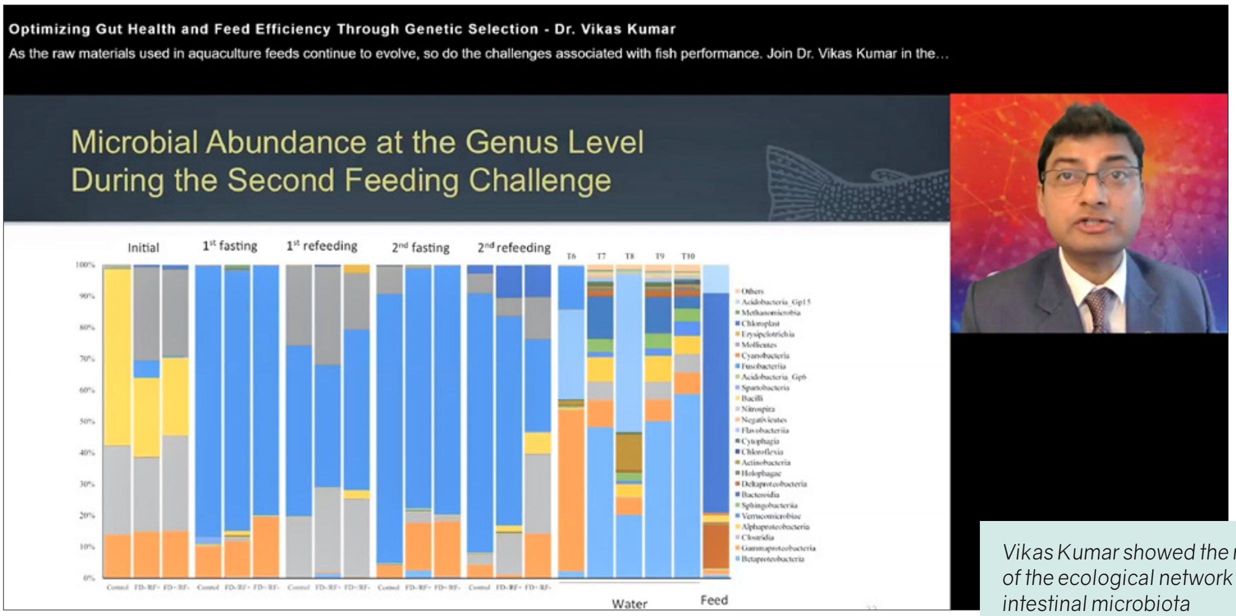
Dr Vikas Kumar, University of Idaho, USA, looked at the research to improve fish gut health and feed efficiency via genetic selection. Defatted soybean appears to be a sustainable protein source, but there are limitations.

“Especially in the case of carnivorous species like salmon or trout, if you add more than 20% or 30% of soybean meal into their diet, their gut health deteriorates and the distal intestine becomes inflamed,” said Vikas. “Our Aquaculture Research Institute’s mission was to find a way to utilise more soy protein in rainbow trout feed. Our university collaborated with the USDA in early 2000 when they started the genetic selection program.”

As part of the research, trout lines which can take higher soy protein in their diet, 15%, 20% or more were selected. The completely plant-based diet contained almost 51% soy protein and 10% gluten meal. The initial weight of fish was around 30g when feeding trials were conducted using soy protein diet. Within 5 months, the fish grew up to 175g. When genetic selection was done again in 2015, the fish were almost 380g within 5 months of the feeding trial. In 2019, they grew up to 450g.

A trial was conducted with two strains of trout that were fed two types of diets: fish meal-based and plant protein-based diets. One strain was a non-selected commercial trout and the other, selected vegetarian trout. It was found that the selected trout fed the plant protein-based diet performed better than any other groups, including the fish meal fed commercial trout. The selected trout had a 10% to 15% higher growth rate than the commercial trout. Looking at the distal intestine and their morphology, the vegetarian trout paired with a plant-based diet had well-developed villi. Enteritis and goblet cell secreting mucus were absent.

However, for the non-selected plant protein-fed commercial trout, they had some issues with their gut such as hypoplasia, submucosal inflammation and leukocyte infiltration. “This is a host and diet kind of interaction. That means the host’s diet influences the microbial ecology of the distal intestine which supports the hypothesis that utilisation of plant protein could be a product of the function of good microbiota.”



Vikas Kumar showed the results of the ecological network of the intestinal microbiota

Dynamic nutritional modelling

Professor of Animal Nutrition and Aquaculture, University of Guelph, Canada, **Dr Dominique Bureau,** discussed the potential use of modelling to address challenges in aquaculture nutrition.

One of the challenges of aquaculture nutrition is predicting the digestible nutrient contents of feed. A way to do that is by relying on R&D and published literature to create rules of thumb and coefficients, see the effects of different factors and how they interact on the digestibility of different nutrients. The combination of many different factors and the need to accurately quantify the combined effects of different factors can be quite complex.

"As an example, phosphorus, present in many forms in feeds and feed ingredients, will have different digestion dynamics. Using a simple equation led by mathematical modelling, it is possible to predict digestible phosphorus content by applying coefficients to the various forms of phosphorus in the feed. This was done in rainbow trout, a carnivorous fish species with a small gastrointestinal (GI) tract and an acid stomach. There are several experimental evidences which demonstrate that an increase in the digestible phosphorus level of feed has a negative impact on phosphorus digestibility. The opposite is where increased levels of digestible phosphorus in the feed had no impact on phosphorus digestibility. It is difficult to interpret this information without a systematic approach."

Analysing 22 studies that were sufficiently reliable and 137 treatments, PhD researcher Dr Katherine Hua used a statistical approach to generate some coefficients of digestibility of the different forms of phosphorus. In the rainbow trout, Nile tilapia and common carp, Hua quantified differences in phosphorus digestibility from different phosphorus sources. The University of Guelph has implemented a simple equation in the least cost formulation program used by feed companies and demonstrated they were reliable under commercial conditions.

"We wanted to establish a more dynamic experience where we could look at the data, observe, predict, make changes and look at the impact of different factors," said Bureau. "By looking at what is happening inside the fish, we can determine the digestibility, the input of feed, the output in the faeces and digestion dynamics. With a simple mathematical model, a few biological and chemical principles as well as mathematical equations, we were able to monitor or model the absorption of phosphorus, not just overall but in different compartments of the GI tract."

This is not just applicable to phosphorus, but also for protein, amino acids, lipids and fatty acids. According to Bureau, "We could also use this to study the digestion of keratin and pigments, astaxanthin and canthaxanthin used in salmonid feeds, which are expensive and not always well-characterised or good for digestibility. By applying the same kind of modelling principle, we could elucidate several different processes involved in the digestion of different nutrients."

The take-home message is that experimental work and traditional research work can be combined with statistical and dynamic modelling tools to better understand the dynamics of nutrient digestion and the factors that affect the digestive processes. "This type of approach could be valuable in the future to examine the mode of action and effectiveness of different feed additives and nutritional solutions, mainly in improving nutrient digestibility and bioavailability of nutrients, and therefore gut health."

Trace minerals and malnutrient effects

Research Director at Alltech's European Bioscience Centre **Dr Richard Murphy** presented on how different forms of trace minerals can have unwanted malnutrient-type effects.

In fish farming, dietary trace elements, such as zinc, iron, copper and selenium are added into aquafeeds for healthier and faster fish growth, as well as to combat stressors in culture conditions, pathogens and nutrition. Murphy said, "One of the key differences, when we think about inorganic and organic minerals, is their bioavailability. The mineral source is not just to meet the dietary requirement, but also that we avoid toxicity or keep within the maximum tolerable limits."

Furthermore, the move from marine-based to more plant-based sources in recent years have resulted in decreasing levels of essential trace elements such as zinc, selenium and iron in the diet. "Therefore, do we need to revise the mineral requirements for farmed fish as inorganic trace elements have the inherent ability to be potentially toxic and can cause damage to DNA, lipids and proteins through the so-called Fenton reactions and stimulate reactive oxygen species?"

On the other hand, fish can achieve better health and performance through a de-stressing process by switching from inorganic to organic mineral supplementation. A study by Dr Katerina Kousoulaki, Nofima, found that organic elements in the diet resulted in improvement in fillet gaping and greater muscle selenium retention. Increasing the organic mineral supplementation could also reverse the negative impacts caused by increased vitamin supplementation (mortality, decreases in body growth and feed conversion efficiencies).

Murphy discussed the different strategies to bind organic minerals to a carrier group as protection as it transits through the GI tract. "All molecules interact differently with the trace element, hence leading to differences in stability and bioavailability. If you can maximise the stability, you can optimise the mineral's bioavailability and delivery to the intestine." By enhancing the bioavailability of organic trace minerals, malnutrient effects can be reduced.

"When reformulating diets, by increasing mineral supplementation levels and reducing levels of fish meal in the diets, we need to be sure that we have the correct form of trace elements present. Inorganic materials, by their very nature, are not only reactive and toxic, but they do not enable fish to deal with environmental challenges."

However, different organic trace mineral sources may have unwanted malnutrient effects, competitive inhibition of uptake or simple toxicity associated with the fact that they are easily oxidised. Therefore, manufacturers need to choose carefully to avoid these negative impacts.

