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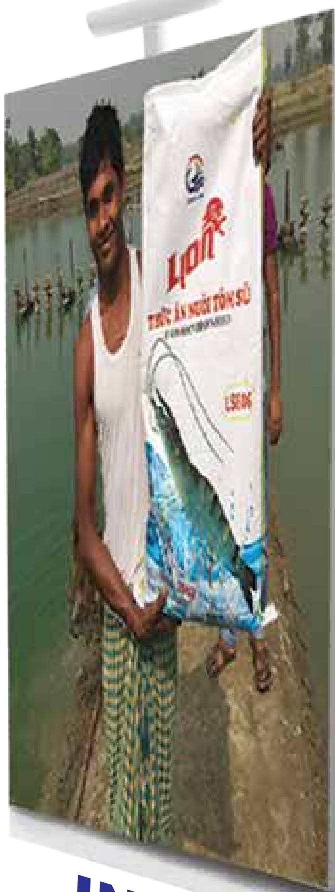

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Black tiger post larvae, p12

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Zuridah Merican

Wish list for 2021: Markets must lead production

A wish list for our industry is more akin to a five-year plan such that the wish list for 2020 in the editorial of Jan/Feb 2020 remains relevant today. However, Covid-19 really threw a spanner in the works and from February onwards, the industry spent more time firefighting than planning for the future. We can look at this as a stress test which exposed all the weaknesses in the current model but at the same time, showed us there are opportunities.

The immediate challenge was falling demand and route to market. This is still relevant. Moving forward, the lesson to be learnt is that the market must lead our production strategy. The pandemic has highlighted the product preferences between the food service and retail segments. HOSO shrimp in various sizes is the mainstay of the food service segment while most consumers want value-added and ready-to-cook shrimp from online channels and supermarkets.

1. Producers need to offer a variety of products ranging from preparation, processing, marination and packaging. The pandemic also highlighted the need for value adding at source. Being over dependent on restaurants and fresh markets, live and chilled marine and freshwater fish faced significant reduced off-take. Processing and freezing for long-term storage and value adding for local and export markets are needed.

Shrimp is an elastic commodity. The retail market has learnt that with promotions and price discounts, demand increases but how far can the price drop before the farmers are impacted and may have no choice but to reduce supply. We now see direct cost of production for the vannamei shrimp to be in the region of USD 3.60-4.00/kg for 18-25g shrimp, and farmers in Asia may skip cycles with unsustainable ex-farm prices.

2. Will generic marketing help increase demand for Asian shrimp? The consensus is yes but unlike the generic marketing of salmon in Norway and shrimp from Ecuador, we are from numerous countries and a multitude of industry players such that cooperation remains more of a dream today.

The black tiger shrimp is indigenous to Asia and we have a unique tropical product and a competitive edge. Bangladesh has not forsaken the black tiger shrimp for the vannamei shrimp yet while Vietnam is still the leader.

3. The past three years has seen a renaissance of the black tiger shrimp with the availability of domesticated and SPF broodstock. What is required now is branding and sustainability for a premium price and to differentiate it from the ubiquitous vannamei shrimp.

Ranging from salmon and shrimp to pangasius, supply has been chasing the China market over the past 5 years but the pandemic has shown the weakness, of an over reliance on a single market.

4. Market diversification is the only way to ensure stability. A lesson to learn is how prices for Ecuador's shrimp, reliant on the China market were the lowest globally in 2020.

The GOAL survey 2020 showed that rising feed costs was the major complaint of the shrimp industry. The root cause was the strength of the US dollar and all feed ingredients are denominated in USD. Feed quality depends on quality ingredients and the industry pays for what it gets.

5. AAP has always promoted the industry move away from cost of feed to the value of feed cost per kg of fish produced. This is where survival rate is the biggest determining factor. Any improvement in survival rate, whether for fish or shrimp, will automatically reduce feed cost per kg of fish produced. Today, we have added tools for optimising feed consumption, ranging from automatic feeders to artificial intelligence for real-time monitoring. Farmers must realise that overfeeding is not only money lost but also deteriorates the water quality leading to disease outbreaks, in both shrimp and fish farming.

The Asian industry comprises many small and medium scale farms. Today's consumers are willing to favour them and pay a premium for products with provenance, traceability and even better, with a story to tell. However, all of this is 'lost in translation' as the product moves along the supply chain of brokers, processing plants and distribution.

6. Yes, the market must lead production but the industry has to work out the kinks in the supply chain such that the product does not become commoditised.

If you have any comments, 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.

The main portal of entry for shrimp-related pathogens

The antennal gland of Penaeid shrimp is a much more complex organ than previously thought. An intrabladder inoculation study showed the high susceptibility of the nephropore to both pathogens, white spot syndrome virus (WSSV) and Vibrio campbellii. The authors concluded that during conditions such as sudden salinity drop like during heavy monsoon rains, aggression, establishment of social dominance and feed intake combined with a high virus load in the surrounding water, the antennal gland has to be considered a major portal of pathogen entry. Furthermore, a new morphology was proposed. Additional findings show that pathogens may indeed enter through this organ naturally, infecting shrimp and that the diverticles, connected with the antennal gland are involved in molting. These insights into the molting process and pathogen entry open doors in fundamental biology and the potential development of disease control measures

This summary is extracted from an article titled: The shrimp nephrocomplex serves as a major portal of pathogen entry and is involved in the molting process by Gaëtan De Gryse, Thuong Van Khuong, Benedicte Descamps, Wim Van Den Broeck, Christian Vanhove, Pieter Cornillie, Patrick Sorgeloos, Peter Bossier and Hans Nauwynck. www.pnas.org/cgi/doi/10.1073/pnas.2013518117

One of the major bottlenecks in the marine shrimp aquaculture industry is the occurrence of diseases which may cause serious financial losses to farmers. Although many studies have been conducted to identify pathogens and to implement treatments, there is still a lack of information on one very important aspect - pathogen entry in the host. The main portal of entry for shrimp-related pathogens remains vague; without clear knowledge and understanding on the entry portal, diseases may be difficult to treat and control.

In shrimp, the cuticle constitutes a strong pathogen barrier; regions which lack cuticular lining can be the Achilles heel where pathogens may be able to penetrate into the shrimp body. The shrimp's excretory organ, the antennal gland, which does not have a cuticle-lined lumen, may be an entry portal to pathogens.

This study was thus planned to investigate the role of the antennal gland as a portal of entry of pathogens. The antennal gland is involved in haemolymph filtration and osmoregulation; these functions, together with the fact that certain infectious diseases such as white spot syndrome emerge upon a salinity drop during heavy rainfall, further strengthened the authors' belief that the antennal gland could act as a major portal of pathogen entry.

Materials and Methods

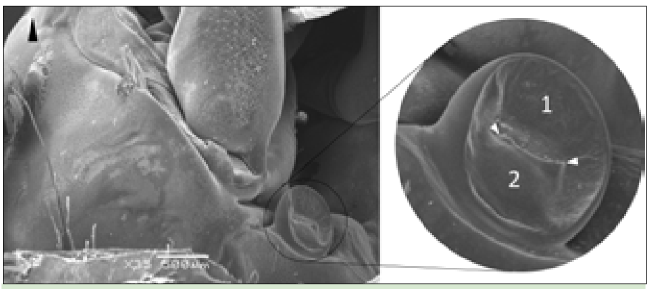
The antennal gland and surrounding organs were studied using a three-dimensional (3D) reconstruction by superposition of serial hematoxylin and eosin-stained sections (10µm) of the cephalothorax. Besides the histological 3D reconstruction with AMIRA software 6.0, a different imaging technique was used to confirm the correctness of the histology-based 3D reconstruction: serial micromagnetic resonance imaging (µMRI).

Test animals used for the infectivity studies were specific pathogen free (SPF) penaeid shrimp, *Penaeus vannamei* with a mean body weight of 2.8g. Infectivity studies were carried out to compare white spot syndrome virus (WSSV) and *Vibrio campbellii* infections in shrimp subjected to intrabladder, intramuscular or peroral inoculations, and results were interpreted against those obtained from control treatments. A study to investigate natural WSSV infections via the antennal gland was also carried out.

The antennal gland

The study fully described the anatomy of the shrimp's excretory organ - the hitherto little known antennal gland (Figure 1) which was identified as a major portal candidate. Dissection of the antennal peduncle revealed a white, bean-shaped structure which was bilaterally located at the transition from the peduncle to the cephalothorax. This bean-shaped structure was identified as the compact glandular compartment (CGC) of the antennal gland. The CGC was found to be connected to a urinary bladder, which, depending on the size of the shrimp, could either be visualised by the naked eye or by bright-field microscopy. The antennal gland was found to be a three-part organ: a coelomosac responsible for the filtration of the haemolymph; an efferent labyrinth which alters the filtrate (together they constitute the CGC); and a terminal ductus consisting of a bladder, several diverticles, and a small ductus leading to the nephropore, which seals the antennal gland from the outside world.

The involvement of the antennal gland during molting was also established in this study. Micromagnetic imaging not only confirmed the morphology in *vivo*, but also revealed the filling of the caudal extensions to be linked to the molting stage of the shrimp. The contents of the caudal extensions of the antennal gland in perimolt were, on average 3.25 times greater when compared to intermolt.



SEM image of the nephropore at the antennal base of P. vannamei shrimp. Black arrowhead is pointing to the rostrum; 1, rostral valve; 2, caudal valve; white arrowheads, fissure.

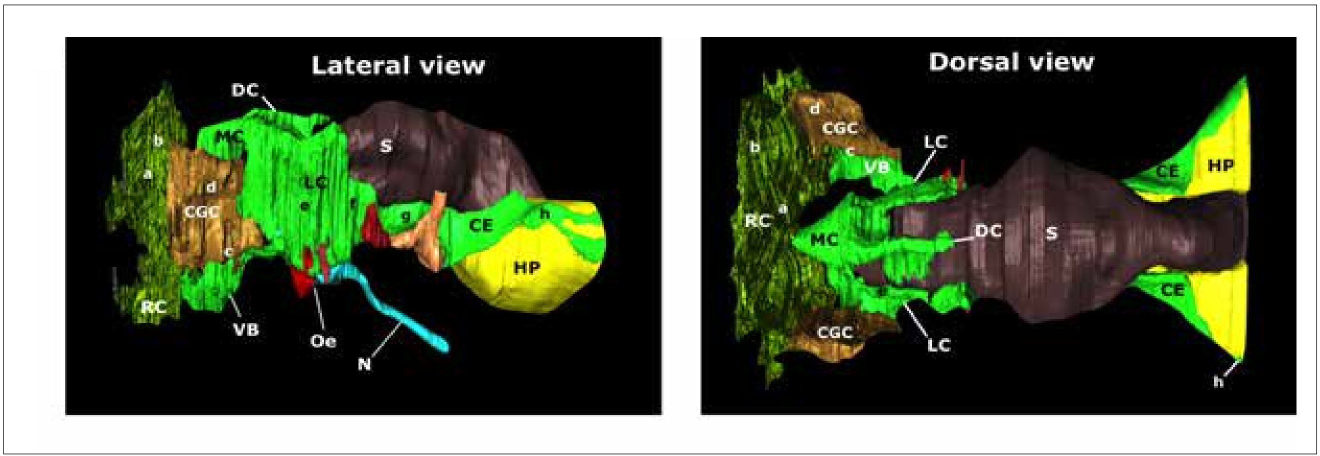


Figure 1. Morphology of the nephrocomplex and surrounding areas. A 3D reconstruction of the nephrocomplex by superposition of serial hematoxylin and eosin-stained cross-sections of the cephalothorax.

Infection upon intrabladder inoculation with comparison to intramuscular and peroral inculations

The infections of *V. campbellii* after intrabladder, intramuscular and peroral inoculations were compared. The findings demonstrated that compared with the intramuscular route, only 62 times more *V. campbellii* were required to kill the shrimp via intrabladder inoculation whereas it was not possible to kill shrimp via the peroral route.

Pathogenesis of WSSV in the antennal organ after intrabladderly and intramuscularly inoculation was investigated. In the intramuscularly inoculated group, the first WSSV-infected cells were observed at 18h post inoculation (hpi) in all investigated tissues- ventral urinary bladder, coelomosac and labyrinth, heart, gills, lymphoid organs, hepatopancreas, haematopoietic tissues, and cuticular epithelium of head, body and hindgut. WSSV positive cells in the haemolymph were detected at 24 hpi. In the intrabladder inoculation group, infection was only detected in the epithelial cells of the bladder at 18 hpi. From 24 hpi onwards, WSSV positive cells were seen in the other investigated tissues and in some cells in the haemolymph.

Natural infection via antennal gland

The experiments were conducted with two control groups, and urine and haemolymph samples were taken every 12h. To produce natural infections, shrimp were exposed to WSSV ($10^{5.5}$ SID_{50} mL^{-1}; 1L) during a drop in salinity (from 35g.L^{-1} to 5g.L^{-1}) for 5h. In this treatment, virus was detected in the shrimp 12h after post infection while haemolymph stayed negative. Virus was detected in the haemolymph in all but one shrimp after 24h. All shrimp were observed dead at 48h. Shrimp of control group 1 (drop in salinity, no WSSV) and of control group 2 (no salinity drop, with WSSV) remained completely virus free, and all shrimp survived.