Fish oils and alternative dietary lipid sources for finfish

The farming of the Atlantic salmon and other finfish species needs options to ease pressure on fish oils from capture fisheries

By Gerald N Misol Jr

Industrial transformation is apparent in the farming of the Atlantic salmon, *Salmo salar* which currently constitutes >90% farmed global salmon production with Norway and Chile being the major producing countries (Asche et al., 2013). At an annual 8% global growth rate, the baseline projection for Atlantic salmon aquaculture in 2030 is estimated at 5 million tonnes, which is a 100% increase of the current global production. An important feature of farmed Atlantic salmon is the high amount of long chain polyunsaturated fatty acids (LC-PUFAs) in comparison with other fish species and livestock (Figure 1). LC-PUFAs are essential for human health and have been established to be important for maintaining the human brain and visual tissues.

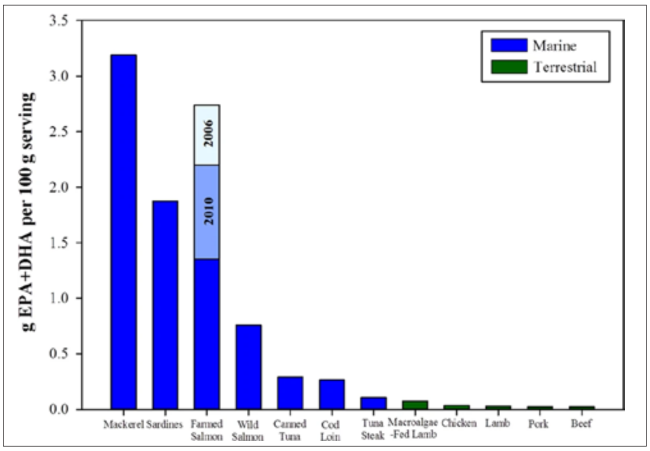


Figure 1. Comparison between the levels of EPA + DHA (g/100g) in Scottish farmed Atlantic salmon compared to other fish species (blue) and terrestrially (green) produced animals (Sprague et al., 2016).

LC-PUFAs

Two major LC-PUFAs important in human health are omega-3 (n-3) fatty acids, eicosapentaenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA, 22:6n-3); they are mainly sourced from fish oil while omega-6 (n-6) fatty acids, like arachidonic acid (ARA, 20:6n-6) are sourced mainly from plant-based oils. However, there has been a shift in the Western diet in the last three decades where the intake of n-6 rich oils sourced from plant-based oils has relatively increased as compared to n-3 rich oils which is mainly sourced from fish oil. Unfortunately, this has also coincided with increased reports of cardiovascular and gut diseases and depression cases (Ghosh et al., 2013; McNamara, 2016). Subsequent investigations then elucidated that diets with excessive n-6 rich oils tend to enhance inflammatory conditions and a balanced n-6/n-3 diet is required to attenuate this condition. Therefore, there is a significant shift now to increase the consumption of n-3 rich oils to balance increasing n-6 rich oil intake in the effort to reduce these disease risks (Ghosh et al., 2013). According to the European Food Safety Authority (EFSA), the general recommendation for a daily EPA and DHA intake is 250mg for brain development and protection against coronary heart disease (EFSA, 2010). While alpha-linolenic acid (ALA), the precursor of n-3 rich oils can also be sourced from plant-based oils, its bioconversion to EPA and DHA in the human body is inefficient. Therefore, fish oil, mainly salmon-based remains as the major source of EPA and DHA.

Stagnating supply of fish oil

Certain fish species contain relatively high percentages of n-3 PUFAs, mainly due to an ascending accumulation in the aquatic food chain beginning from marine algae. Salmon in the higher trophic level naturally contain high amounts of n-3, hence its historical importance in the human diet. One of the main drivers in the domestication of the Atlantic salmon is to create a sustainable product with a similar or improved percentage of n-3 PUFAs. However, producing a farmed Atlantic salmon with the desired amount of n-3 requires between 2.7% of EPA + DHA of dietary lipids. Since 1980, the major source of n-3 for aquafeeds (~20% content) originates from capture fisheries such as the Peruvian anchovy, *Engraulis ringens*, South American sardine, *Sardinops sagax*, capelin, *Mallotus villosus*, and herring, *Clupea harengus* among others, with Chile, Peru, the Scandinavian countries and the US as major producers. Current estimations observed that ~81% of global fish oil supply is absorbed by aquaculture, where use in salmon and trout feeds constitutes 68% of the total used. However, the recent stagnation in the global supply of fish oil (~1 million tonnes/year due to several factors has created a fish oil conundrum between aquaculture and human consumption, according to a Globefish report. Occurrences of *El-Nino* have caused fluctuations in *E. ringens* landings as seen in 2003 while implementation of sustainable fishing practices has firmly regulated fishing quotas to prevent exploitation of resources (Figure 2).

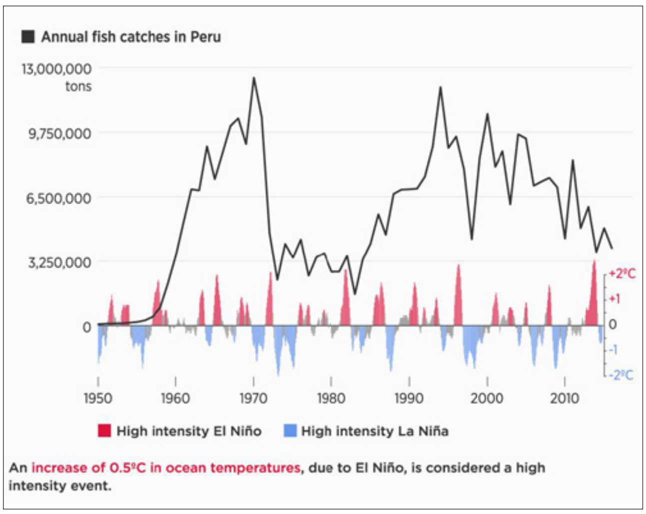


Figure 2. Climate change affecting the Peruvian fishery in which the Peruvian anchoveta is the main species caught (Inter-American Development Bank).

The increase of global fish oil price in the last two decades has stagnated its utilisation in aquaculture. In 2018, it was almost USD2,000/tonne as compared to approximately USD500/tonne in 2000 (OECD-FAO Agricultural Outlook 2020-2029). This situation and the direct use of fish oil as n-3 supplements in human diets have encouraged substitutions of fish oils with plant-based oils in aquafeeds thus decreasing the share of total fish oil use in aquaculture to 12% in 2014 from a 25% share in 2004 (Misund et al., 2017).

Fish oil from Peruvian anchovy

Fish oil composition tends to vary in specifications depending on the fish species. The best composition comprises oils high in LC-PUFAs and low in short chain fatty acids (SFAs). Currently, the main source of n-3 LC-PUFAs for the Atlantic salmon originates from the Peruvian anchovy. The fish oil has high levels of n-3 LC-PUFAs, at 15 to 17% EPA and 7 to 9% DHA and are suitable for aquafeeds as well as human consumption. Average landings of Peruvian anchovy between 2001 to 2006 showed an average of 720,000 tonnes. However, conversion through the reduction process yielded only 270,000 tonnes of fish oil. The utilisation of this oil in Atlantic salmon feeds has been the benchmark for performances of alternative lipid source.

Generally, Peruvian anchovy oil containing up to 22% EPA and 13% of DHA is >90% in the form of triacylglycerides (TAG). It also has lower monounsaturated fatty acids (MUFA) compared to herring or mackerel oils which albeit have seasonal oil contents. Furthermore, fish oil is known to contain vitamins A, D and E. Fish oil contains undesirable persistent organic pollutants (POP) through natural accumulation in the tissues, such as polychlorinated biphenyls (PCB), organochlorines and polycyclic aromatic hydrocarbons and dioxins that originate from industrial deposits in the marine environment. PCBs are considered as the most hazardous due to its carcinogenic nature. In 2004, POP accumulation in Atlantic salmon attracted attention. However, it was shown that accumulation was below the maximum limit set by the World Health Organization (WHO) and EFSA. Several options are discussed below either for the replacement of fish oil partially or completely.

Krill oil

Oils from the Atlantic krill, *Euphausia superba* have recently emerged as a fish oil replacement. The obvious attribute of this lipid source is mainly due to the high content of EPA+DHA (~65%) in phospholipid (PL) form as compared to TAG form found in fish oil. Krill is also the largest zooplankton biomass with a reported total allowable catch (TAC) of only 2%. Both attributes can be associated with its position, lower in trophic food chain similar to marine microalgae. One of the major reasons for the surge of interests in this alternative oil is the better bioavailability of EPA+DHA in krill oil in the human diet. Although studies do not provide any significant differences on the bioavailability of EPA+DHA in either TAG and PL forms, it is found that EPA+DHA exist in krill oil in various forms such as TAG, PL and as free fatty acids (FFAs) with EPA+DHA in FFAs at 43%. This high relative percentage of EPA+DHA in FFA is suggested as the main driver of higher krill oil bioavailability in the human diet. This initial assumption is then supported by a bioavailability study comparing fish oil and krill oil that showed higher n-3 LC-PUFAs content in mice livers after supplementation while also demonstrating better anti-inflammatory effects (Figure 3).

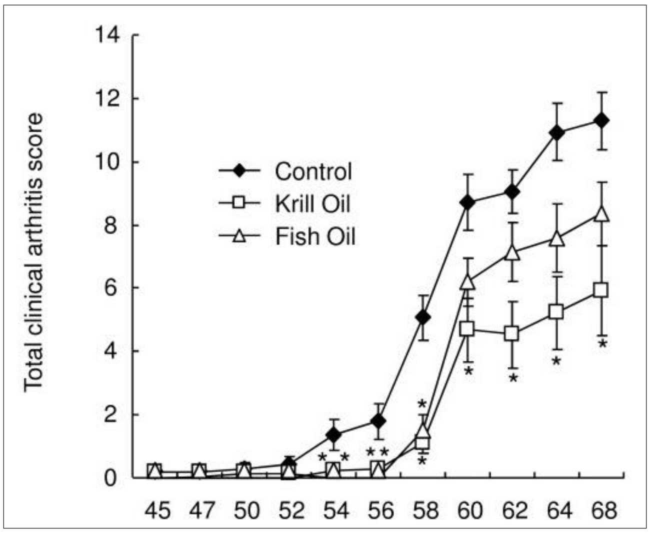


Figure 3. Advantage of krill oil as compared to fish oil in suppressing induced arthritis in experimental mice (Ierna et al., 2010).

Another study carried out to investigate the effects of krill oil supplementation in the human diet found that krill oil can reduce body blood glucose and increase plasma levels. Krill oil also contains astaxanthin which is a good antioxidant for human health and induces the signature pink pigmentation in Atlantic salmon fillets. However, the PUFA contents in krill oil are subject to seasonal variations in which environmental and physiological changes are major factors.

Microalgal oil

In nature, n-3 LC-PUFAs are consistently produced primarily by marine microalgae. However, accessibility to the abundant n-3 LC-PUFAs requires biotechnology for further utilisation in aquaculture. There are several species which have been studied for potential mass-production and commercialisation such as *Phaedoctylum tricornutum*, *Nannochloropsis* sp. and *Desmodeus* sp. (Gong et al., 2017; Sørensen et al., 2016). These have produced inconsistent n-3 LC-PUFAs percentages although complete replacement using microalgal oil in Nile tilapia¸ *Oreochromis niloticus* has produced considerable success at a trial level (Sarker et al., 2016). One of the more promising microalgae for consideration is the heterotrophic *Schizochytrium* sp. which can yield ~40% of DHA relative to its total fatty acid content. Initial production began in 1990 and since 2001, it is being commercialised mainly as a fortifying ingredient in more than a hundred available products. Production-wise, this microalga can grow extremely rapidly and produce high cell densities in fermenters (Ratledge, 2013).

Schizochytrium sp. can also produce a high amount of DHA (33% to 52%) in culture conditions with temperatures ranging from 20°C to 30°C within 30 to 66 hours although EPA production only averaged 1%. A trial using *O. niloticus* by Sarker et al. (2015) has shown that increased replacements of fish oil in the feed produced superior

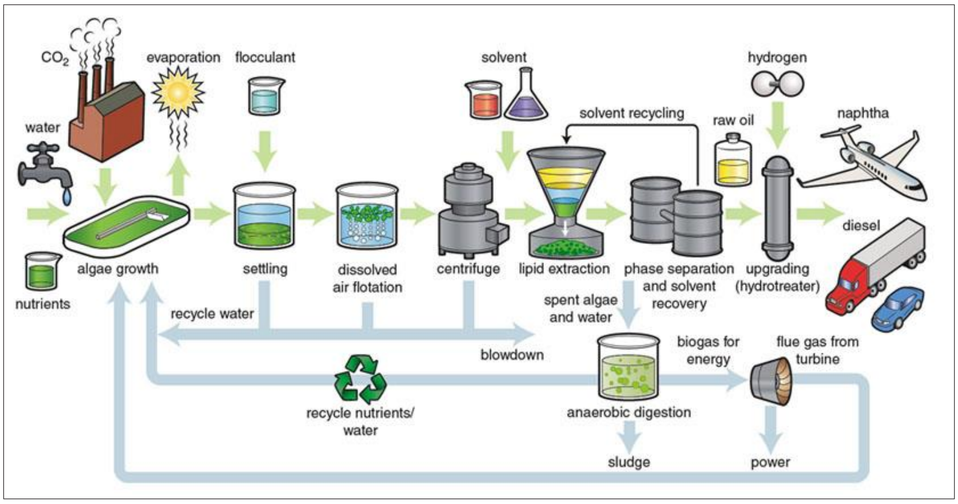


Figure 4. A schematic on an algal biorefinery system used by the National Renewable Energy Laboratory (NREL) in USA (Illustration by Barbara Aulicino, 2018).

growth performance in terms of final weight, weight gain, and feed conversion ratio with a significant difference observed at complete replacement. Nutritional analysis on the fillets of the trial Nile tilapia also showed significant increases of DHA content at every replacement level. However, the EPA content in the fillets decreased from 52% at zero replacement to 6% at complete replacement with algal oil.

Plant oils from transgenic false flaxseed

Oil production from seeds such as rapeseed, palm kernel, linseed and soybean is common over the last three decades especially for human consumption. These plants have an advantage of high-volume production; however, they also suffer from inconsistent PUFA composition. As a result, oil production from seeds are usually composites of rapeseed, palm oil, linseed oil and small proportions of soybean. Therefore, improvements in selective breeding and use of genetic modifications should be implemented to overcome the challenges mentioned.

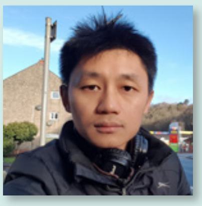
Figure 5. Different parts of *Camelina sativa* from the stalk until the production of oil (left to right) (Source: Wikimedia, 2018).

An interesting candidate for consideration is the false flaxseed, *Camelina sativa* which, in recent times has provided scientific and application evidences as a potential alternative lipid source in salmon feed. This plant has re-emerged as a robust candidate which is highly tolerant against diseases, pests and drought. A limiting factor is the need for high clay and organic soils. *C. sativa* is also a short season crop requiring only 85 to 100 days to mature with as little as 11 inches (28cm) of rain and production can average approximately 2.24 tonnes/ha with 16-18 inches (40.6-45.7cm) of rain. Currently, there is no systematic information system on the global production of *C. sativa* although cultivation is reported in Slovenia, Ukraine, China, Finland, Germany, Austria and USA.

The oil content is high, between 30 to 45%, but the major disadvantage of *C. sativa* is that the only principal fatty acids available are alpha-linolenic acid (18:3n-3), linoleic acid (18:2n-6) and gondoic acid (20:1n-9) but no available n-3 LC-PUFAs. Therefore, there has been an effort to metabolically-engineer *C. sativa* to produce high levels of essential n-3 LC-PUFAs. In this process, *C. sativa* was inserted with gene cassettes that contained five or seven fatty-acyl desaturase and elongase genes found in marine algal species. This insertion then added an additional metabolic step in the biosynthesis pathway inside *C. sativa* to produce end products of EPA and DHA (Ruiz-Lopez et al., 2014; Usher et al., 2015). However, optimisation of the n-3 LC-PUFAs synthesis process is still ongoing to produce EPA and DHA at a level comparable to fish oil. In addition, there have also been multiple studies aimed to completely replace fish oil with the improved *C. sativa* in post-smolt salmon and in the European seabass, *Dicentarchus labrax* without any negative health effects (Betancor et al., 2015, 2017, 2018, 2021).

The way forward

Estimations based on available data showed that the fish oil supply situation will continue to plateau. Krill oil continues to be an interesting candidate given its unique EPA+DHA composition and the fact that its abundance is well above the maximum sustainable yield. Recent studies have also indicated positive outlooks on its use in aquafeed mainly by improving digestion and growth (Burri et al., 2020; Rufino et al., 2020). Plant and algal oils are also interesting candidates but inconsistent EPA+DHA composition and risks associated with GMO persist to limit their potential use. Nonetheless, if these challenges are met, utilisation of plant and algal oils can reduce dependence on fish oils, thus contributing to sustainable practices in aquaculture.



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Prospects of *Artemia* production in Cox's Bazar, Bangladesh

Integrating *Artemia*, salt and fish/shrimp aquaculture has the potential to increase income and profitability of its salt farmers

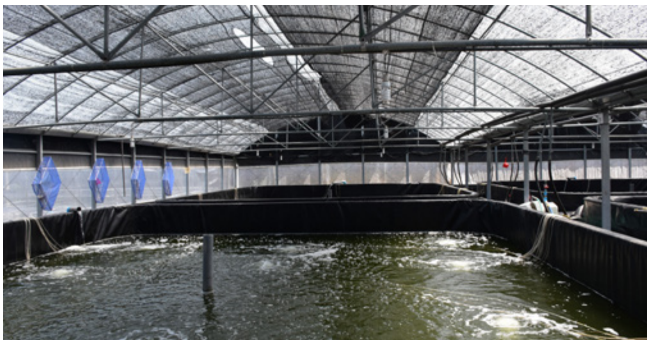
By Muhammad Meezanur Rahman and Patrick Sorgeloos

Bangladesh is one of the most densely populated and climate vulnerable countries in the world. The Cox's Bazar District, located on the south-east coastal zone of Bangladesh, is one of the least developed and most vulnerable regions in the country. Its situation is aggravated by the Rohingya refugee crisis which, since August 2017, has resulted in the migration of more than 700,000 refugees from Myanmar (Tay et al., 2018) and keeping in mind that already before August 2017 an estimated 500,000 refugees were already present in the region. This crisis has placed enormous extra pressure on the land, local communities on the local and national governments, resulting in increased price inflation, unemployment and higher environmental degradation.