The distribution of the antennal gland is not just limited to the antennal peduncle. The antennal gland resembles a kidney, and is connected to a urinary bladder with a nephropore (exit opening) and a complex of diverticula spread throughout the cephalothorax. Based on this complexity, the authors proposed a new name for this organ: the nephrocomplex.

The findings of this study showed that pathogens may indeed enter through the antennal organ naturally infecting the shrimp. These insights into the molting process and pathogen entry open the doors in fundamental biology and the potential development of disease control measures with emphasis on the nephrocomplex.

The findings in this paper will cause a major shift in shrimp pathogen research, especially in the field of WSSV where all current findings are until now, solely based on intramuscular and peroral inoculations.

Conclusion

The study fully described the anatomy of the shrimp's excretory organ, the antennal gland. This gland is a much more complex organ than previously thought. Its anatomy, morphology, and cellular structure are designed as a pathogen entry portal. The intrabladder inoculation study showed the high susceptibility of the nephrocomplex to both WSSV and *V. campbellii*. The sealing function of the nephropore valves was found to be an efficient pathogen barrier, however, at the end of the urination process, the blocking function is briefly compromised. Thus, during conditions where frequent urination takes place (sudden salinity drop during heavy monsoon rains, aggression, establishment of social dominance and feed intake) combined with a high virus load in the surrounding water, the antennal gland has to be considered a major portal of pathogen entry.

The identification of the nephrocomplex as a pathogen entry point will spur further studies focusing on the development of disease control measures aimed at blocking pathogen entry through this portal.

Shrimp broodstock and hatchery in 2020: Making waves with fast growth lines

New vannamei broodstock lines meet farmers' wishes for fast growth, survival and needs of diverse farming environments.

By Zuridah Merican

Vannamei broodstock.

In early 2020, it was time to restock ponds all over Asia, but the hatcheries had yet to receive new broodstock! India's high season for post larvae demand starts in February to end of March. Broodstock suppliers resorted to various ways to reach customers amid chaos with logistics. Chartered flights were used in India and Vietnam to deliver broodstock while some countries such as Bangladesh and Sri Lanka were caught short and did not receive broodstock over a certain period, according to major broodstock suppliers. The SyAqua team innovated and made flexible logistics arrangements. "This included using multiple routes and even refrigerated trucks from the multiplication centre in Phuket to Bangkok when flights were grounded," said Dr Thomas Gitterle, Breeding and Genetics Director, SyAqua.

Over in Hawaii, the Hendrix Genetics team had difficulty getting its supplies of Kona Bay broodstock from Kauai Island to Asia. "If we were able to find an airline that was willing to take our stock, they were less experienced in handling live animals or connections were slower. This ended up in longer transit time with subsequent higher mortality rates," said Ton Hovers, Business Development Manager at Hendrix Genetics.

While costs of logistics rose, so did the cost of brood stock, which rose by 30% to 50%. With a shortage of broodstock, there were reports of hatcheries resorting to existing broodstock and extending their use from the usual 3 months.

In recent years, there have been many new players in Asia's SPF (specific pathogen free) vannamei broodstock trade. Readers can refer to the review by Willem van der Pijl on the *Litopenaeus vannamei* broodstock production, trade and trends, published by Shrimp Insights (https://shrimpinsights.com). In 2020, the Coastal Aquaculture Authority of India approved SyAqua for their USA origin Kentucky lines. The company's largest broodstock market is China and is growing fast in Indonesia where it also has a hatchery.

New shrimp lines excite farmers

In 2020, we saw the commercial introduction of several genetic lines. In an article in *Aqua Culture Asia Pacific*, July 2020, Dr Robbert Blonk, R&D Director of Aquaculture, Hendrix Genetics outlined the three Kona lines to meet the needs of shrimp farming. These have been introduced to the market with promising results. "Kona Bay Balance is a hybrid of the two original lines, is crossed at local hatcheries and will be used in our joint venture in Indonesia," said Hovers.

In the second half of 2020, more farmers in Indonesia produced larger size shrimp 25-40/kg which farmers say was a result of better broodstock – robust and fast growing strains. "Indeed broodstock in this market has been improving fast with regard to growth and robustness. It might be possible that farmers keep the grow-out period the same but the result is heavier shrimp due to the faster growth."

SyAqua's Balanced Line which combines fast growth and high survival rates in commercial farm conditions has been creating waves, at least in Malaysia. "Shrimp farmers across Asia are generally very pleased with the Balanced Line as they manage to get higher yields," said Gitterle.

For several years now, Charoen Pokphand Foods (CPF) has the Turbo line for fast growth. Today, market talk is on its CP Kong. Robins McIntosh, Senior Vice President said, "CP Kong is a new SPF shrimp with significant white spot virus tolerance and pond robustness. Its growth rate is about 80% of the main line Turbo. CP Kong was developed for larger ponds without significant biosecurity possibilities. The target will be Latin America and China initially. In China, farms using this shrimp line reported good results. We can make this available to others wishing to try out this line."

Oscar Hennig, Operations Director, Benchmark Genetics said that its 2020 Market Orientation Trial saw shipments of 25,000 broodstock from their three commercial lines, BMK Yield, BMK Protect and BMK LowSal, from Florida to Vietnam, Thailand, Indonesia and China. The trial was to evaluate product performances under local conditions in hatcheries and farms to finetune the commercial launch.

In mid-2020, Shrimp Improvement Systems (SIS) did a product launch in India for its Hardy Line with growth improvement (0.347g/day) and resistance to disease before outbreaks. Lakkaraju Satyanarain, SIS consultant quoted 87% survival, yield at 8.6 tonnes/ha at 100 days of culture (DOC) in Indian farming conditions, in a news report in the Hindu Times. He also claimed that with appropriate conditions, it is possible to grow shrimp to 40g at DOC 100 with an AWG (average weekly growth) of 3.5g. In terms of fertility, production is at 6.5 million nauplii over the reproductive life of the broodstock.

In October, Sea Products Development held a webinar to launch its SPF Quantum Shrimp. "This is the epitome of SPD's genetic selection with AWG of 3g and ADG (average daily growth) of 0.428g," said General Director, Eduardo Figueras. The broodstock was available in India in December in limited numbers. Nauplii production was given as 300,000 with 20% of females spawning in a secure facility. Such high AWG is dependent on pond management and nutrition. Figueras reported results in China, with averages of 1.54g/week and ADG of 0.226g. Results at the University of Arizona showed resistance to AHPND and WSSV.

Going local

In October, Hendrix Genetics and PT Suri Tani Pemuka (STP), the aquaculture arm of Japfa Comfeed Indonesia formed a joint venture, PT Kona Bay Indonesia, to establish a multiplication centre. The nucleus centre in Hawaii will supply the Indonesian facility with the best quality post larvae to ensure year-round availability of genetically enhanced broodstock. Initial operations will be based at a SPF facility in West Java. Within two years, it will move to brand new state-of-the-art SPF facilities in North Bali, capable of producing over 100,000 SPF vannamei broodstock/year.

What are farmers asking in terms of genetics for vannamei shrimp?

Active in India's shrimp industry, Ravi Kumar Yellanki, Vaisakhi Bio-Resources Pvt Ltd, has been vocal on the need for tolerance lines. "Since 2014, I have been asking for tolerance lines as we continuously face diseases. But preferably, farmers do not wish to lose out on growth. In 2020, we are glad to see an increase in the range of lines on offer, giving us a choice depending on our culture environment." Vaisakhi Bio-Resources operates seven hatcheries, farms and processing plants in Tamil Nadu, Visakhapatnam and West Bengal.

At a recent webinar in January 2021, conducted by the Society of Aquaculture Professionals (SAP), with inputs from several successful farmers, the message was that fast growth takes priority over all else. With fast growth lines, farmers feel that they can easily manage disease threats. Nevertheless, there is still a desire for disease tolerance lines. Ravikumar said that he has been testing several lines for tolerance and noticed that the newer ones have much higher survival rates. However, at the hatchery level, such lines have lower hatching rates and lower fecundity.

Broodstock providers understand that customers' demands vary since farming conditions are diverse. Fast growth is always popular as it allows farmers to harvest quickly and reduce the exposure of their crop to disease. "Usually farms with better farming conditions target fast growth. This allows for more crops per year. Farms where water quality is less consistent and exposure to disease and stress is higher, tend to look for more tolerant/resistant lines in the hope of better survival rates. SyAqua truly believes that its pioneer approach focussing on the Balanced Line, combining fast growth and high survival rates, gives a comparative advantage to all farmers, regardless of their situation," said Gitterle.

McIntosh noted that as much as growth is always a significant part, it cannot be at the expense of survival. "My emphasis on genetics is growth and survival. But with survival it always depends on the farmer to have the right biosecurity, otherwise we cannot achieve fast growth. When we had AHPND, we turned to pond robustness and APHND tolerance. We are always testing the correlation between growth and survival, and tolerance; so far we have no negative correlation. Therefore, you can have growth with disease tolerance if you design the program correctly."

Future planning

Hovers said that the company is in the process of merging the specific pathogen tolerance line (SPT) from Malaysia

into their Kona Bay Strength population on Kauai, which will make the latter line even stronger. Hendrix Genetics wants to be less dependent on transport and is moving to more local multiplication centres. There is one in Ecuador and in progress are others in India and Vietnam.

SyAqua has some R&D developments using genomic selection for lines which focussed more on disease resistance. The commercial launch date is still to be decided.

In 2021, Benchmark Genetics expects a commercial launch of its BMK broodstock, doubles the capacity of its facility in Florida and starts the operational phase of its joint venture multiplication centre in Thailand. "While the challenges are with disease and uncertainty with Covid-19, the year augurs well with the planning of two new multiplication centres in Asia, development of a high performance line and further improving three existing commercial lines," said Hennig.

Hatchery

This year, hatchery operators reported higher transportation costs (2-3 times higher) because with passenger flights cancelled, they had to use costly cargo freight. In Indonesia, most of the large hatcheries are on the main islands of Java and Sumatra, while the more successful and disease unaffected farms are in Sumbawa, Sulawesi etc. In India, hatcheries are mainly along the east coast. The 4-5 hatcheries on the west coast, cater to perhaps up to only 20% of the demand of farms.

CPF has the major share at 60% and 35% in the post larvae markets in Malaysia and Thailand respectively. McIntosh reaffirmed that CP Vietnam has around 20% of the market in Vietnam, attributed to good post larvae performance in terms of growth and health. "This is evident in the tighter coefficient of variation. Post larvae are also very consistent with ramped up quality control emphasising on zero tolerance for AHPND or EHP."

Some 30% of the post larvae market in Thailand is shared among Top Gen, Thai Pacific, Sunantha and Thai Union. The market share in India is spread over several players: Vaisakhi Bio-Resources, BMR, Golden Marine and Sapthagiri. In China, the major player is the Haid Group. In 2020, Indonesia saw new players in addition to expansion by STP.

The annual post larvae production of 100 billion in Vietnam are from 300 large hatcheries using SPF broodstock and numerous smaller ones purchasing nauplii from the larger hatcheries or supplying wild black tiger post larvae. Industry also said that 60 billion was sold whereas the rest given out on promotions. India's production of post larvae in 2020 is expected to remain similar to 2019 at 70 billion. Thailand has 872 hatcheries and nursery farms (DOF, Thailand) in addition to 2,000 large, medium and small-scale backyard hatcheries.

In 2020, post larvae prices in Indonesia rose by IDR2-3/PL to around IDR45-48/PL. In the Philippines, prices rose by PHP0.02 to PHP0.30/PL with higher freight cost. Hatcheries are mainly located in the Visayas and Mindanao where prices ranged from US5,200 to USD6,250/million PL. The price was stable at THB0.15/PL in Thailand. In Vietnam, standard post larvae cost VND95-100/PL but those supplied by leading players cost VND 130-140/PL. Prices are lower by VND10-15/PL in the central region, nearer to hatcheries. In India, prices differ with location since 30% of cost is for transport. It was INR0.25-0.35/PL in Andhra Pradesh and in Gujarat, it averaged INR0.55/PL.

Country	Post larvae production (billion)	Post larvae efficiency (tonnes of shrimp/ million PL)	Cost of post larvae (USD/ million)
India	70	8.6	3,400-7,500
Vietnam	60	6.7	4,324-6,090
Indonesia	37.2	7.5	3,200-3,500
Thailand	26.5*	9.7*	4,950
Philippines	4.6	10.4	5,200-6,250
Malaysia	3.6	9.8	4,714
China	400	1.3	2,000-3,000
*DOF, Thailand, data for 11 months in 2020			

Figure 1. Some estimates of vannamei post larvae efficiency index.

"In India, the peak demand is during February to the end of March and picks up again in mid-June to August. Farmers in Andhra Pradesh can farm from the last week of January to end of March. In my experience, the best post larvae quality is associated with those stocked at end of March to mid-April; the crop never fails," said Manoj Sharma, Mayank Aquaculture in Surat, Gujarat.

Vannamei PL efficiency index

This was introduced by McIntosh at TARS 2016. Since then, it has been applied as a measure of efficiency of the industry country-wide and can be indicative of disease outbreaks. The calculated PL efficiency index for 2020 is given in Figure 1. As a comparison, at the Eurotier China webinar in June 2020, Dr Putth Songsangjinda, Department of Fisheries, Thailand gave an index of 8.99 for 2019.

Black tiger shrimp

Domesticated and SPF *Penaeus monodon* broodstock are available in selected countries. There are three global broodstock suppliers; CPF (Thailand), Moana Technologies (Hawaii, USA) and Unima (Madagascar). In Malaysia and Thailand, the use of CPF broodstock has been instrumental in pushing for the revival of monodon shrimp farming. The Coastal Aquaculture Authority of India approved the imports of monodon broodstock in March 2019 from Moana Technologies and Unima. Moana has a multiplication centre in Ninh Thuan province in Vietnam and is setting up a centre in India.

In Bangladesh, a third black tiger hatchery using CPF SPF broodstock started production in 2020. The other two hatcheries are using either Moana or CPF broodstocks or both. "We estimate SPF post larvae production at 401 million for the three hatcheries for 2020 and post larvae production from wild broodstock at 7.6 billion – a significant drop from the last few years when it has been 12-13 billion. There were 49 wild broodstock hatcheries operating in 2020. Several other hatcheries are looking seriously at switching to SPF broodstocks and the government has a target of five SPF hatcheries in operation in 2021," said David Currie, Aquaculture Production & Trade Specialist, Safety Project, Bangladesh, Winrock International.

SPF monodon post larvae cost USD9,900/million in Malaysia. It was reported that costs have risen as hatcheries try to increase profitability in Bangladesh. In Vietnam, prices ranged from VND80/PL (USD3,480/million) to VND120/PL (USD5,220/million) for SPF post larvae. Thailand's post larvae production in 2019 was 1.7 billion and with 13,806 tonnes produced, the PL efficiency index was 8.27 (DOF, Thailand).

Delivery of vannamei broodstock in China. Picture courtesy of Jianguo Shi, Hendrix Genetics, China.

Can a tiger be domesticated?

The story of the domesticated SPF *Penaeus monodon*, from Thailand to the rest of Asia.

By Robins McIntosh and Chalor Jeerajit

Back in the 1990s, we had *Penaeus monodon*, the black tiger shrimp as the dominant cultured marine shrimp. It was also the prevalent shrimp in world markets. However, late in the 1990s black tiger shrimp culture began to fail. For unknown reasons, harvest sizes became smaller and feed efficiency and survival deteriorated to the point that its culture became a non-profitable business. The failure of the black tiger opened the door for the successful introduction of the domesticated specific pathogen free (SPF) white shrimp, *Penaeus vannamei*, from the Americas. (Figure 1).

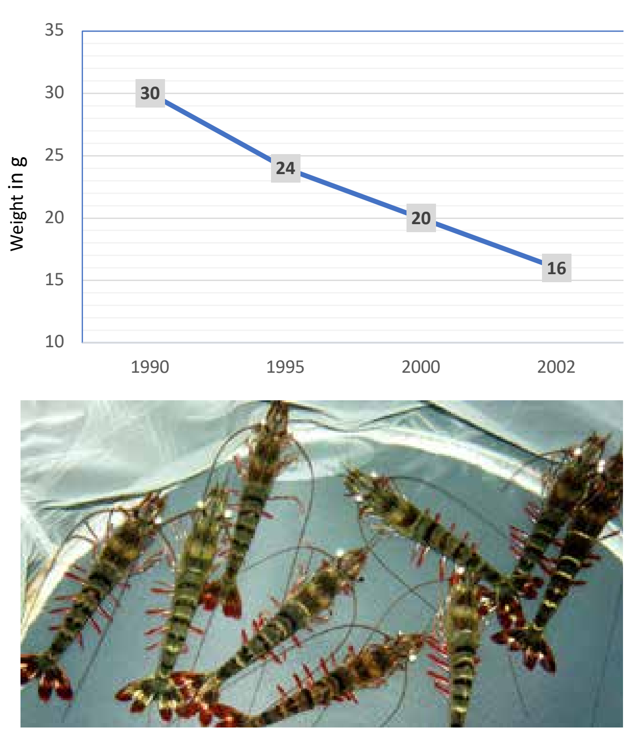


Figure 1. The decline in performance (in terms of harvest weight) of cultured wild black tiger from 1990 to 2002.

Back then, black tiger shrimp culture was based on the collection of broodstock from the wild. By the year 1999, it also became apparent that the black tiger shrimp had to be domesticated but domestication was not a new idea. Since the 1980's, several groups tried to develop domesticated black tiger shrimp. Projects in Thailand and India failed. Both faced similar problems: mating success was poor and survival to the second and subsequent generations were extremely low. These types of problems were not encountered during the domestication of *P. vannamei*. Understanding and overcoming these two main bottlenecks were the main challenges faced.

SPF black tiger shrimp

In Thailand, Charoen Pokphand Foods (CPF) had already developed a domesticated SPF *P. vannamei* broodstock program initiated in 2003, that had brought spectacular success to its shrimp farming industry. Productivity and disease tolerance surpassed all expectations from this species. Understanding the potential value of *P. monodon*, CPF decided to start a parallel program to develop a SPF *P. monodon*. That effort began in 2003 with initial imports of wild *P. monodon* broodstock from around the Pacific region (Figure 2). Captured wild brooders were transported to Thailand from Fiji, Western Australia, the Andaman Sea and the East Coast of Africa to ensure wide genetic background and pathogen free specimens.

Figure 2. Geographical areas where *Penaeus monodon* founders were collected.

Shrimp from each import were separated into individual culture tanks within a designated and approved primary quarantine station. Complete PCR testing for all known pathogens were conducted on appropriate tissues and faeces after temperature and salinity stress tests (Table 1). Any shrimp found to have a positive outcome was discarded. Viruses that led to discard of wild broodstock were gill-associated virus (GAV), white spot syndrome virus (WSSV), infectious hypodermal and haematopoietc necrosis virus (IHHNV), Mourilyan virus (MoV), hepatopancreatic parvo-like virus (HPV) and monodon baculo virus (MBV). To be noted, much of the IHHNV was not a virus but a DNA insert or endogenous viral element (EVE) of the IHHNV genome; these animals were discarded as well as the ones hosting the whole virus.

WSSV	White spot syndrome virus
YHV	Yellow head virus
IHHNV	Infectious hypodermal and haematopoietic necrosis virus
MBV	Monodon baculo virus
TSV	Taura syndrome virus
IMNV	Infectious myonecrosis bacterium
HPV	Hepatopancreatic parvo-like virus
MoV	Mourilyan virus
LSNV	Lamsing noda virus
GAV	Gill-associated virus
NHPB	Necrotising hepatopancreatitis bacterium
EHP	Enterocytozoon hepatopenaei
AHPND	Acute hepatopancreatic necrosis disease
SHIV **	Shrimp haemocyte iridescent virus
** Started monitoring from July 2018	

Table 1. List of the 14 ppathogens monitored in *Penaeus monodon* at CPF's Nucleus Breeding Centre (NBC).

The remaining females were mated with spermatophores from marked males and the spawn were collected and grown out in separate tanks to post larvae. The parents were then sacrificed and sent for histological tissue evaluation. Spawn were discarded if either parent was found with a suspect lesion or issue. Samples of nauplii from each of the individual spawn were again sent for PCR testing and if the spawn was found to be negative for all viruses, the resulting post larvae were grown out after being transferred to a new facility designated as secondary quarantine. During the grow out phase, periodic additional PCR testing were performed. The shrimp were kept in secondary quarantine until they reached 80g and were of reproducible size and age.

A second round of mating was done followed by PCR and histological examination of all the parents involved as well as a sample of the offspring from this mating. If no issues were detected either by PCR or histology, offspring were moved to the newly established nucleus breeding center (NBC) in Chanthaburi province, Thailand.

A challenging process

CPF SPF *P. monodon* broodstock are grown out in the same type of closed zero water exchange raceways that were being used successfully for the white shrimp. However, health issues developed in the second generation. Shrimp became weak and many died of what appeared to be bacterial infections, commonly referred to as vibriosis. Different culture strategies were tried: changing bottom substrates, applying more water exchange and the periodic moving of shrimp to new culture raceways. All the strategies tried did not overcome the problem and the shrimp were continuously affected with chronic mortality (Figure 3).

Figure 3. Diseased shrimp from Generation 2 affected by idiopathic hyaline granulomatous syndrome (IHGS).

The few specimens that survived the grow-out had a difficult time to reproduce and thus from the founder families many failed to make to the second generation. The third generation, the fourth and the fifth generations repeated this pattern of chronically dying shrimp in the raceways.

During each generation it was hoped that there would be sufficient shrimp at the end to create a new generation. It was at this time that doubts began to arise on whether the black tiger shrimp could be domesticated. Maybe not all shrimp can be domesticated just like not all terrestrial animals can. However, work persevered and by the sixth generation, shrimp survival improved in the raceways and, by the eighth generation, growing the *P. monodon* in the raceways had become as easy and consistent as with SPF *P. vannamei*. At that point it was felt that domestication had been attained.

Managing IHGS

All new *P. monodon* programs seem to have the same problems: chronic mortality and difficulty reproducing the subsequent generations. What is the issue? No one has confirmed this definitely; but we believe it is due to a condition named by Professor Donald Lightner as idiopathic hyaline granulomatous syndrome (IHGS). This condition causes many and some massive granulomas mainly in connective tissue of the shrimp. These granulomas are small if at all visible in wild broodstock but become very invasive during the grow-out of the second generation and onwards. After eight generations of culture, these lesions are no longer visible by histology (Figure 4). No one to date has defined the causative agent for these granulomas but they were found to be infectious (James Brock, pers. comm).

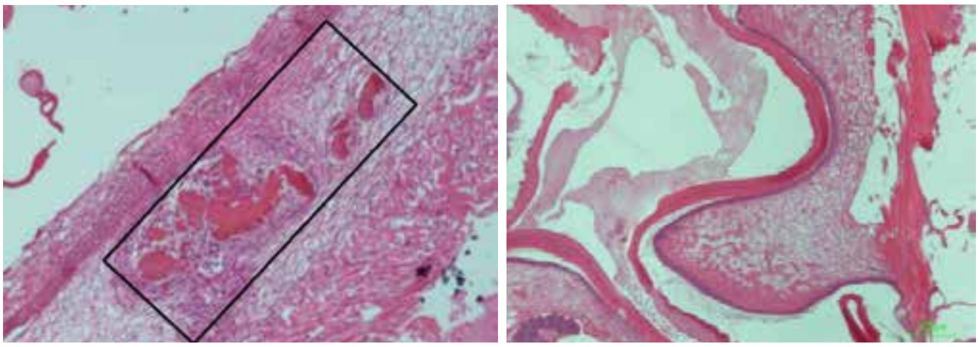


Figure 4. Histology of idiopathic hyaline granulomatous syndrome (IHGS) in connective tissue in Generation 3 (left) and no granulomas in Generation 8 (right).

Selective breeding post Gen-8

After eight generations, *P. monodon* became as domesticated as the current stocks of *P. vannamei* which allowed the gains of the breeding program to show. Survival in the broodstock raceways became predictably high and shrimp manipulation in maturation was easy. Also noted was the high survival rates from nauplii to post larvae in the hatchery. Selective breeding began in 2014 using similar protocols that CPF uses in its white shrimp selection program. Shrimp are selected for superior growth rate and robustness against pond stressors and *Vibrio*. Since 2014 growth rates have improved by an average of 35% per year in the raceway grow-out from an average daily growth (ADG) of 0.15g to an ADG greater than 0.3g today. Survival has improved from 85% to 95 % or a gain of 2.3% per year. Uniformity is high with size variation averaging 10% for females and 8% for males when grown under our broodstock raceway conditions (Figure 5).

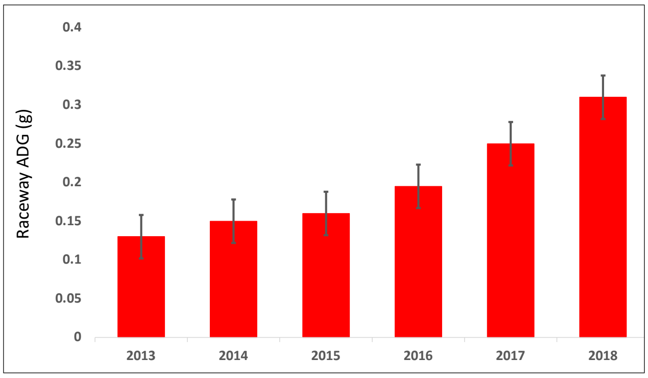


Figure 5. Selective breeding gains in growth rate in shrimp culture in raceways.

Location	CP Farm	CP Farm	CP Farm	Krabi	Ranong	Chanthaburi
Pond bottom types	HDPE plastic	laterite	HDPE plastic	laterite	laterite	laterite
Harvest strategy	single	single	single	single	partial	partial
Density/m^2	33	35	46	42	63	59
Days of culture (DOC)	147	153	145	101	152	104
Final mean body weight (g)	46	38	39	34	33	29
ADG (g/day)	0.31	0.25	0.26	0.34	0.22	0.27
Yield (kg/ha)	11,089	11,187	14,463	8,039	20,197	12,309
Survival %	74	85	85	60	65	75
FCR	1.7	1.8	1.7	1.2	1.8	1.5

Table 2. A selection of pond harvest data in 2020.

What is the future for the black tiger?