Cox's Bazar area has played a significant role in the Bangladesh economy for aquaculture, fisheries, crude salt production and tourism. At the same time, the area is additionally threatened by climate change and the other above-mentioned pressures. WorldFish is currently implementing the EU financed project "*Artemia*4Bangladesh" for technological improvements in integrating *Artemia* production and aquaculture in solar salt farms in Cox's Bazar District as a potential climate smart solution to the various challenges of this important but vulnerable region of Bangladesh.

Importance of aquaculture and fisheries

Together, aquaculture and fisheries production in Cox's Bazar District meet the demand for aquatic foods in the area. It also provides fish and other aquatic products across the country and beyond, contributing to foreign exchange earnings and offering livelihoods to millions of people. The major activities of the area are capture marine (e.g. *Hilsa* fisheries) and inland fisheries, shrimp and tilapia hatcheries, extensive salt-cum-fish farms, intensive shrimp and fish farms, crab farms and dried fish production (Table 1). In recent years, two shrimp hatcheries in Cox's Bazar have been producing specific pathogen free (SPF) *Penaeus monodon* post larvae.



MKA hatchery is one of two shrimp hatcheries in Cox's Bazar producing SPF Penaeus monodon post larvae.

Aquaculture and fisheries resources	
Extensive shrimp/fish production area	44,457 ha
Number of shrimp hatcheries (*P. monodon*)	48
Number of tilapia hatcheries	10
Number of crab hatcheries	2
Number of tilapia farms	718 (206 ha)
Number and area of intensive shrimp farms	12 (200 ha)
Number of crab farms	146
Shrimp post larvae production/year	> 10 billion
Farmed shrimp production	16,400 tonnes
Hilsa production	15,256 tonnes
Farmed crab production	632 tonnes
Dried fish production	25,178 tonnes
Total fish production (aquaculture + capture fisheries.)	245, 894 tonnes
Number of registered fishermen	48, 393
Number of registered aqua farmers	40,000

Table 1. Aquaculture and fisheries activies in Cox's Bazar

Crude salt production

The salt industry is the largest labour-oriented cottage industry in the country. Salt farming is a seasonal activity occurring during the drier winter and pre-monsoon months between November to May. The entire practice is dependent on favourable climatic conditions such as low rainfall, sunny days, high temperature and evaporation rates. The practice is already becoming affected by climatic changes such as pre-monsoon rainfall anomalies, cyclonic surges, tidal inundations, floods and cold weather conditions. These changes may lead to shortening of the salt production season, reduced productivity, income and employment. Climate variability (i.e. high temperatures, cold wave, low/heavy rainfall) is also affecting the aquaculture operations and management decisions. These climatic variabilities need to be assessed for Cox's Bazar to better manage climate induced risks to aquaculture and fisheries and identify potential climate sensitive management decisions.

Some 95% of the 1.8 million tonnes crude salt produced annually in Bangladesh originates in the Cox's Bazar area. The crude salt is produced in about 27,000 ha of land operated by 50,000 artisanal salt farmers, providing livelihood to approximately 1.5 million people. Land ownership of salt farms is varied, with owned, leased and shared land. More than 50% of salt farmers lease the land for salt production, but 90% do not have access to formal credit flow. On an average, 60% of the farmers' annual income comes from salt production (Hossain, 2018).

Cox's Bazar contributes 95% of the 1.8 million tonnes crude salt produced annually in Bangladesh.

The profitability of salt farming varies with different factors, such as crude salt price, as well as costs of labour, land lease, loans, price of polythene, fuel and pump, sluice gate operation and use of insecticides. The low profitability, labour dependency, climatic risk involvement, limited options for livelihood improvement all cause economic vulnerability to the salt farmers.

Artemia cyst and biomass production

Brine shrimp *Artemia* is a primitive crustacean with a segmented body with broad leaf-like appendages that greatly increase the apparent size of the animal. The total length is usually about 8-10mm for the adult male and 10-12mm for the female. The genus, *Artemia*, consists of bisexual and parthenogenetic strains. Females of most *Artemia* strains reproduce ovoviviparously and oviparously, releasing either nauplius larvae or encysted embryos, respectively. Reproductive mode may switch; in good rearing conditions *Artemia* tend to reproduce ovoviviparously, whereas under adverse situations they reproduce oviparously (Abatzopoulos et al., 2002) (Figure 1).

Supply and demand of *Artemia*

Artemia nauplii constitute the most widely used live-food item for the larviculture of different species of crustaceans and marine fish. Annually, about 3,500 tonnes of *Artemia* cysts are marketed worldwide. Indeed, the unique property of the small branchiopod crustacean *Artemia* to form dormant embryos, so-called 'cysts', accounts to a great extent to the designation of a convenient, suitable, and excellent larval food source, rich in highly digestible proteins and essential fatty acids. The cysts are available year-round in large quantities along the shorelines of hypersaline lakes, coastal lagoons and solar salt works scattered over Asia, Europe, America and Australia.

After harvesting and processing, cysts are canned for storage and after some 24-hour incubation in seawater the cysts release free-swimming nauplii. These nauplii are mostly utilised as a nutritious live-food source for the larvae of crustaceans and marine fish (Lavens and Sorgeloos, 1996). At present, Bangladesh imports 40-50 tonnes dry *Artemia* cysts annually worth an approximate value of USD4 million (Meezanur Rahman, sourced at hatcheries).

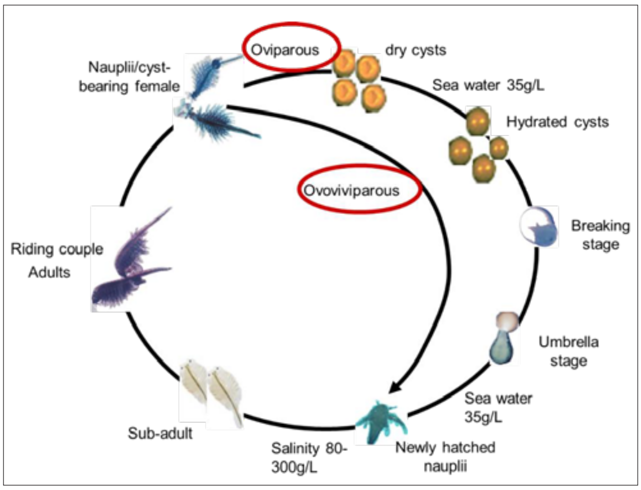


Figure 1. Life cycle of *Artemia*

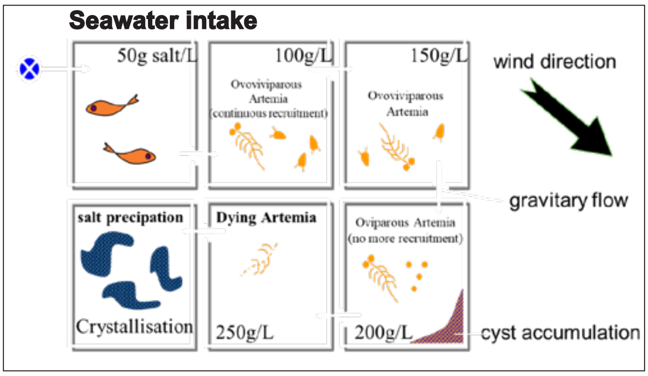


Figure 2. Schematic diagram of a solar salt operation with natural occurrence of *Artemia*

Integrated *Artemia*- salt-aquaculture

Several Southeast Asian countries such as Vietnam and Thailand have been successful in adopting new technologies for the production of *Artemia* (cysts and biomass), integration of salt and aquaculture production, and alternative use of concentrated sea water to increase income and profitability of the salt farmers. Similarly, new projects have been launched in Bangladesh, Cambodia and Myanmar. The technological improvements are necessary to upgrade the livelihoods of the thousands of salt farmers in Bangladesh. Principles of *Artemia* culture in solar salt ponds have been developed following the behaviour of *Artemia* in natural habitats as shown in Figure 2.

At the end of the salt production season, the majority (75%) of salt farmers in Bangladesh transition their land for aquaculture purposes. However, as mentioned, the aquaculture production and productivity are very low due to the practice of traditional farming systems. Recent field visit observations and workshop findings suggest that Bangladeshi salt/aquaculture farmers are unaware of the opportunities with *Artemia* farming, and the consequent technological improvements for saline tolerant crustacean and fish production in the salt farms during the rainy season.

Interventions would include improving bio security, compliance of better management practices including stocking of pathogen free seed, nursery rearing, periodic sampling, application of inputs (lime, inorganic fertiliser, feeds), water depth management, reduction of stocking frequency and poly culture; all these are required to improve productivity, profitability and reduction of disease incidence (Rahman et al. 2018).