Now that we have a high-performance SPF domesticated *P. monodon* stock, farmers have a choice between the white shrimp and the black tiger shrimp. The black tiger shrimp is more suitable for farmers that will not invest in pond modifications required for the intensification of the white shrimp. Black tiger shrimp does very well on hard clay bottoms (as well as in lined ponds) and does not require the high aeration that is commonly required in white shrimp culture. As mentioned before, when farmers are failing with white shrimp farming due to disease in an area, the black tiger shrimp offers an alternative that can often successfully be cultured at a profit. More importantly is that given that the CPF black tiger shrimp is SPF, this black tiger shrimp can be grown in polyculture with *P. vannamei*. This offers an interesting combination of harvesting large black tiger shrimp and white shrimp with increased biomass over a monoculture of black tiger shrimp. Polyculture of the black tiger shrimp at a stocking density of 25 PL/m^2 combined with white shrimp stocked at 35 PL/m^2 have yielded 14-16 tonnes/ha of 35g shrimp (both black tiger and white shrimp) in 100 days of culture.

The domestication of the black tiger shrimp has not been easy, but once domesticated this black tiger shrimp is as easy to culture at both hatchery and grow-out stages, as the white shrimp. In addition, having a domesticated SPF *P. monodon* provides a farm with another option, when there is insufficient capital to upgrade ponds and culture units for *P. vannamei* culture.

"..given that the CPF black tiger shrimp is SPF, this black tiger can be grown in polyculture with *P. vannamei*. This offers an interesting combination."

Chalor Jeerajit

Robins McIntosh is Executive Vice President, Charoen Pokphand Foods Public Company, Thailand.

Chalor Jeerajit is Vice President, Marine Shrimp Broodstock Center in Chanthaburi, Thailand.
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CPF's Penaeus monodon nucleus breeding centre (NBC) in Chanthaburi province, Thailand

Managing the shrimp production supply chain in a post-pandemic world: Vietnam's case

As farmers mitigate price fluctuations with delayed pond stocking in the first half, a lower production was expected. Exports remained constant, supplemented by a high inventory from lower domestic consumption.

By Samson Li

Vietnam and India are Asia's top farmed marine shrimp producers; in 2019, Vietnam produced 579,000 tonnes while India's production reached 800,000 tonnes. In terms of growth, figures for three years (2017-2019) showed that Vietnam's CAGR (compound annual growth rate) was around 3% while India's was about 20%. Vietnam's higher production volumes have been attributed to the much higher productivity levels, averaging ~15 tonnes/ha/cycle to only ~10.6 tonnes/ha/cycle in India. Over the years, vannamei shrimp production is gaining popularity in Vietnam as intensive farming gains a foothold. Growth of vannamei shrimp production was 5% over the three years (2017-2019), while it was -1% for the black tiger shrimp. But black tiger is still very significant in Vietnam at almost 40% of the total production in 2019 (Figure 1).

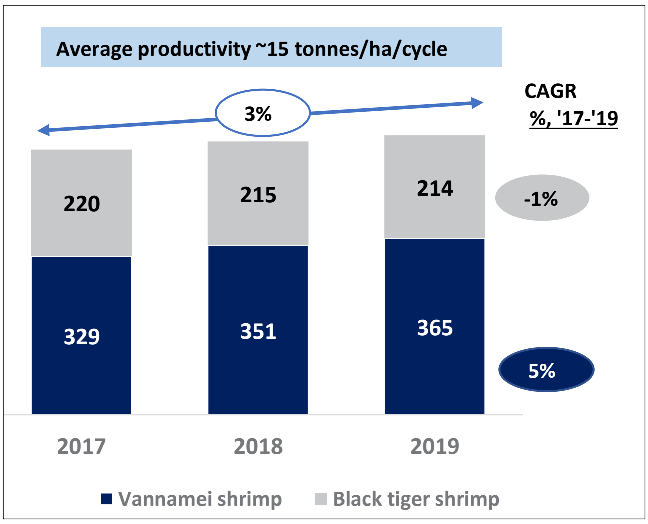

Figure 1. Composition of Vietnam shrimp production by species ('000 tonnes, 2017-2019). CAGR is from 2017 to 2019. *Source: Agromonitor, Seafood Trade Intelligence Portal, Hatch Global Shrimp Farm Technology Report, Grobest Analysis.*

Shrimp exports

Exports from Vietnam reached 234,000 tonnes in 2019, and these are mainly value-added products. with markets in China, the EU, Japan and Korea. Vietnam is targeting China as a major export market and recently this is being done directly, moving away from the grey export channel via Haiphong. EU demand is driven by France, Germany and the UK where there has been a significant growth rate of around 10% over the last five years (2015-2019). Exports to Korea grew 12% over the same period.

Vietnam has a free trade agreement with the EU which came into effect from the second half of 2020. Therefore, more exports from Vietnam to the EU countries can be expected in the fourth quarter of 2020 and all the way forward.

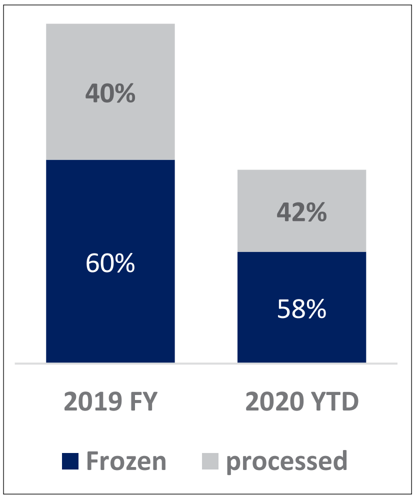

Figure 2. Vietnam's shrimp exports (%) by category in 2019 and up to July 2020). *Source: UK AC Nelson, Seafish, Euromonitor*

In general, the product preference by Vietnam's major markets is a mix of about 60:40 for frozen: processed shrimp as shown in Figure 2. This has largely remained in 2019 but up to July 2020, there was a slight shift towards more processed products at 58:42 (frozen: processed). This is not a surprise, given that the retail sector is ahead of the food service sector because of dine-in restrictions which affected the latter during this pandemic. Retail channels are getting a lot more traction in terms of value. We do not have the latest figures for 2020, but we would expect the retail sector in China to keep going upward. With their long history in value adding and in product differentiation, Vietnam's processing segment is extremely well prepared in diversifying their product range and in servicing the retail sector. This could help Vietnam mitigate the impact of this Covid-19 pandemic.

Managing supply chain in 2020

In Vietnam, there was minimal impact on its shrimp farming supply chain. However, due to shrimp price fluctuations in markets, farmers were less motivated to stock ponds in the first half of 2020. Production started to recover in July with 70,000 tonnes. Overall, the drop was 15%; up to July 2020 it was only 305,000 tonnes as compared to 358,000 tonnes for the same period up to July 2019.

Vietnam's shrimp aquaculture is usually supported by a strong domestic consumption at 30%. Travel restrictions and the lockdown in Vietnam affected the food service sectors, resulting in significant lower domestic consumption which has dropped by 26% in 2020. In terms of volume, it was 128,000 tonnes by July 2019 to 95,000 tonnes by July 2020.

However, demand from export markets has remained constant and to fulfil export orders, we believe that imports from India (when logistics was still open), were re-exported to other markets. By July, the local inventory dropped 43% and Vietnam may have dipped into its inventory to supplement the lower domestic production. Because of the product mix, producers were also well positioned for the export market.

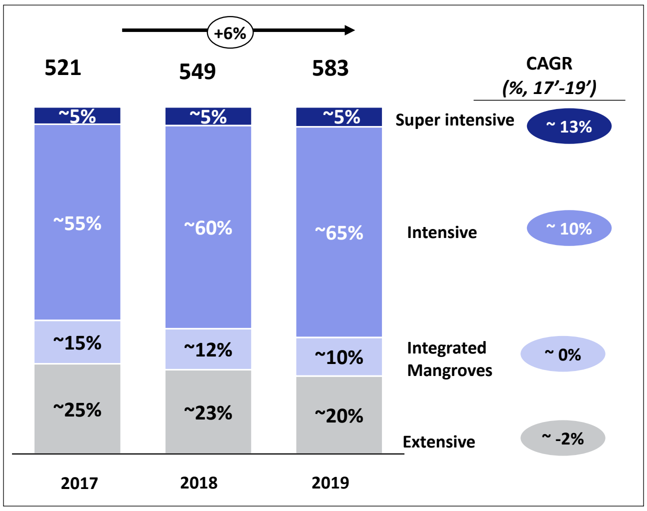

Figure 3. Production volume by farming models. *Source: Seafood Trade Intelligence Portal, Grobest Analysis.*

Shift towards intensification

Vietnam's increase in production, especially over the years from 2017 to 2019 at 6% was attributed to an increasing shift toward intensive and super-intensive farming models, with CAGR (2017-2019) 13% for super-intensive models, intensive models at 10% and extensive at -2%. In 2019, extensive farming was only 20% of the total production, a drop from 25% in 2017, while intensive farming rose to 65% from only 55% in 2017. The central government, industry players as well as local village community leaders have been pushing for intensive farming. This move towards more intensive farming has also helped the Vietnamese farmer to be much more professional with industrial farming methods (Figures 3 and 4).

Intensification in shrimp farming in Vietnam will increase. By 2023, intensive farming will be the major segment contributing to the country's shrimp production at 67% of volume and the CAGR (2018-2023) will be 8% for the intensive farming model. The forecast is that super intensive farming models will be the fastest growing segment at 11% CAGR, contributing to 7% of the production by 2023 (Figure 5). No growth is expected for integrated mangrove shrimp farming (mainly for black tiger shrimp) and growth will be at -2% for extensive systems.

	Generation 1 (Extensive)	Generation 2 (Semi-Intensive)	Generation 3 (Intensive)	Generation 4 (Improved intensive)	Generation 5 (Super-intensive)
Description	▸ Low operating costs ▸ Relies on natural productivity of the environment and crop wastes as feed	▸ Improves stocking density through aeration and feed inputs	▸ Focus on biosecurity through Vinyl pond linings	▸ Focus on increasing stocking density through waste management and increased aeration	▸ Full environment control with total recirculation and total waste capture
Pond type	▸ Soil	▸ Soil	▸ Vinyl	▸ Vinyl	▸ Vinyl round Tanks
Primary shrimp species	▸ Black tiger	▸ Black tiger, Vannamei	▸ Vannamei	▸ Vannamei	▸ Vannamei
Average density *(PL/m²)*	▸ ~10	▸ 30-60	▸ 90	▸ 200-400	▸ 200-500
Average productivity *(tonnes/ha)*	▸ 0.5-3	▸ 3-12	▸ 10-20	▸ 15-40	▸ 30-60
Average farm size *(ha)*	▸ 5-30	▸ 1-2	▸ 0.5-1	▸ 0.2-0.5	▸ 0.2-0.5

Figure 4. Production volume by farming models. The evolution of shrimp farming models in Vietnam, moving from largely extensive models to super-intensive. *Source: Seafood Trade Intelligence Portal, Grobest Analysis*

Industry support

Large farms are taking the lead to increase control over their supply chain by improving self-sufficiency as well as reducing production costs through four primary initiatives. A case study is Minh Phu Seafood Corporation, the largest shrimp processor and exporter with integration from post larvae production to farming and processing, sales and export. It has a 2.8 billion post larvae capacity hatchery, and farms with a total of 844 ponds to supply 4.4% of raw material for processing plants with a total capacity of 74,000 tonnes/year. It continues to look at more vertical integration and is putting a lot of money and effort into research.

Minh Phu wants to be not only self- sufficient in post larvae supply but also wants to carry out research into genetics suitable for their farms. It uses automatic feeding machines and apps to monitor all the different parameters related to farming situations and real time monitoring, from feeding patterns, water quality and weather and health conditions. The farming protocol used is a 2-3-4 multi- stage farming model, where the first phase nursery of 30 days is followed by a grow-out phase of over 80 days with regular transfers of stock to push up survival rates.

As Minh Phu does not produce all the raw materials that it needs from its own farms, it works with contract farmers, provides capital for joint ventures and reaches out to banks to help the farms with financing and insurance. It locks in farmers to get shrimp as raw materials for its processing activity.

Financing models for shrimp farming

For a long time, farmers in Vietnam have access to informal financing from feed dealers. In general, the smaller farms producing 1-10 tonnes/year have difficulties securing financing and they get extended credit terms from feed dealers or small capital expenditure (capex) for upgrades. In return, feed dealers benefit from a steady demand of feed and supplementary farm products. A recent change in Vietnam is that big shrimp processors may offer to finance large farms or cooperatives producing 10-100 tonnes/year with capex investments. As these farms move from extensive farming model to intensive ones, they need capital to support construction of additional infrastructure. For the shrimp processor, it can be assured of raw material for processing.

The formal financing from banks deals directly with the farmers and requires collaterals. However, an aquafeed producer like Grobest, or a shrimp processor can also work with the banks. Banks can provide guarantee for small or large farms and so as a supplier of the feed, we also feel safe to support the farmer.

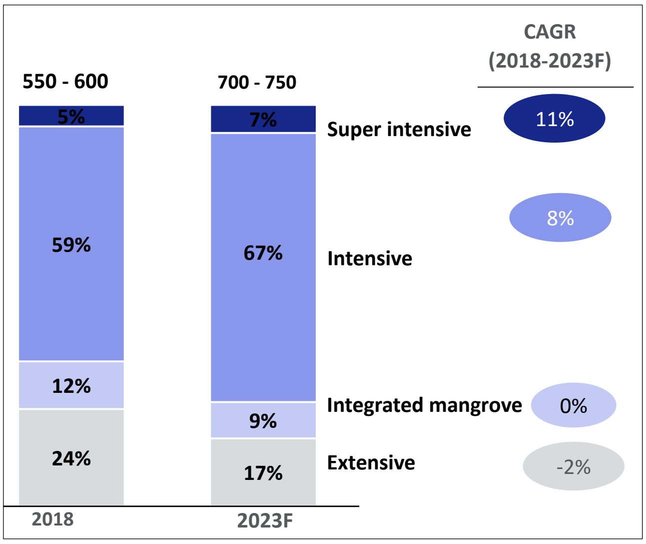

Figure 5. Projections on Vietnam's farmed shrimp output to 2023 by farming model. *Source: Grobest Analysis.*

Investing in farms

Farms may sell 20% of the shrimp harvest to processors and 80% to buyers. Processors not only invest in farms and motivate farmers to increase production, but they also encourage farmers to strive for quality and achieve certification. In fact, some subsidise as high as 75% of the certification costs. Their aim is to ensure the traceability and transparency of supply chain, all the way for the raw materials from feed to harvesting. Together, the government, processors and farmers are very much aware of how important export markets are, and the need for the numerous regulations. Recently, within Grobest, we see more traction on this; there are many queries from farmers on the documentation required to support certification, such as for the Aquaculture Stewardship Council (ASC). Farms with third party certifications such as Best Aquaculture Practices (BAP) or ASC have the priority to sell shrimp directly to processors (thus bypassing brokers and middlemen) and can sell at 11% premium price.

Cost drivers

In terms of shrimp product size, "one size fits all" does not apply, as we know that the US market prefers large sizes and for the China market, the preference also includes small size shrimp (100/kg). As industry in Vietnam moves into more intensification, how will this help farmers from a cost standpoint? Figure 6 shows that profit margins for an average shrimp price of USD4.7/kg for size 50/kg shrimp, are high at 27% using a super-intensive farming model. The production cost was USD4.3/kg for extensive farming; USD3.7/kg for intensive and USD3.4/kg for super-intensive model (Figure 6).

Compared to extensive or semi-intensive farming, the main cost drivers with intensive farming are feeds and post larvae. Feed costs can be reduced by 5-10% with the adoption of more advanced methods such as the use of autofeeders and functional feeds. Post larvae costs can be lowered by having higher survival rates at around 70%. Energy and labour costs are higher with intensification; the latter includes higher salaries for better qualified and experienced technicians. But this is compensated by higher productivity. Those in favour of intensification will know that additional costs include upfront investment which needs to be depreciated.

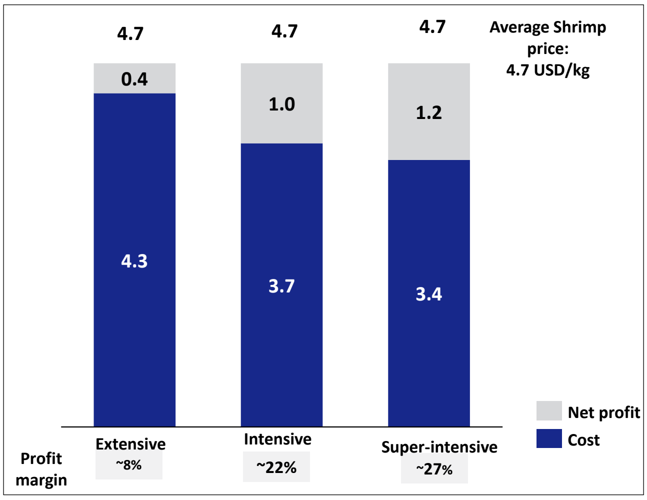

Figure 6. Comparison of cost of production (USD/kg) in 2020 by farming models in Southeast Asia.

Note: (1) Grobest analysis for indicative cost in Vietnam, Thailand and Indonesia, based on inputs from Grobest's RSMs and research data from FAO, Vietnam Aquaculture magazine as well as marketing materials; assuming all farms produce the same shrimp size of 50/kg in favourable conditions (2) Shrimp price for Vannamei at size of 50/kg in Ca Mau province on 1 Sep 2020. Exchange rate: 1 USD = 23,256 VND. Source: Grobest Analysis

Large versus small shrimp

Overall, in producing a large shrimp (size 20-25/kg) profitability would go up. Table 1 shows that with intensification and the use of quality feeds, farmers adopting better farming techniques will reap higher survival rates, with the best margins with large shrimp (size 20/kg) versus size 100/kg. Although prices are higher with large size shrimp, production costs are also higher but margins also increase. For the smaller shrimp (100/kg), the average margin will only be at 5% whereas with size 20/kg, margins can go up to as high as 38%.

Shrimp size (pcs /kg)	**Average sales price** USD/kg)	**Average farming cost** (USD/kg)	**Net profit** (USD/Kg)	**Average margin** (%)
100	3.4	3.2	0.2	5%
70	4.0	3.3	0.7	17%
50	4.7	3.7	1.0	22%
30	6.1	4.0	2.1	35%
25	6.6	4.3	2.3	34%
20	7.6	4.7	2.9	38%

Table 1. Cost of production (USD/kg) for various shrimp size (pcs/kg) and profit margins. *Source: Grobest Analysis*

Beyond 2020

The expectation is that production output will grow from the second half of 2020 with growth driven by supply, market demand and low inventory of major trade partners. Current information indicated that production in 2020 is expected to drop by 9% to 570,000 tonnes, down from 630,000 tonnes in 2019. A recovery to the 2019 level is expected in 2021 signifying a loss of a years' growth because of the pandemic.

Post-Covid recovery

Beginning in the last quarter of 2021, the recovery is expected to steadily increase production at a 3% annual rate to reach 730,000 tonnes by 2025. Drivers of this growth are intensification, support from processors and best aquaculture practices. A trend towards high value products is expected with better integration between farmers and processors.

In this journey during this particularly challenging year, we see that the progress over the last five years has been helping farmers to grow from extensive to intensive farming models and trying to tailor their product mix. As a feed producer, we must deal with several challenges, among which are diseases such as early mortality syndrome (EMS). Intensification brings in relatively more controlled environment but stress increases with higher stocking density. This is where we hold the edge: with our strong knowledge of the industry in Vietnam and our capability in developing functional feeds using additives which we have developed in-house, we are confident that we can address the disease problems as well as the other challenges.

Samson Li is CEO Grobest Group.

This article was adapted from a presentation at the "Global Shrimp Markets: Looking Beyond the Pandemic", a 2-day virtual conference organised by the Society of Aquaculture Professionals (SAP), India, September 24-25, 2020.

Effects of dietary astaxanthin krill oil and high protein krill meal on the growth and survival of post larvae in hyper intensive nursery culture

New findings released in September 2020 showed enhanced growth performance of whiteleg shrimp during 51- and 42-day trials at the nursery stage, demonstrating the possibility of a shortened production cycle and reduction in shrimp mortality after transfer to grow-out ponds.

In shrimp farming, the post larval (PL) stage is an intermediate phase between the larval and juvenile stages. In a single-stage farming model, post larvae, usually at PL9-12, are transferred directly to the grow-out ponds; while in a 2 or 3-stage farming model with one or two nursery phases, the grow-out usually starts with shrimp with <3g body weight. The duration of the nursery phase is relatively short in the shrimp production cycle, and it is often characterised by an aggressive feeding program, which is typically high in frequency coupled with the use of nutrient-rich diets. The stocking density is quite dense at this stage, which stresses the shrimp significantly. Shrimp stocking density can range from 500-5,000 PL/m^3 and end with juveniles between 300mg and 3g of body weight with a final yield of 1–3 kg/m^3. Once shrimp complete the nursery phase, they are transferred to grow-out farms where they are grown to harvest sizes over a culture duration of 70 days or more.

After focussing on juvenile *Litopenaeus vannamei* and getting to know a lot on the effects of astaxanthin krill oil and krill meal on growth and survival in indoor and outdoor rearing systems under hyper saline rearing conditions, **Dr Alberto J.P. Nunes**, from the Instituto de Ciências do Mar, Brazil (Labomar) then turned his attention to the post larval stage. Below, he shares a first-hand perspective on the findings from a recent study on shrimp post larvae.

In previous studies, the dietary supplementation of astaxanthin krill oil (AKO), a source of omega-3 polyunsaturated fatty acids (n-3 PUFAs) and the antioxidant astaxanthin, has been shown to improve the growth performance of juvenile whiteleg shrimp farmed under high salinity (Castro et al., 2018; Rufino et al., 2020).This study carried out in partnership with Aker BioMarine, determined how dietary graded levels of AKO and/or a high-protein krill meal (HPK) impact growth and survival of whiteleg shrimp during this critical stage of development.

Dr Alberto J.P. Nunes is Professor at the Instituto de Ciências do Mar, Brazil (Labomar).

What was your hypothesis when you set up this study?

Given the evidence on the impact of krill products on shrimp during the juvenile stage, we wanted to look at a new stage in the shrimp lifecycle, the post larval stage. Our goal was to evaluate whether dietary supplementation of krill oil and krill meal had a similar effect as with the juveniles, namely enhanced growth and survival. In addition, we also looked at osmotic and thermal stress resistance of post larvae reared under hyper-intensive nursery culture conditions.

How did you set up the study and what was unique in this setup?

We decided to study two different types of rearing systems: one outdoor and one indoor. We ran the study over 52 and 41 days, respectively, testing a range of dietary treatments on shrimp post larvae. Our aim was to mirror the dense conditions in commercial nursery systems by stocking tanks at a high density. We used PL10 (average body weight 3.6mg) from a local hatchery.

We designed the setup to simulate some culture practices as close as possible. The outdoor tanks were enclosed in a greenhouse using 70% dark shading net but were kept exposed to sunlight and rainfall. In the other rearing system, we had indoor tanks where there was 12 hours of artificial lighting. These conditions provided a greater control over environmental variables compared to the outdoor system. The other unique feature was the particle size of the feed pellets. We also used a counter to precisely determine the number of post larvae we stocked into the tanks.

What were the treatment diets fed to the post larvae?

For the approximately 3,500 shrimp (stocking density of 2,370 PL/m^3) in each of the outdoor tanks, we supplemented their diets with varying levels of AKO (Qrill™ AstaOmega Oil from Aker BioMarine), and compared them to a control diet lacking in krill-based products. For the approximately 1,200 shrimp/tank (stocking density 2,371 PL/m^3) in each of the indoor tanks, we supplemented the shrimp diet with varying levels of AKO along with HPK, testing their effectiveness as a substitute for fish oil and fish meal. These diets were compared to a krill-free control diet.

Post larvae were fed daily. In the outdoor system, shrimp were fed 20 times within 24-hour periods using an automatic feeder. In both studies, meals were adjusted daily for each rearing tank assuming an estimated daily drop in shrimp survival and daily increase in shrimp body weight across all diets. We also fed different particle sizes during the nursery period; in the outdoor tanks, four particle sizes were used, while six particle sizes were used in the indoor tanks. We observed the ability of the post larvae to capture the feed particles using a 1-L Becker glass container stocked with 20 post larvae.

About the study

The study, titled "Effect of dietary graded levels of astaxanthin krill oil and high protein krill meal on the growth performance and resistance of post-larval *Litopenaeus vannamei* under hyper-intensive nursery culture", was authored by Alberto Nunes, Artur Soares, Hassan Sabry-Neto and Lena Burri. It was published in the Aquaculture Nutrition Journal. Aquacult Nutr. 2020; 00:1– 15. https://doi.org/10.1111/anu.13187


Hinter
— Your Personal Aquaculture Nutritionist
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Aquafeed
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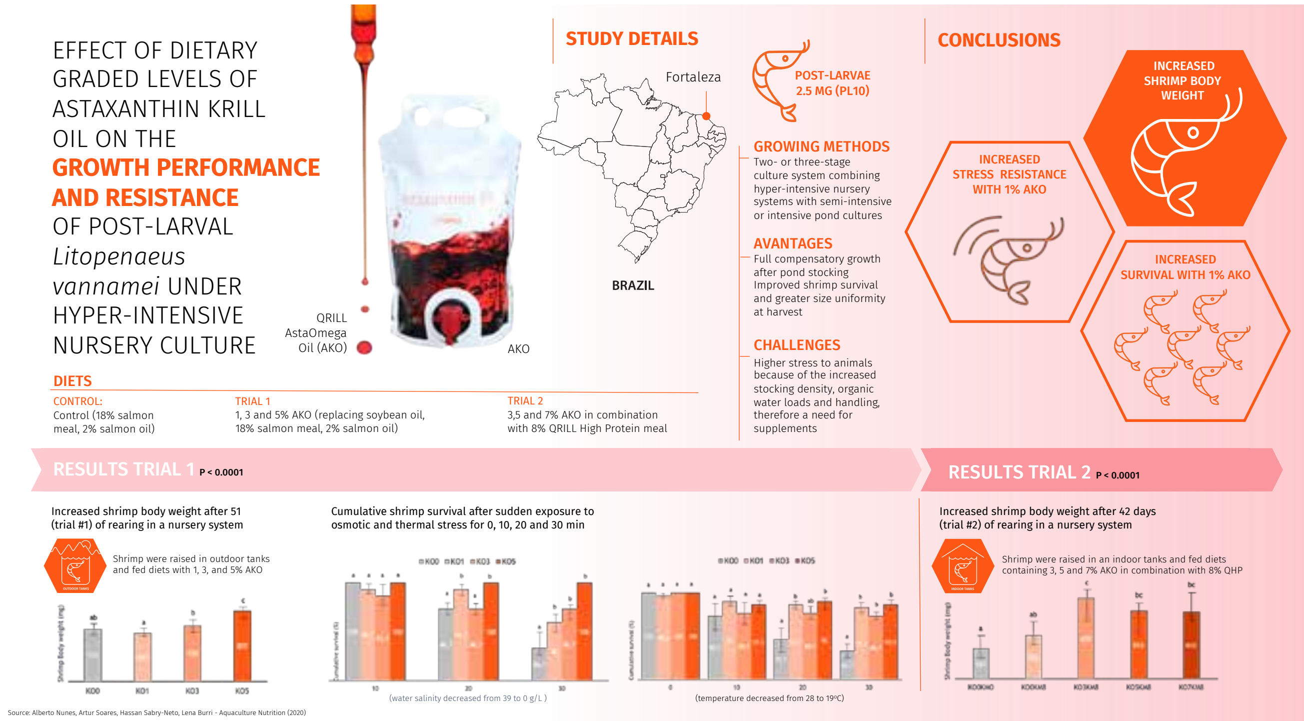

Was there a final body weight difference between shrimp reared indoors or outdoors?