Conclusion

The livelihood of the population in Cox's Bazar District has been affected due to climate induced risks, low productivity in coastal aquaculture, low profitability of salt production and Rohingya refugee influx into the area. Many countries adopted technologies for *Artemia* cyst and biomass production in the salt farms. The availability of seed, improvement of seed quality and better management practices all show promise to improve productivity and profitability of costal aquaculture in this area. The *Artemia*4Bangladesh project plans to improve the livelihood of salt cum fish farmers through integrated salt, *Artemia* and aquaculture production in the salt farms of the Cox's Bazar District as a climate smart solution to mitigate the challenges in this region.

Acknowledgement

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Concept of a 'fish meal equivalent'- could it be insect meal?

With amino acid profiles more comparable to fish meal, would insect meals be a preferable alternative to soybean meal for aquafeeds?

By Partha P. Biswas

According to the FAO (2018), there are around 600 aquaculture species with a production at more than 100 million tonnes. The global value of aquaculture production is about USD170 billion, which corresponds to about 45% of the global fish production; this production is predicted to grow by 62% by 2030. Fish contain 16-20% protein compared to 12% in eggs, 3.5% in milk and 6-8% in rice and wheat. It is very palatable, highly nutritive and an excellent source of essential minerals, vitamins and essential amino acids. At present, some 31% of the total animal protein supply in the Asian region is fish protein.

Feeding fish to fish

However, according to Fulton (2016), aquaculture is apparently not a sustainable and environmentally friendly form of farming as it depends on large scale wild fisheries for the production of fish meal and fish oil. Fears have been raised that this trend may have disastrous consequences for the ecosystem. Feeding 'fish to fish' is inefficient and wasteful. It takes more than 6kg of wild fish to produce 1kg of farmed fish (Schipp, 2008; Edwards et al., 2004). This is particularly true for the culture of carnivorous fish species.

Future demand for fish meal is expected to increase dramatically as aquaculture production increases and some species, such as catfish, are increasingly fed pelleted diets containing fish meal. It was reported that 40 species of fin fish and crustaceans comprise the so called marine "trash fish"(a misnomer) used as a feed or aquafeed ingredient in Vietnam (Edwards et al., 2004). This approach of using wild catches is jeopardising the conservation of marine resources and the sustainability of fisheries; both these issues are highlighted by most international and national institutions.

Insect meal pellets for fish

Towards sustainable inputs

The increasing demand for fish meal and fish oil and other marine protein sources for aquafeed production is now a pivotal problem (FAO, 2011). There is insufficient fish meal and fish oil leading to prices gradually escalating. Against this background, researchers seek alternative solutions to mitigate the environmental problems and to keep farming costs down. These two sustainability dimensions of the industry cannot be assessed separately, but rather must be addressed in synergy. From the standpoint of sustainability, it is now imperative to reduce fish meal and fish oil use in aquaculture and to use alternative sources (Gasco, et al., 2018).

Until now, the main protein source in fish feed is fish meal, because of its high protein content, good essential amino acid profile, palatability and digestibility, lack of anti-nutritional factors (ANFs) and easy availability. Many previous reports (Daniel, 2018), therefore, did not recommend replacing fish meal in the diets. On the other hand, several investigators demonstrated that plant ingredients can be used to replace fish meal in the diet if the animal showed no difference in the overall performances while being fed feeds containing plant meals.

Challenges with plant meals

However, there are several challenges associated with the use of plant meals to replace fish meal and this will require further research. Plant protein concentrates prepared from soy, corn or wheat gluten are costly compared to fish meal. Soybean meal contains only 48% crude protein, much lower than fish meal. Proteins from oilseeds, in general, contain more ANFs which are of concern for fish. Anti-nutrients in plant proteins include phytic acid, glucosinolates, saponins, tannins, soluble non starch polysaccharides and gossypol.

The phosphorus in phytic acid is not available to fish and passes through the gastro-intestinal tract. Phytic acid also ties up divalent cations under certain conditions, making them unavailable to fish. Thus, fish can become deficient in essential minerals, especially zinc, when the phytic acid level in feeds is high, unless the diet is fortified with extra zinc. Phytic acid is present in all plant protein ingredients.

Glucosinolates are present in rapeseed (canola) products and interfere with the thyroid function in fish. Saponins are found in soybean meal and are reported to lower feed intake. Gossypol is a constituent of cottonseed meal that is well known to cause reproductive problems in livestock and fish, including reduced growth. Non-starch polysaccharides are not toxins but are poorly digested by fish and may interfere with uptake of proteins and lipids.

It has been found that fish fed plant protein meals received a reduced number of certain vitamins such as riboflavin, niacin, pantothenic acid and vitamin B12 (Hertrampf and Piedad-Pascual, 2000). Vitamin B is very essential for the proper metabolism of animals. Approximately 75% of the phosphorus in plant feedstuffs exists in the form of a phytate-phosphorus complex that has low digestibility in fish which does not produce a phytase enzyme.

The main alternative to fish meal is soybean meal, which is already widely used in fish feeds. However, soybean production has been criticised for generating high land-use competition and significant environmental deterioration (including endemic species extinction), deforestation, pesticide and herbicide use (Fearnside, 2001). Soybean contains several ANFs which cause inflammation of the digestive tract of fish; it has low palatability and contains few sulphur rich amino acids (methionine and cysteine). Only some ANFs of nutritional significance can be destroyed or inactivated by proper heat treatment (eg. trypsin inhibitor) (Hardy, 2010; Yasothai, 2016).

Insect meals

Extensive scientific information shows that insects represent a valid substitute for fish meal, fish oil and conventional protein meals (Henry et al., 2015). Overall, the amino acid profile of insect meal is more comparable to fish meal than plant-based feeds. Therefore, insects would be a preferable alternative to soybean meal for instance (Barroso et al., 2014; Tran et al., 2015). Potentially, it would be necessary to supplement those amino acids which are not found in insects to cater for the needs of specific farmed species.

Crude protein (CP) profiles for many species of insects show similarity to fish meal (>50% or even higher such as silkworm pupae 75.5% of dry matter) as compared with 45% CP in soybean meal (SBM). Amino acid profile of insects is similar to fish meal with the exceptions of histidine, threonine and lysine. Dipteran insects have the protein profile akin to fish meal. (Table 1). SBM is also low in lysine and sometimes lacks the amino acids tryptophan and threonine. However, insects are rich in essential amino acids (Bukkens, 1997).

Lysine and methionine are commonly the most limiting in raw material designated for fish nutrition. Lysine in different insect meals are much higher than those in SBM. In insect meals, methionine, tryptophan and glycine levels are much higher than in SBM. According to a review of Józefiak and Engberg (2017), insect proteins could be a promising source of antimicrobial peptides and an alternative to antibiotics.

Fish meal is rich in n-3 polyunsaturated fatty acids (PUFAs) with high amounts of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). EPA and DHA in fish diets promote good growth and are also essential for the immune system. These are practically absent in insect meals but there are higher ratios of n-6 and monounsaturated fats. The ratio of alpha-linolenic acid to linoleic acid in insect oils is not as good as in fish oil, but is better than in plant oils. Interestingly, fatty acid composition of insects can be modified by modulating the content of the feed substrate and thus can potentially be adjusted to fit the requirements of a specific fish species more closely (Makkar et al., 2014; Brunella et al., 2019).

Meal worms are larvae of a beetle

Combination of species

To determine the potential of insects as a substitute for fish meal in aquafeeds, 16 different species had been investigated (Barroso et al., 2014). Five of them were examined at different stages of development; the insects studied belonged to the orders Coleoptera (4), Diptera

Insects		Essential Amino Acid Profile												
		ARG	CYS	HIS	ISO	LEU	LYS	MET	PHE	THR	TRP	TYR	VAL	Total
BSF	Larvae	5.2	ND	3.6	4.4	7.2	6.5	1.9	4.0	3.3	1.22	ND	6.7	44.0
	Pre-pupae	5.1	ND	3.7	4.5	6.8	5.7	1.7	3.9	3.9	ND	ND	6.1	41.4
HF	Larvae	4.9	0.7	2.8	3.2	5.7	6.9	2.2	5.0	3.3	3.2	5.1	4.4	47.5
	Pupae	4.7	0.4	2.4	3.5	5.3	5.5	2.1	4.4	3.2	ND	5.2	4.2	40.9
MW	Larvae	5.8	5.8	3.6	6.7	10.7	6.4	2.1	5.4	5.1	1.6	7.8	8.2	69.0
GH	Meal	5.6	1.1	3.0	4.0	5.8	4.7	2.3	3.4	3.5	0.8	3.3	4.0	41.5
SW	Pre-Pupae	4.69	0.52	2.79	4.33	6.5	6.6	2.12	5.17	4.48	ND	6.32	5.3	48.8
	Pupae	6.31	0.97	3.28	4.73	7.04	7.52	3.88	5.58	5.58	1.70	6.55	5.7	58.84
FM		6.2	0.8	2.4	4.2	7.2	7.5	2.7	3.9	4.1	1.0	3.1	4.9	48
SBM		2.90	0.74	1.02	2.07	7.72	2.62	0.52	2.12	1.66	0.65	3.11	2.6	27.73

Note: BSF= Black Soldier, HF= Housefly, MW= Mealworm, GH= Grasshopper, EW= Earthworm SW= Silkworm, FM= Fish meal, SBM= Soybean Meal; ND= ND:not determined; Ref: Dawit M. Zegeye (2020), Nutritional Evaluation of Insect's Pupae-Larvae and its Utilization in Poultry Compound Feed. The Open Agriculture Journal.14: 1-8.