In the outdoor tanks, given the more varying environmental conditions, we saw that 50g krill oil/kg feed was an effective amount to enhance the body weight. However, in more controlled conditions indoors, just 30g krill oil/kg feed combined with 80g krill meal/kg feed, was sufficient in increasing final body weight.

You mentioned the high stress, dense conditions in this stage of shrimp development. Did the krill oil or krill meal have any impact on shrimp survival?

AKO supplementation had a significant effect on survival when shrimp were subjected to a severe drop in both temperature and salinity. We saw clear evidence that by including a minimum of 10g of AKO/kg feed, shrimp can withstand a sudden and acute drop in water salinity and temperature.

What is it about krill that promotes growth and survival?

The enhanced growth and increased survival under stress that we witnessed during this study may be due to the increased amount of eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and astaxanthin that Antarctic krill provides. These nutrients give the post larvae a much-needed boost at this critical developmental stage.

Our diets have also exceeded the recommended quantitative levels of n-3 highly unsaturated fatty acids (HUFA) for the optimum growth of the *L. vannamei* juvenile (0.4–4.7g body weight), which has been determined to be 5g/kg of the diet as reported by González-Félix et al. (2002). In both the outdoor and indoor culture systems, shrimp weight was maximised with a total dietary HUFA (sum of arachidonic acid (ARA), EPA and DHA) content of 8.3 and 7.0g/kg, respectively.

What is your recommendation for shrimp farmers after the completion of this study?

Our team concluded that krill oil, especially when combined with krill meal, can deliver significant advantages to shrimp in the post larval stage. The enhanced growth performance during nursery culture, serves to shorten the overall production cycle, saving farmers both time and money; their overall yields are better given the high survival, despite the high density and extreme conditions.

We also recommend further work to explore whether the acquired beneficial effects during the nursery phase can be sustained at the later stages of shrimp growth.

How did the shrimp post larvae respond to the test diets?

The indoor-reared shrimp showed better survival overall, which I believe may be due to the greater environmental control. Regardless of rearing systems, all post larvae receiving astaxanthin krill oil showed significant improvements in body weight by the end of the experiment.

We also noticed that body weight started to differentiate between dietary treatments early during the nursery phase, that is after 10 days of stocking in both the outdoor and indoor tanks.

Feed production for organic tiger shrimp farming in Madagascar

Principles – Constraints – Opportunities

By Alexandre Bédier

The shrimp farming industry in Madagascar has been focusing on high-end markets in Europe for decades, generally producing large-sized HOSO (head-on shell-on) shrimp.

Although most of the shrimp farming industry worldwide is on the path of production intensification, several producers take the other route and focus on the rapidly expanding niche organic market. Organic farming is regarded as one of the sustainable ways of farming. In the European Union (EU), it is regulated by Regulations (EC) No 834/2007, (EC) No 889/2008 and the EU import guideline. EU organic farming is not restricted to the EU territories and can be practiced outside its borders by following equivalent standards.

The shrimp farming industry in Madagascar has been focusing on high-end markets for decades, generally producing large-sized HOSO (head-on shell-on) shrimp. Thanks to market opportunities and appropriate farming conditions, most of the farmers have adopted organic shrimp farming. Organic shrimp farming in Madagascar concentrates on farming the black tiger shrimp (*Penaeus monodon*) which is naturally abundant locally. Farms are geographically isolated in order to offer a clean and undisturbed environment suitable for farming the tiger shrimp according to the EU organic standards. Farmers have to follow rigorous husbandry practices in order to comply with EU organic regulations amongst which is the exclusive use of organic-certified feed.

Located on the nearby French territory Reunion Island, NUTRIMA is the leading shrimp feed supplier for Madagascar. The company supports the Malagasy organic shrimp farmers by providing a reliable supply of tailor-made organic feed. Since organic feed cannot contain preservatives, proximity to the farms enables fast delivery to maintain the feed's freshness for optimal performance.

Complementary feed in organic shrimp farming

Organic shrimp feed is fundamentally considered as a complementary feed, meaning that the shrimp does not rely exclusively on the feed for its nutrient uptake but has to take advantage of the pond's natural productivity. In this regard, organic tiger shrimp farming is practiced in natural earthen ponds without bottom liners. In order to comply with the EU standards for organic feed, organic shrimp feed has to be formulated with the following principles in mind:

Animal health and welfare

Shrimp shall be fed with organic feed that meets its nutritional requirements at the various stages of its development. Feed ingredients need to be of natural origin and respect the animal's propensity to grow in a favourable environment. In this regard, most additives, growth promoters, synthetic amino-acids, preservatives and feed colourants are forbidden. It is therefore necessary to rely only on the benefits offered by selected ingredients.

Animal welfare is also regarded as an important feature of the EU organic standard. In order to limit animal stress, shrimp are stocked at a maximum density of 22 post larvae (PL)/m^2 and maximum instantaneous biomass of 240g/m^2 in large ponds (5 to 10ha). With fewer shrimp per m^2 than in intensive systems, the cultured shrimp are able to access endogenous food sources. The attractability and palatability of organic compound feed must be enhanced to meet the demand of the tiger shrimp.

Eye-stalk ablation is forbidden and broodstock domestication is strongly encouraged. Specific organic broodstock and maturation feeds are necessary to produce organic-certified larvae and guarantee the organic certification during the entire lifecycle of the shrimp.

High shrimp quality (taste and biosecurity)

The nutritional composition of a farmed organic tiger shrimp shall be as close as possible to a wild and healthy tiger shrimp. The shrimp flesh needs to be of high quality (taste, texture) and free of pesticide residues. This is achieved by rigorous controls on the farming site and surroundings; the isolation of Malagasy farming sites further enhances the biosecurity.

Organic shrimp farming is a long-term process and cannot be applied straight away to a farming site. Firstly, non-organic ponds will need to go through a transition period of 6 months during which all organic principles must be applied before an organic certification of harvested shrimp is processed.

It is only after this 6 months transition period (without any certification) that the ponds and the farmed shrimp can then be considered for organic certification. Any failure to maintain the organic standards in ponds results in the downgrading of shrimp into the non-organic category resulting in major economic losses. As feed is one of the major inputs in ponds and directly affects the quality of shrimp, sourcing feed from a reliable supplier is vital for organic shrimp farmers. To secure its customers and their supply, an organic feed supplier must have absolute control over the organic sourcing and traceability of ingredients. Additionally, its organic feed shall go through an extensive control procedure before being allowed on farms to eliminate the risk of pesticide bioaccumulation in shrimp tissue.

Low environmental impact

Reduced environmental footprint is a keystone of organic farming. The aim is to create a total sustainable farming system with minimum environmental impacts resulting from shrimp farming activities whether on the farming site or in association with the farming operations, such as raw material sourcing.

The destruction of mangroves is strictly forbidden and ponds must be built with the natural pre-existing clay. Fertilisation of organic ponds can only be carried out using natural products, such as non-GMO (non-genetically modified) rice bran and molasses. Chemical fertilisers are forbidden.

The plant fraction of feed shall originate from organic production; they must be non-GMO and free of pesticide residues. Hence, raw materials of plant origin must come with screening analysis reports to prove the absence of pesticide residues and be authorised for organic feed production.

Ingredients derived from marine animals (marine meals, oils, solubles etc.) shall be sourced from sustainable fisheries and be certified by third-party organisations, such as Marine Trust or sourced from organic farming (e.g., fish oil derived from organic salmon). Besides, the EU organic standard aims to limit the inclusion of ingredients derived from marine animals in feed. Inclusion rates range from a maximum of 25% in EU regulations, and up to 35% in third-party organic standards recognised by the EU. Limited use of marine ingredients aims to alleviate pressure on marine wild stocks associated with growing demand as a result of the expansion of global aquaculture.

The EU standards for organic shrimp feed requires use of ingredients originating from organic production, non-GMO and free of pesticide residues. Raw materials of plant origin must come with screening analysis reports to prove the absence of pesticide residues and authorised for organic feed production.

Production of organic shrimp feed is a painstaking endeavour requiring stringent control management and dedicated strategies. The increasing awareness of consumers towards the environmental footprint and health benefits of their seafood has steadily fuelled the demand for sustainable seafood including shrimp.

In this regard, organic shrimp farming has a role to play. It can shift the lingering perception of a detrimental industry into a sustainable farming activity capable of offering healthy and tasty shrimp even to the most demanding shrimp aficionados.

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A sustainability transformation worldwide

How the DSM initiative can move beyond corporate confines to the aquaculture landscape in Asia.

"We Make It Possible" – this is the challenging cutting edge, but committed initiative, that DSM Animal Nutrition and Health (AHN) launched in August 2020. It is targeted at making sustainable animal protein production while reducing environmental costs – what a populous burgeoning world needs. The goal is better food, health and nutrition and to grow aquaculture, reducing the reliance on marine resources.

It is not an impossible challenge, said Ivo Lansbergen, President DSM ANH. "Sustainable animal farming to feed billions at lower cost to the environment is achievable through a holistic, concerted transformation within the agriculture industry itself. It reflects a win-win collaborative effort to benefit all stakeholders, because the goal is to "provide affordable proteins to the world population and make it profitable for farmers while reducing the footprint of animal farming."

The time has come to step out of merely being a part of the value chain, and be the change agent to advocate for, bring together collaborative efforts of industry players, and lead them into a sustainability transformation that extends beyond corporate confines, farming fields to industry wide spheres, ultimately worldwide transformation. Lansbergen said, "We see ourselves, steering the global conversations, connecting the various stakeholders of the farming ecosystem, thinking ahead, generating ideas and accelerating new smart ways of working."

This initiative comes after many years of investment and innovation in scientific solutions searching for real answers to the challenges facing the agriculture industry. It marks not a new beginning, but a significant acceleration of the journey towards a more sustainable future. How can this initiative benefit aquaculture?

Achyuth Iyengar, Director Speciality Products (Asia Pacific) and **Chiow Yen Liew**, Regional Marketing Manager Aqua (Asia Pacific), explain what galvanises the company to come up with "We Make it Possible", what this means for aquaculture, and how DSM will leverage on its expertise to play its part in fostering sustainable aquaculture.

Achyuth Iyengar: *Tackling food safety and loss amidst global demand*

Chiow Yen Liew: *Aquaculture needs to achieve sustainable growth, for now and in the future.*

What are the key drivers behind this initiative, specifically on aquaculture?

AI: Marine resources and aquaculture act as invaluable sources of proteins around the world; for more than 3.1 billion of the global population, fish protein accounts for at least 20% of their intake of animal protein. Aquaculture growth has been heavily dependent on the extraction of omega-3s from wild-caught fish for fishmeal and fish oil production in aquafeeds, such as for commercially farmed salmon, trout and marine shrimp.

Within the next 10 years, we expect global demand for seafood to rise by 30 million tonnes. This growing demand, which is already placing tremendous pressure on our planet's finite natural resources, will take our food systems well beyond the planet's boundaries. Already, around 33% of the world's fisheries are either depleted or overfished. Continuing to operate as we have done in the past is no longer an option. Providing enough animal protein for a growing population, while reducing the environmental costs of farming, calls for urgent, collaborative action across the entire value chain.

Ours is a global strategic initiative which aims to lead a robust and achievable transformation worldwide in sustainable animal protein production. Through cutting edge science and innovation, the initiative aims to connect stakeholders (from producers, farmers, processors, retailers to consumers) to address the major challenges facing the animal farming industry and accelerate sustainable, scalable solutions that will foster a brighter future.

We are working hard to reduce global food loss and waste. Globally, over 1 billion tonnes of food is wasted annually. Our ambition, therefore, is to reduce food loss and food waste by 50% in the next decade, and we have signed the Sustainable Development Goals (SDGs) to affirm our commitment to this cause. By applying our expertise on optimum vitamin nutrition, we seek to limit food loss and waste at every stage in the food supply chain.

In addition to tackling global food loss and waste, we also seek to improve the health and welfare of animals at every stage of life to create more sustainable food systems.

CYL: Specific to aquaculture, we aim to reduce our reliance on over-exploited marine resources by developing alternative sources of highly unsaturated omega-3 fatty acids and protein raw materials to enable the industry to achieve sustainable growth, for now and in the future. Our joint venture with Evonik, Veramaris, creates a sustainable substitute to fish oil derived from natural marine algae, which is currently undergoing trials across Asia Pacific. Developed in a large-scale, land-based waste-free fermentation process, this algal oil provides equivalent levels of omega-3 EPA and DHA as 1.2 million tonnes of wild fish. Our feed enzymes improve the digestibility whilst increasing the nutritional value of plant-based feed raw materials, thus lowering the reliance of fishmeal required for production.

Collectively, these innovative science-based solutions aim to reduce our reliance on marine resources and foster the sustainable growth of healthy and nutritious seafood to meet the growing needs of a growing population.

The initiative aims to make aquaculture more sustainable. In your view, where is Asian aquaculture today with regards to sustainability?

CYL: Aquaculture, like any other animal-based protein production, is resource dependent and relies on land and feed. As a result, this gives rise to environmental impacts. Although aquaculture is often seen as a more environmentally friendly source of animal protein as compared to other sources of land based animal proteins, it faces increasing criticism for its environmental impact and depletion of natural resources.

AI: Today, almost half of the global fish supply for human consumption is from aquaculture with 90% of the production volume produced in Asia. Given Asia's prominent role in aquaculture output, the pressure to deal effectively with food safety, quality issues, as well as to minimise social and environmental impacts, is intense.

The race to have a more sustainable aquaculture production in Asia requires support across the value chain. At DSM, we believe in adopting a systems perspective on sustainability: from the use of sustainable resources to responsible production cognisant of managing environmental impacts; all of these whilst meeting the demands of the value chain.

A responsible production that considers better use of raw material; produces good quality feed with highly digestible nutrients for different development stages; having appropriate on-farm feeding; and proper farming technologies, should be adopted. For example, the use of enzymes in environment management and aquafeeds should be accelerated. We have seen how their catalytic capabilities have transformed the animal husbandry industry whilst ensuring the animals have the welfare features which allow them to thrive. We can do this in aquatic species too.

Health and nutrition affect the sustainability of aquaculture. How does DSM want to transform this?

CYL: A sustainable aquaculture production must provide a survival rate and growth performance that allow farmers to generate profits. Disease has been one of the key challenges in the aquaculture industry in Asia, resulting in huge losses.

At DSM, we prevent the spread of diseases, manage health and welfare of aquatic animals right through macro- and micro-nutrient levels, such as with OVN™ and functional ingredients in feed as excellent alternatives to a healthy diet, leading to better health and higher survival rates that maximise production yields and greatly increase food security.

Under the umbrella of "We Make It Possible", we take an active role in improving food safety, tackling the use of antimicrobial resistance (AMR) through antibiotic-free production.

In protein production via aquaculture, which are your priorities to achieve your goals of 'improving quality of fish, making efficient use of natural resources and reducing AMR'?

AI: We believe in a systems perspective to sustainability. The overarching goal of our aquaculture solutions is to support the use of sustainable resources, encourage responsible production that considers the environmental impacts, and tackling AMR to meet the demands of the entire value chain.

We strive to make efficient use of natural resources by providing more flexibility in aquafeed production using feed enzymes and reducing the aquaculture industry's reliance on fishmeal. Similarly, with Veramaris' algal oil, we provide the much-needed omega-3s traditionally found in fish oil without having to rely on wild fish stocks.

Technologies applied in our products extend shelf life. Antioxidants like vitamins C and E are scientifically proven to slow down oxidation processes, extend shelf life, and reduce spoilage and waste, making aquaculture products more available for consumers and increasing profit margins for farmers.

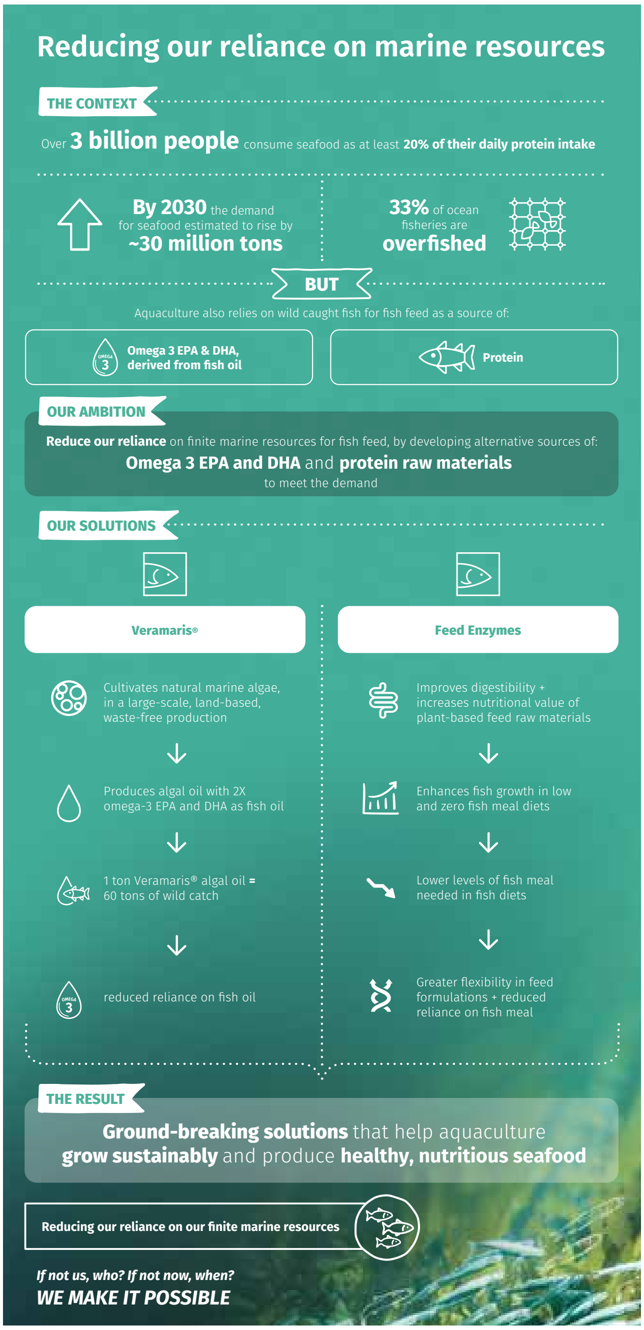
How will DSM measure itself as an agent of change?

AI: Our initiative aims to drive transformation that relies on the collaborative efforts of all industry players to address the challenges facing our industry. It calls for greater engagement amongst stakeholders and greater focus on how our fish is produced - animal welfare standards, the provenance, and the environmental footprint it produces. Our success is grounded in the six sustainability platforms and the tangible impact our efforts bring towards achieving the SDGs.

We will achieve our targets by ensuring that all new investments by our business are carbon neutral, and we have dedicated investment programmes on renewable energy and energy efficiency. For example, we have adopted an Internal Carbon Price €50/tonne CO2eq in the valuations of key investment projects and in the profit and loss statements of the business groups for internal management reporting. In 2018 DSM also concluded a new €1 billion Revolving Credit Facility with our long-term banking partners that links the interest rate payable to our GHG emission reductions, underscoring the importance of sustainability in everything we do – including corporate finance.

At DSM, sustainability is fully engrained in our purpose, strategy, business and operations. Our approach for bringing about positive change is to improve, enable and advocate. We seek to improve our operations by decreasing our phosphorus and nitrogen emissions into water bodies; to enable our customers and partners deliver sustainable and healthy solutions for the planet and our society; and to advocate and accept the responsibility we share to drive change and be a strong contributor to society.

"We Make It Possible" demonstrates our ongoing commitment to provide real answers to the challenges facing the aquaculture industry and marks a significant acceleration towards a more sustainable future.




Reducing our reliance on marine resources
We're focusing our passion and expertise on cultivating marine algae that naturally produce omega 3, EPA/DHA, so we can help reduce the reliance on wild fish stocks and enable the aquaculture industry to grow.
We are transforming animal nutrition and health to build a sustainable future, responsibly.
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Growth in white shrimp fed with diets containing DDGS as partial replacement of SBM

Trials in Batam showed that distiller's dried grains with solubles up to 15% can be an effective protein source in 8% fish meal diets.

By Romi Novriadi and Ronnie Tan

Distiller's dried grains with solubles (DDGS), is a co-product from the ethanol industry. It contains moderate protein and lipid levels as well as vitamins and trace minerals and may have the potential to improve the efficacy of soy protein in aquafeeds. As DDGS does not contain anti-nutritional factors such as trypsin inhibitors, phytate, and gossypol and is also less expensive than soybean meal (SBM), its inclusion to partially replace SBM can be an alternative to enhance the nutritional quality of plant-based diets and keep feed costs down. Despite several studies demonstrating that DDGS can be successfully used as a protein source in shrimp diets, especially for the Pacific white shrimp *Litopenaeus vannamei* (Rhodes et al., 2015; Sookying and Davis, 2011), information on the efficacy of DDGS in commercial practical diets is limited. Thus, the aim of this study is to explore the biological response of *L. vannamei* fed with various inclusion levels of DDGS. The proposition is to only partially replace SBM in commercial shrimp feed formulations while at the same time retain commonly used inclusion levels of fish meal in the feed.

Ingredient (as is %)	Experimental diets			
	V1 (Basal)	V2 (5% DDGS)	V3 (10% DDGS)	V4 (15% DDGS)
Soybean meal	25.0	22.5	20.0	17.5
Poultry by-product meal	20.3	20.3	20.3	20.3
Chilean fish meal	8.0	8.0	8.0	8.0
Corn DDGS USA	0.0	5.0	10.0	15.0
Tuna hydrolysate	2.0	2.0	2.0	2.0
Squid liver powder	6.0	6.0	6.0	6.0
Wheat flour	31.9	29.3	26.8	24.2
Soy lecithin	1.5	1.5	1.5	1.5
Fish oil	1.0	1.0	1.0	1.0
MCP	1.8	1.8	1.8	1.8
L-Lysine HCl	0.00	0.04	0.09	0.14
DL-Methionine	0.19	0.18	0.17	0.17
L-Threonine	0.08	0.08	0.08	0.09
Mineral premix	1.20	1.20	1.20	1.20
Vitamin premix	0.41	0.41	0.41	0.41
Magnesium Sulphate	0.35	0.35	0.35	0.35
Choline Chloride	0.20	0.20	0.20	0.20
Anti-Mold	0.12	0.12	0.12	0.12

Table 1. Composition of ingredients (as is %) of diets containing various levels of distiller's dried grains (DDGS) incorporated into the basal diet and fed to *Litopenaeus vannamei* for 52 days.

Diet formulations

All test diets were formulated to be iso-nitrogenous and iso-lipidic (37% protein and 9% lipid). In this growth trial, the basal diet was designed with fish meal (FM), poultry by-product meal (PBPM), SBM and wheat flour as the main ingredients. The three experimental diets were then formulated to utilise increasing levels (5, 10 and 15%) of DDGS to partially replace SBM which was 25% in the basal diet. All experimental diets were produced at the PT Suri Tani Pemuka (Japfa Group) Aquafeed Research Center using standard procedures for shrimp feed processing. Dry pellets were crumbled, packed in sealed bags, and stored in a freezer until use.

Figure 1. Experimental diets fed to *Litopenaeus vannamei* juveniles for 52 days.

Time	Parameters					
	Temperature (°C)	Dissolved oxygen	pH	Salinity (‰)	Ammonia (mg TAN/L)	Nitrate (mg NO_2-N/L)
AM	27.76±0.85	5.96±0.23	7.81±0.09	24.22±2.74	0.22±0.38	28.4±7.69
PM	29.27±0.98	5.71±0.41	7.69±0.26	23.60±8.51		

Table 2. Overall water quality measurements during the 52 days shrimp grow-out phase of the experiment. Data are presented as mean± standard deviation.

The growth trials were conducted at the PT Batam Dae Hae Seng Research Station (Batam, Indonesia). White shrimp post larvae (PL7) were obtained from PT Maju Tambak Sumur (Kalianda, Lampung, Indonesia) and nursed in a semi-indoor recirculating system. Post larvae were fed with a commercial feed (Evergreen Feed, Lampung, Indonesia) for three weeks until they reached the suitable size for stocking. Juvenile shrimp (initial mean weight, 1.04±0.04g) were stocked into 70 x 35 x 40cm (98L) aquaria tank with 15 juveniles/aquarium (equivalent to 150 PL/m^2).

Feed management

There were ten replicates per treatment. The dietary experiment followed a standard nutritional research protocol. Shrimp were fed over a duration of 52 days at 4 times/day. Based on previous trial experiences, feeding was pre-programmed assuming the normal growth of shrimp and feed conversion ratio of (FCR) 1.5. Daily allowances of feed were adjusted based on observed feed consumption as well as weekly counts of the live shrimp to assess mortality.

Sampling for growth performance and water quality

For all tanks, pH, dissolved oxygen (DO), water temperature and salinity were measured four times daily using Aqua TROLL 500 Multiparameter Sonde instrument and connected to AquaEasy apps (Bosch, Singapore) for data monitoring and recording. Total ammonia nitrogen (TAN), nitrate and nitrite were measured by absorption spectrophotometry (DR890, HACH, USA).