Table 1. Comparative essential amino acid profile (g/100g of total essential amino acids) of insect meal and conventional feeds of soybean meal and fish meal.

Larvae of black soldier fly

(7) and Orthoptera (5). Using different insect species in combination could compensate for the lack of certain amino acids in some species. For instance, the amino acid profiles of the black soldier fly *(Hermetia illucens)* and house fly *(Musca domestica)* larvae partly complement each other and together they match the profile of fish meal much more closely than they do individually. Most insect meals are deficient in calcium and phosphorus. Therefore, their supplementation in the diet is also required. Furthermore, the chitin of insects has been suggested to be an ANF that impedes the absorption of nutrients in fish. This would be an issue when insects are utilised in fish feed.

EU legislation

Since July 1, 2017, the European Union legislation has identified seven insect species which are permitted (EU-enactment 2017/893) for aquafeeds. These comprise the following: black soldier fly *(Hermetia illucens)*, housefly (Musca domestica), mealworm or yellow mealworm *(Tenebrio molitor)*, lesser mealworm or litter beetle *(Alphitobius diaperinus)*, house cricket *(Acheta domesticus)*, tropical house cricket or banded cricket *(Gryllodes sigillatus)*, and Jamaican field cricket *(Gryllus assimilis)*. Rearing of insects is not allowed on substrates that contain kitchen or food scraps, meat or bone meal, liquid manure or faeces.

Overall, insects as feed components in aquaculture, replacing fish meal have been receiving increasing recognition and have great potential due to their high energy and protein content.

Companies such as Ynsect (France), Agriprotein (Singapore), Hexafly (Ireland), NextProtein (France) and Enterra (Canada) are looking to refine insect meals and to scale up production to control the cost of fish feed. It will be exciting to follow the development of how and to what degree these insects will be used in aquafeed over the next few years.

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Extru-Tech introduces Self-Adjusting Die/Knife Cutter Head

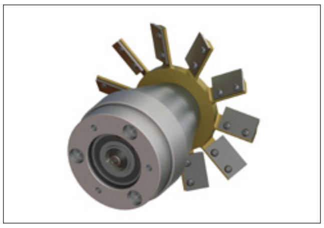
Dramatic reductions in maintenance costs and downtime are just two of the benefits of a new Self-Adjusting Die/Knife Cutter System from Extru-Tech, Inc. Equally important, the new advanced feature cutter head can be used across the full spectrum of wear plates.

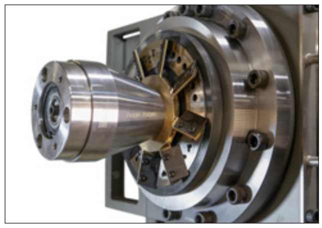
According to John Menold, field service manager for Extru-Tech, the new die/knife cutter system offers a cleaner cut than cast blade configurations due to a "precision" pressure pack and individually replaceable blades, which can be sharpened from three to five times.

"Not only can they be re-sharpened, but the new blades have been reported to last from 2 1/2 to 10 times longer than cast blades," Menold adds. "This translates into lower overall cost, particularly when you consider the automatic adjustment feature that allows one cutter head system to be used on multiple dies. The cutter assembly is easily secured and automatically set parallel to the wear plate with just one bolt."

Menold notes that the self-leveling feature also allows the system to accommodate non-perpendicular die stubs and worn plates.

For additional ease of maintenance, the self-adjusting die/knife cutter system is rated for wash-down and utilises high temperature, sealed bearings for longer life. The single cutting edge of the blades also minimises the risk of injury to employees and personnel.
www.extru-techinc.com





Scientists to test feasibility of novel protein in fish feed

The Institute of Aquaculture will evaluate a single-cell protein (SCP), produced from industrial emissions of carbon dioxide, as a substitute for marine and terrestrial meal in salmon feeds. The study – supported by the Scottish Aquaculture Innovation Centre (SAIC) – forms part of the overarching REACT-FIRST project, which has received £3 million in funding from Innovate UK.

The project is led by carbon recycling biotechnology company Deep Branch and consists of 10 industry and academic partners. It aims to produce a scalable model – demonstrating the sustainable generation of protein using waste carbon dioxide and using that protein to produce fish and poultry feeds.

The main alternative to fish meal in aquafeeds is vegetable meal, however, this has its constraints, and SCP is an excellent alternative as it is nutritionally optimised to meet the demands of aquaculture. Dr Mónica Betancor, who is leading the University of Stirling's involvement in the study, said, "The project aims to evaluate and validate a SCP produced from industrial emissions of CO_2, with an amino acid profile tailored to meet the end-user requirements of the aquafeed industry, and also support and improve the sustainability and development of UK aquaculture by contributing to UK food security."

Polly Douglas, aquaculture innovation manager at SAIC, added, "REACT-FIRST is a highly innovative way of turning the CO_2 produced by another process into a key component of our food chain, providing a sustainable source of feed for fish. It could make a significant contribution to food security in the UK, while reducing the supply chain's carbon footprint – both of which have seldom been of more relevance."

REACT-FIRST will use microbes to convert carbon dioxide directly from industrial emissions into high-value products, specifically a novel SCP called Proton™. The project team will collect critical data on the cost, digestibility, nutritional quality, and carbon footprint of the product.

Peter Rowe, CEO of Deep Branch, said: "Projects like REACT-FIRST are key to help the industry move towards achieving net-zero emissions. Its solution uses the technology developed by Deep Branch, but whilst this has huge transformative potential, commercialisation is not possible without cooperation with key stakeholders across the value chain. REACT-FIRST addresses this, with its consortium of industrial and academic organisations, and even though relationships within these verticals are well established, the project represents the first time that the resources and expertise of all parties have been unified towards a single goal."

The project will also involve: Drax, the UK's largest renewable energy producer; BioMar, one of the world's largest aquafeed producers; AB Agri, the UK's leading producer of monogastric feed; Sainsbury's; the Synthetic Biology Research Centre at the University of Nottingham; the School of Animal Rural and Environmental Sciences at Nottingham Trent University; and Innogen at the University of Edinburgh, experts in value chain integration and responsible innovation. www.stir.ac.uk/about/faculties/natural-sciences/aquaculture/

Success in replacing fish meal, fish oil in farm-raised carnivorous fish

Researchers in Kona, Hawaii, have made a breakthrough in the quest to develop a cost-effective "fish-free" feed for farm-raised Kampachi, or almaco jack, a carnivorous marine fish prized for its rich, buttery flavour. The ability to replace fish meal and fish oil currently used in carnivorous marine fish diets will have important implications for ocean sustainability and meeting the growing demand for seafood around the world.

"This is the first time – to our knowledge – that fish meal and fish oil have been totally eliminated from the diet of a marine carnivorous fish, with no deleterious consequences," said Neil Anthony Sims, CEO of the Hawaii-based mariculture company, Ocean Era, where the trial was conducted. "Kampachi are a fast-growing, sashimi-grade fish, so this a significant breakthrough for the sustainability and scalability of marine fish farming." Ocean Era, LLC (formerly Kampachi Farms, LLC) is a Kona, Hawaii, based R&D company, dedicated to softening humanity's footprint on the seas, by expanding production of the ocean's living resources.

During the three-month trial funded by a Saltonstall-Kennedy grant from the National Oceanic and Atmospheric Administration (NOAA), 480 juvenile Kampachi (*Seriola rivoliana)* were fed one of four diets. Two of the diets contained no fish meal, and one of these also contained no fish oil. Fish meal replacement relied primarily on poultry meal, from up-cycled poultry trimmings. Fish oil replacement was achieved using Veramaris® natural marine algal oil, which contains high levels of two critical omega-3 fatty acids, DHA and EPA. A fish meal and fish oil diet were used as a control, together with an additional commercial control diet. The fish were stocked into sixteen tanks for the comparative grow-out trial.

The fish that were fed the zero fish meal/zero fish oil diet performed as well as the fish fed with the fish meal and fish oil diet. Performance was evaluated in terms of growth, feed conversion ratio (FCR), fillet yield and survival. The fish fed the zero fish meal/zero fish oil diet also had a more desirable taste compared to the fish fed the commercially available control diet.

"The results clearly show that algal oil can replace fish oil 100% without any reduction in growth of this marine fish," said Rick Barrows, a fish nutrition expert with Aquatic Feed Technologies and co-principal investigator of the study.

The feed formulations used in this trial are available as open source formulation through the F3 Feed Innovation Network (F3 FIN) for anyone working to replace wild-caught fish ingredients in animal feed. F3 FIN encourages sustainable innovations in fish-free aquafeeds ingredients by sharing experimental protocols, testing facilities and ingredient providers.

Algae oils have been shown to contain twice the amount of EPA and DHA omega-3 fatty acids as fish oil, both of which are important for maintaining fish health and imparting heart and brain health benefits to humans.

"Development of diets that use these upcycled ingredients and microalgal oils is critical to the long-term scalability of marine fish culture, and therefore to our ability to sustainably feed a planet of nine billion people with heart-healthy seafood," said Sims.

The project, titled "Developing cost-effective fish meal-free and fish oil-minimised diets for high market value US marine fish aquaculture," was funded through NOAA's Saltonstall-Kennedy Grant Program (NA18NMF4270208). The United States Department of Agriculture's (USDA) Agricultural Research Service provided feed milling support for the trial. Anthropocene Institute and Ka'upulehu fish ponds were collaborating partners on the NOAA grant. The trial results are detailed in a technical article in the Global Aquaculture Alliance's Advocate. A video about the study can be viewed on YouTube at: https://youtu.be/rW9yk_U6z1U

eFishery raises Series B round

Indonesian agritech startup **eFishery,** announced in August, that it has successfully closed its Series B round, co-led by Go-Ventures and the Northstar Group, together with existing investors including sustainable aquaculture investment fund Aqua-Spark and early stage enterprise and deep tech VC Wavemaker Partners. The funds raised will be used to strengthen product development, anchor eFishery's position within the domestic aquaculture industry, and grow the team.

"eFishery's solutions, which directly support local fish farmers, also address wider issues, including strengthening food supply chains, alleviating global food shortages and helping to boost both Indonesia's fishing industry and overall economy. As eFishery expands first within Indonesia and subsequently regionally, we look forward to seeing these benefits grow exponentially," said Aditya Kumar, VP of Investments, Go-Ventures, a venture capital fund that aims to invest in early stage companies with demonstrated traction in their target markets.

"We are really inspired by the impact that eFishery is having on the aquaculture supply chain," said Patrick Walujo, co-founder of the Northstar Group. "The company's ability to deliver fish farmers the latest in smart-hardware integrated with cloud-based mobile analytics is transforming a very traditional business in Indonesia. We are proud to partner with the eFishery team and see great things ahead." Based

New strategic initiative to transform global animal nutrition and health

The need to provide enough animal protein for a growing population, while reducing the environmental costs of farming will require smart science and innovative solutions. To address this challenge, **DSM** Animal Nutrition and Health has launched its cutting edge new strategic initiative: *We Make it Possible*. Its mission is to lead a robust and achievable transformation worldwide in sustainable animal protein production, and to accelerate solutions that will foster a brighter future.

"DSM is purpose-led and performance-driven, and we know that the agriculture industry can transform itself from within," said DSM's Animal Nutrition and Health President Ivo Lansbergen. "For too long, sustainability has been someone else's problem, a problem for tomorrow. But it is not an impossible challenge. We believe we can make animal farming sustainable. Our need is to be providing a decent living for farmers and affordable proteins to the world population, all while reducing the footprint of animal farming. *We Make it Possible* is a commitment to tangible and actionable solutions that cater to the customers we care most about: people and planet earth.

"Sustainability is in our DNA. We want to demonstrate our new vision, both within DSM and beyond, how we see the future of the farming industry and the role we want to play. This strategic initiative reflects our commitment not only to be part of the value chain but to be a change agent, steering the global conversations, connecting the various stakeholders of the farming ecosystem, thinking ahead, generating ideas and new ways of working. If not now, when?"

Aligned with the UN's Sustainable Development Goals 2, 3, 12, 13, and 14*, the strategic initiative is driven by six sustainability platforms that will address the major challenges facing the animal farming industry. These are:

- Improving the lifetime performance of farm animals
- Improving the quality of food (i.e. meat, milk, fish, eggs), while reducing food loss and waste
- Reducing emissions from livestock
- Making efficient use of natural resources
- Reducing the reliance on marine resources
- Helping tackle anti-microbial resistance

"DSM has a long and rich heritage in the sustainability arena, and it is on that basis that we operate as a purpose-led company. Companies can no longer delay this aspect. They must step up and embrace sustainability in all aspects: it is vital to the success of business, just as it is vital to everything else," said Christie Chavis, Vice President at DSM Animal Nutrition and Health. "We will create value across three dimensions simultaneously: People, Planet and Profit."

"By applying our science, innovation and sustainability leadership behind these key areas, we believe we can make a substantial difference to the sustainability of the animal protein industry," said David Nickell, VP of Sustainability & Business Solutions at DSM Animal Nutrition and Health. "At DSM, we are taking responsibility for our own role in protecting the planet, and have and continue to develop business solutions that enable the industry to make affordable and measurable improvements in the sustainability of animal protein, and we hope that many others will follow suit."

The *We Make It Possible* strategic initiative comes after many years of investment and innovation in scientific solutions aimed at providing real answers to the challenges facing the agriculture industry, and marks not a new beginning, but a significant acceleration of the journey towards a more sustainable future. www.dsm.com

**The UN SDGs are a blueprint to achieve a more sustainable future for all. The goals listed above are as follows: 2 - Zero hunger; 3 - Good health and wellbeing; 12 - Responsible consumption and production; 13 - Climate Action; 14 - Life below water (sdgs.un.org/goals).*

in Singapore, the Northstar Group is a private equity firm managing more than USD2.0 billion in committed equity capital dedicated to investing in growth companies in Indonesia and to a lesser extent, other countries in Southeast Asia.

Launched in 2013 and based in Bandung, eFishery offers an end-to-end platform providing fish and shrimp farmers with access to feed, financing and markets. The company serves farmers in 24 provinces across Indonesia. eFishery raised a pre-Series A round in 2015 and a Series A round in in the late 2018. eFishery's business has quadrupled over that period and was profitable over past two years.

"Through the introduction of new technologies, we increase yields and lower costs for fish and shrimp farmers. With products that support the entire aquaculture ecosystem, from ponds to last mile distribution, we help farmers build more profitable and sustainable farming businesses," said Gibran Huzaifah, Co-founder and CEO of eFishery. "This new funding will allow us to grow the company, roll out across Indonesia, and achieve our vision of being a leading aquaculture intelligence company. We are excited to partner with Go-Ventures and the Northstar Group, who we believe can add significant value to our platform."

Founded in 2013, eFishery develops innovations in the aquaculture field and has vast networks across Indonesia, with all products being developed locally. eFishery's vision is to a build an aquaculture ecosystem, that is not only profitable to all stakeholders, but also sustainable for local fish and shrimp farmers. www.efishery.com

Launch of phytogenic solution in aqua market

Disease outbreaks, food safety assurance, and unstable productivity are just a few challenges in aquaculture. On these demands, **Delacon** brings along a full phytogenic solution to serve modern aquaculture practices. In August, Delacon's aqua team proudly announced the worldwide launch of Syrena® Boost, a premixture of specific saponins, spices and essential oils. The premixture targets gut performance and productivity. It is a solution for all aqua species. To date, trial results are available for tilapia.

The phytogenic solution serves an efficient, profitable yet sustainable aquaculture production, say Delacon experts: Trial results show improved feed intake (6%), a boost in specific growth rate (5%), and a ROI (4:1).

"For developing Syrena® Boost, we released our phytogenic expertise. *In vivo* and *in vitro* trials underline the performance of the product. It is a natural product with high quality, standardised and proven active ingredients," says Alex Makol, Species Leader Aqua.

Sensitive ingredients of Syrena® Boost are micro-encapsulated. This ensures thermal stability and slow intestinal release of sensitive ingredients.

Binh Nguyen Ngoc, Asian Regional Sales & Technical Manager Aqua, added, "The aqua market is developing fast. Farmers rely on performance and productivity. Additionally, they carefully look at future economic and political factors. Using a full phytogenic feed additive such as Syrena® Boost will be very attractive."

Delacon's mission is to make the most effective phytogenic solutions for health and nutrition available to all. The company develops plant-derived products for livestock and aquaculture. www.delacon.com/phytogenic-performance-in-aquaculture-production

Alex Makol, Species Leader Aqua has been leading Delacon´s Aquaculture line development since February 2017. He has been involved in fish nutrition and aquaculture industry for the last 15 years. Alex has an MSc and a PhD. at the University of Las Palmas de Gran Canaria, focusing on the effect of fatty acids on European sea bass (Dicentrarchus labrax) metabolism physiology and immune system. Before joining Delacon, Alex worked for five years in the feed mill industry as a product developer.

Nguyễn Ngọc Bình, joined Delacon as Regional Sales and Technical Manager Aqua in March 2020. With over 17 years of expertise in the aquaculture field, he will establish phytogenics as a reliable solution in the Asia region. Nguyễn Ngọc Bình has a PhD in Veterinary Medicine and a master's degree in animal production. Prior to Delacon, Nguyễn Ngọc Bình worked as Aqua Technical Sales Manager in Vietnam and Myanmar, where he had a good relationship with the feed mill and farm system.

Insect technology startup raises USD1.6 million

Protenga has closed its latest round of seed investment, raising USD1.6 million with UK agritech company Roslin Technologies and the investment arm of Enterprise Singapore, Seeds Capital. With this, Protenga becomes Roslin Technologies' flagship insect technology investment globally.

In partnership with Roslin Technologies, a world leader in animal genetics and agri-sciences, Protenga is embarking on research to identify genetic insect strains that will further improve bioconversion performance in its Smart Insect Farm systems. The work will be carried out at Roslin Technologies' soon-to-be-completed bespoke genetic nucleus facility near Edinburgh, Scotland. To support these activities, Protenga is defying the gloom of the COVID-19 economy and hiring across a number of biology, engineering, operations and R&D roles.

"Production and bioconversion opportunities using the Black Soldier Fly are enormous," announced Leo Wein, CEO of Protenga. "Working with Roslin Technologies provides the perfect opportunity to expand Protenga's capabilities and scale up across our key markets. We are also delighted to receive support and funding from Seeds Capital – together, we plan to drive transformational change in the global food supply chain."

Glen Illing, CEO of Roslin Technologies, said, "This investment is the start of our journey into the insect protein and nutrition market. Protenga has the right technologies, capabilities and culture to succeed in providing new sustainable production and waste bioconversion practices using Black Soldier Fly. We are also excited about applying enhanced breeding technologies to develop improved insect lines with Protenga from a new genetic nucleus facility currently being built near Edinburgh. Protenga is at the cutting edge of sustainable protein production and is the next important building block in our portfolio of agritech ventures."

Geoffrey Yeo, General Manager of Seeds Capital commented, "The investment in Protenga builds on our existing focus in agrifood technologies and further develops the alternative protein ecosystem in Singapore. We are delighted to be supporting Protenga as they continue to grow and expand their operations." www.protenga.com

Asian Pacific Aquaculture 2021

Surabaya, Indonesia, September 7-10

After the highly successful APA16, World Aquaculture Society-Asian Pacific Chapter (WAS-APC) has decided to return to Indonesia for the 2021 edition of the Asian Pacific Aquaculture or APA21. Surabaya is on Java Island, a leading centre of aquaculture in Indonesia. With nearly 20% increase in the last 5 years in terms of hectarage for aquaculture production and over 50% annual increase in production volumes for the last 10 years, it is a chance for the international aquaculture community to observe first-hand the rapidly expanding aquaculture industry in Indonesia. The theme of APA21 is "Bridging Technology Innovation to Elevate the Sustainable Aquaculture Industry".

At APA21 the latest developments in aquaculture in Indonesia as well as in the rest of Southeast Asia will be showcased and shared. Global technology updates will be available at the conference and in the trade show with exhibits from around the world. It is also an opportunity to explore, engage, share knowledge and meet potential business partners from around the world as well as enjoy interesting tourist attractions. "It is also a chance to experience the exquisite culinary, culture, and the warm welcome of our people from the day you land in Indonesia," said local organisers. The event is hosted by the Ministry of Marine Affairs and Fisheries (MMAF). There will be special industry sessions with the latest in practical knowledge for Indonesian aquaculture producers, co-located events and a special producer program; IndoAqua, FITA, Shrimp Club Indonesia (SCI), International Conference on Aquaculture-Indonesia Aquaculture Society (ICAI-MAI) and DigiFish.

APA21 will be held from September 7th to 10th, 2021 at Grand City Hall, Surabaya, Indonesia. For more information: www.was.org; Conference Management, John Cooksey, email: worldaqua@was.com; Booths and Sponsorship, Mario Stael, email: mario@marevent.com; WAS-APC secretariat: email: apcsec@was.org

AQUA CULTURE Asia Pacific in 2021

Volume 17	Jan/Feb	Mar/Apr	May/Jun	Jul/Aug	Sep/Oct	Nov/Dec
Aqua Business *Feature articles from industry players*	Experiences and opinions covering role models and clear and present needs of industry					
Issue focus Recent developments/spotlight on emerging challenges	Nursery & Hatchery	Health & Disease Management	Demand & Supply Equilibrium	Sustainable & Responsible Aquaculture	Aquaculture Innovations	Health & Disease Management
Industry Review Developments, outlook, demand & supply	Marine Shrimp	Marine Fish	Aquafeed Production	Tilapia	Marine Shrimp	Catfish & Freshwater Fish
Feeds & Processing Technology Technical contributions from industry	Larval & Nursery Feeds	Novel Ingredients/ Fish meal/oil Replacements	Extrusion and Pelleting	Sustainable Feeds	Functional Feeds/Additives	Feed Enzymes/Post Pellet Applications
Production Technology Technical information along the value chain	Controlled Systems (hybrid/RAS)	Offshore and Industrialisation	Hatchery Technology	Real Time Monitoring/Big Data	Feed management	Post-Harvest Processing
Marketing activities	Market and product developments, market access, certifications, branding, food safety etc					
Company/Product News	News on activities at international, regional and local conferences and trade shows					
Deadlines - *Technical articles*	***Nov 13, 2020***	***Jan 15***	***Mar 12***	***May 14***	***Jul 16***	***Sep 16***
Deadlines - *Advert Bookings*	***Nov 20, 2020***	***Jan 22***	***Mar 19***	***May 21***	***Jul 23***	***Sep 23***
Events ***Distribution at these events as well as local and regional meetings *Show preview***	**VIV Asia 2021** ***Bangkok, Thailand*** *Mar 10 – 12*	**Aquaculture Europe 2020** ***Cork, Ireland*** *Apr 12 – 15*	***World Aquaculture 2020** ***Singapore*** *Jun 14 – 18*	***TARS 2021: Shrimp Aquaculture** ***Ho Chi Minh City, Vietnam*** *Aug 19 – 20*	**Aquaculture Europe 2021** ***Madeira, Spain*** *Oct 4 – 7*	
		Seafood Expo Global 2021 ***Barcelona Spain*** *Apr 27 – 29*		**DAA11** ***Kuching, Malaysia*** *Aug 23 – 26*	**RAStech 2021** ***South Carolina, USA*** *Nov 3 – 4*	
				Asian-Pacific Aquaculture 2021** ***Surabaya, Indonesia *Sep 7 – 10*		

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Announcement on new dates:

World Aquaculture 2020, Singapore, June 14 –18, 2021
World Aquaculture 2020, scheduled for December 2020 has new dates. In a press release in August, organisers World Aquaculture Society (WAS) and the Asian-Pacific Chapter, (WAS-APC) said that despite the improvements to the Covid-19 situation in Singapore some uncertainty still remains in the near term, where large events are concerned. “The primary objective of safeguarding the health and wellbeing of all participants, exhibitors, staff, speakers and third parties is of utmost importance to us. With this in mind, we have postponed World Aquaculture 2020 until June 14-18, 2021 in Singapore. In doing so, we hope that this will give more people the opportunity to be part of this conference.” The venue will remain the same at Singapore Expo Convention and Exhibition Centre.

WAS will conduct a free webinar for WA2020 participants during December 14-16, 2020 on important aquaculture topics. Details will be posted on the website and social media when they have been confirmed. The abstract deadline submission has been extended until February 3, 2021. www.was.org; contact: Conference management, John Cooksey, email worldaqua@was.org; For booths and sponsors, Mario Stael, email: mario@marevent.com); WAS-APC Chapter secretariat, email: apcsec@was.org

VIETFISH 2021, Ho Chi Minh City, August 25–27, 2021
Vietnam Association of Seafood Exporters and Producers (VASEP) has announced that the 22nd edition of VIETFISH, scheduled for August 2020 has been cancelled. They added that despite the reopening measures taken nationally and locally, there are still too many uncertainties on the impact of Covid-19 will have on travel and mass gatherings in August.

VIETFISH 2020 will be rolled over to VIETFISH 2021. It will be held from August 25–27 at the Saigon Exhibition and Convention Center (SECC), Ho Chi Minh City. www.vietfish.com.vn

VIETSHRIMP Aquaculture International Fair 2021, Can Tho City, March 24 – 26, 2021
Following the guidance of the Ministry of Health against the spread of the novel coronavirus, the organising committee of VIETSHRIMP Aquaculture International Fair 2020 (originally scheduled for March 2020) has announced the rescheduling of the event.

New dates are March 24–26, 2021. The venue will be unchanged at the Can Tho Promotion Agency, Cai Khe Ward, Ninh Kieu District, Can Tho City, Vietnam. The organising committee will monitor the situation closely and will provide details of the rescheduling arrangements to all exhibitors and visitors. www.vietshrimp.net; email: vietshrimp@gmail.com

2020

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**

September 30-October 2
22nd Japan International Seafood & Technology Expo
Tokyo, Japan
www.exhibitiontech.com

December 3-5
Taiwan International Fisheries and Seafood Show
Taipei
www.taiwanfishery.com

December 9-11
Ildex Vietnam
Ho Chi Minh City
www.ildex-vietnam.com/

New Dates 2021

January 10-15
ISFNF 2020
Busan, Korea
www.isfnf2020busan.com

March 10-12
VIV Asia 2021
Bangkok, Thailand
www.viv.net/

March 24-26
VietShrimp Aquaculture International Fair
Cantho City, Vietnam
https://vietshrimp.net

April 12-15
Aquaculture Europe (AE2020 Cork)
Cork, Ireland
https://aquaeas.eu/

April 27-29
Seafood Expo Global 2021
Barcelona, Spain
https://www.seafoodexpo.com/global/

June 14-18
World Aquaculture 2020
Singapore
www.was.org

August 18-19
TARS 2021: Shrimp Aquaculture
Ho Chi Minh City, Vietnam
www.tarsaquaculture.com

August 23-26
11th Symposium on Diseases in Asian Aquaculture (DAA11)
Kuching, Malaysia
www.daa11.org

August 24-26
Livestock Malaysia 2020
Melaka
www.livestockmalaysia.com

August 25-27
Vietfish 2021
Ho Chi Minh City
www.vietfish.com.vn

September 14-17
SPACE 2021
Rennes, France
www.space.fr

November 3-4
RAStech
South Carolina, USA
www.ras-tec.com

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