Statistical analysis

All data were analysed using one-way analysis of variance to determine the significant difference ($P<0.05$) among the treatment means followed by the Tukey's multiple comparison test to determine the difference between treatment means in each trial. The pooled standard errors were used across all the growth parameters as the variance of each treatment is the same. Statistical analyses were conducted using SAS (V9.4, SAS Institute, Cary, NC, USA).

Water quality

The overall mean and standard deviation of morning and afternoon pH, salinity (‰), water temperature (°C) and dissolved oxygen (mg/L) together with ammonia (mg TAN/L) and nitrate (mg NO_2-N/L) are shown in Table 2. Based on the data, all parameters were still within the acceptable range for *L. vannamei*.

Growth performance of shrimp fed with DDGS

In general, there was no significant difference ($P<0.05$) in growth performance of shrimp fed treatment diets containing 5, 10 and 15% DDGS to partially replace SBM. However, biologically, there was an improvement in terms of final biomass, final mean weight, survival and weight gain of shrimp when SBM was partially replaced with DDGS up to 10%. In addition, shrimp fed with diets containing 5 and 10% DDGS exhibited better FCR compared to the basal diet (V1).

Diet code	Final biomass (g)	Final mean Weight (g)	Survival (%)	WG% [1]	FCR[2]	TGC[3]
VI	133.42	10.17	86.79	880.79	1.85	0.0773
V2	148.35	10.90	89.42	932.61	1.72	0.0803
V3	140.91	10.30	90.17	901.31	1.82	0.0781
V4	138.92	10.17	90.75	892.74	1.89	0.0775
PSE[4]	4.8518	0.2367	2.3956	27.0982	0.0447	0.0011
p-value	0.1643	0.0856	0.5985	0.5311	0.0525	0.2257

Note: [1] WG = Weight gain; [2] FCR= Feed conversion ratio; [3] TGC = Thermal growth coefficient; [4] PSE = Pooled standard error

Table 3.Growth performance of Pacific white shrimp *Litopenaeus vannamei* (Mean initial weight 1.04±0.04g) fed experimental diets for 52 days.

With regards to the use of DDGS, Sookying and Davis (2011) concluded that 10% DDGS included in diets with high levels of SBM (58%) had no negative impact on the growth performance of shrimp cultured in 0.1ha ponds. Moreover, Roy et al. (2009) also reported that shrimp fed diets containing 10% DDGS had similar performance to shrimp fed a fish meal diet when reared inland in low salinity waters. The results of the present study confirmed the viable use of DDGS to maintain the optimum growth of shrimp. Under the conditions of the present study, DDGS can be recommended as a potential ingredient and can be used up to 15% inclusion without compromising the growth of *L. vannamei*.

Daily water quality analysis during the experimental period

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2020: Marine shrimp in Asia

Significantly affected by simultaneous demand and supply shocks

As we enter 2021, we look back at developments in the marine shrimp demand and supply sector in 2020. The worldwide pandemic lockdown in March was a significant disruption as for the first time in recent history, the industry faced both a demand shock as well as a supply shock simultaneously. Initially, logistics was in turmoil as containers were stuck in the ports and unable to be at the right place and the right time for shipment.

Furthermore, in Q2, many shipping companies downsized their container capacity and today, the consequence is a shortage of containers and longer waiting time for confirmation. In Q4, China's inspection of all seafood imports for the virus has been intensified leading to a waiting time of as long as 3 weeks at the main ports.

Retail vs food service demand

In the US, the food service sector accounts for 70% of all shrimp imports. In Q2 the lockdown affected the restaurant business with reduced shrimp consumption by a half. The retail segment, however, improved by 40% due to more cooking done at home. The lower prices also attracted higher sales. By summer, when restaurants were open again, the US import market recovered, and US imports in 2020 have been projected to exceed that of 2019 (700,000 tonnes) by 8%, according to Rabobank (undercurrentnews.com).

In China, the second largest market in the world after the US, the food service sector recovered but the retail sector suffered when the virus was detected on shrimp packaging in July/August, especially from the imports originating from Ecuador. "With the virus detected on imports, there was enhanced control; we had to publish online DNA tests to keep seafood sales steady. The nucleic acid test is a gate-pass," said Feng Yu, Seafood Procurement Manager at JD.com, a major seafood online retailer in a presentation at GOAL 2020 conference in October.

The effects on major producing countries vary. Towards the end of 2019, both Ecuador and India were competing for the China market. In 2020, Ecuador and India shared the same problem – lack of workers in processing plants. Guayaquil, Ecuador's centre for shrimp processing, was a Covid-19 hot spot and workers were scared to return to work. While in India, workers were forced to return to their home states during the lockdown. So, both countries faced labour shortages. However, the similarity ends there.

While Indian farmers skipped production cycles due to low prices, Ecuador continued to farm. India harvested small sized shrimp and processed value-added shrimp while Ecuador continued with larger size shrimp and produced nearly all HOSO. HOSO shrimp is primarily demanded by the food service sector which suffered significantly more than the retail sector. Ecuador mitigated the situation by pivoting away from China, focussing instead on the US and EU markets. In August, Ecuador exported 52,800 tonnes of shrimp and managed a split of EU, US and Asia export market at 31%,30%, and 33% respectively. This still did not help much as Ecuador had the lowest ex-farm price of all the major producing countries. At the end of August, ex-farm USD shrimp prices for size 60/kg were: Ecuador 2.80/kg; India 3.82/kg; Vietnam 4.41/kg; Indonesia 5.10/kg; Thailand 5.11/kg and Malaysia 5.50/kg. The latest China import data for March-November 2020 showed about 400,000 tonnes compared to 650,000 tonnes for the full year 2019 (undercurrent news.com).

China's retail segment

In discussing consumption trends in 2020, Yu said that online channels have helped to introduce new seafood products to inland cities and represent the boom in retail. JD imports 40% of its seafood and procures 60% from domestic production. "Online retail contributed to customer education too. We worked with chefs on how to prepare seafood. But there are hundreds of online brands which also increases competition."

JD had quickly adapted by actively giving information on the products. With virus detected on imports, Yu said there was enhanced control at JD on its suppliers. In tier1 cities, the preference has always been for high quality and sustainable seafood. Yu added that the company focusses on generating consumer confidence on seafood and encourages suppliers to demonstrate their efforts on food safety, certification etc.

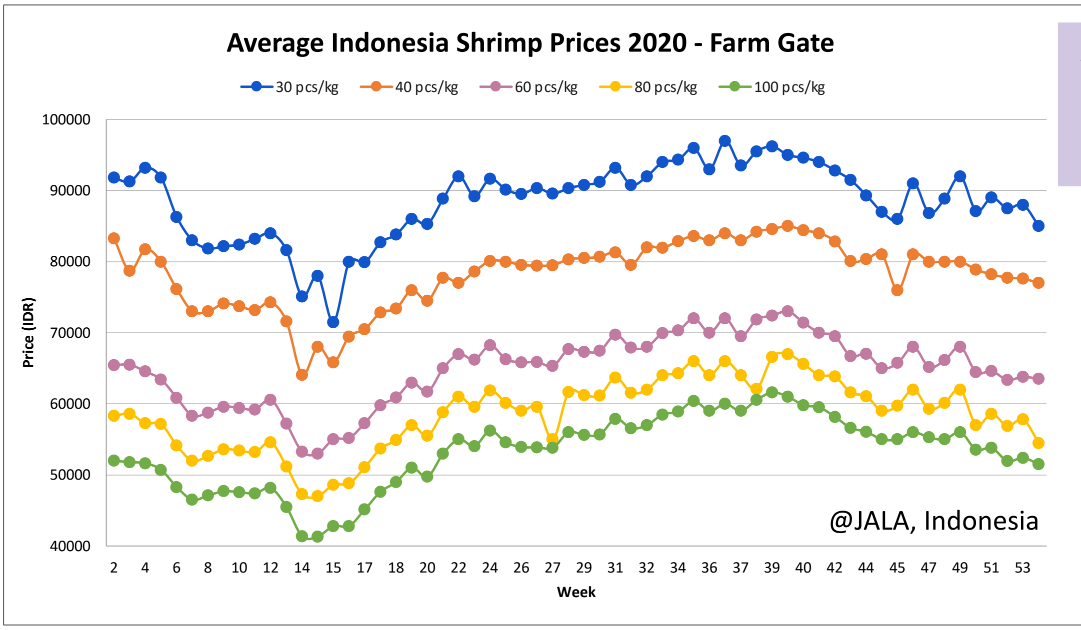
Lower prices

The average shrimp import price/kg has declined since the highs of 2014 (Shrimpinsights). A composite for the major markets of US, EU and China shows a price decline from USD11.16/kg in 2015 to USD7.41/kg in 2019. In 2020, prices declined further and the average price in China of imported Ecuador shrimp declined to just above USD5/kg. In the US, prices declined during the first half of the year but improved in the third quarter due to strong retail demand. Asian prices did not drop much further below the 2019 level because lower production weakened the effect of the Covid-19 related drop in global demand. Moving forward, prices may continue to show a positive trend till January 2021 but are likely to ease due to high inventories especially in the US and EU and due to a lack of demand from China after the Chinese New Year. Prices are expected to decline further in the first half of 2021 but then firm towards the second half of the year.

Demand in 2021

How will demand unfold in 2021? Panellists at the UCN webinar gave some insights on consumption. "Customers are also more flexible, accepting different product forms which helped some importers that do not import value added products," said Jeff Sedacca, Sunnyvale Seafood Co. Jim Gulkin, Siam Canadian Group added that consumption patterns have changed in 2020, with more consumption at home. In the long term, the resumption of consumption will rest on the speed of recovery of major markets for the food service sector such as cruise and tourism industries.

Robins McIntosh, Charoen Pokphand Foods, said that before this pandemic, there had been balanced demand and supply; producers are waiting for the demand situation to improve. It will depend on how much China will be able to absorb. "We need to see where consumption is happening and production will be ready to meet the demand.



Average weekly farm gate prices in IDR for sizes 30-100/kg in Indonesia. Courtesy of JALA, Indonesia.

Production in 2020

In this review on production estimates, in addition to those from the industry for 2020, we present some figures from panellists at various webinars. The forecast for production in 2021 was presented at GOAL 2020 (see pages 40-41). In *Aqua Culture Asia Pacific*, September/October 2020 Soraphat Panakorn reviewed some supply and production challenges until August 2020.

India

In the first half, production was affected by the lockdown, shortage of post larvae (PL) and costly transportation to farms in the north and west coast, and poor survival rates. Industry was affected by low ex-farm prices in March 2020 (with size 100/kg at INR160/kg), and delays in stocking. The uncertainties throughout the year affected production. Total production estimates for 2020 ranged from 575,000 to 620,000 tonnes resulting in a drop of 29% to 22% of production in 2019 (800,000 tonnes).

China

Seafood marketeers estimated a 20% reduction on production from the 500,000 tonnes produced in 2020 (UCN, 2020). "Overall stocking was less than in 2019," said Vincent Lin, Grobest Group (SAP, 2020). "About 40% of ponds in Guangdong, the leading shrimp farming province, and 20% in other parts of China remained unstocked." When the pandemic subsided, decapod iridescent virus 1 (DIV1) reappeared with 60% of ponds infected. In July, when the coronavirus was detected in shrimp imports, prices dropped to a low – CNY22/kg for size 60/kg. Prices later surged with demand in August.

Vietnam

Relative to other Southeast Asian countries, the pandemic had little effect on shrimp farming. Grobest Group's Samson Li expected a small decrease of 9% to 570,000 tonnes of total production in 2020, from 630,000 tonnes in 2019 and production to recover in 2021 to 2019 levels of 365,000 tonnes of vannamei shrimp and 214,000 tonnes of monodon shrimp (SAP, 2020). In contrast, others gave lower estimates for vannamei production in 2020; 360,000 to 400,000 tonnes citing significant EHP outbreaks and pond failures. Monodon shrimp production in 2020 could be from 100,000-150,000 tonnes.

"The stocking density of vannamei shrimp depends on the farming environment," said Dr Loc Tran, ShrimpVet Lab. It ranges from 30-50PL/m^2 in semi-intensive and low saline culture, 50-100PL/m^2 in earthen ponds and 60-70PL/m^2 when stocking large juveniles to harvest large 50g shrimp in large ponds, in a multiphase farming system (SAP, 2021).

Indonesia

In the early part of the year, stocking was delayed because of transport disruptions for PL deliveries. Fewer farms were operating; some stopped operating and resumed only in the later part of the year. "Farmers have changed operating procedures, stocking 100-125PL/m^2 from the usual 150-200PL/m^2 and they also start siphoning ponds from 20 days," said Haris Muhtadi, PT CJ Feeds.

While post larvae sales remained unchanged, industry's production estimate was a 14% drop, bringing 2020 production at 258,000-300,000 tonnes from the 300,000 to 350,000 tonnes in 2019. Future output is expected from new farms expanding aggressively in other islands such as Batam, Maluku, Kalimantan, Sulawesi and Sumbawa. In the first half, production was of smaller size shrimp 40-50/kg but in the second half, larger sizes of 25-40/kg were produced which contributed to higher production volumes. Black tiger shrimp contributed 14% of the production.

Thailand

Official figures by the Department of Fisheries, Thailand, gave production for the first 11 months at 257, 836 tonnes of vannamei shrimp and about 11,000 tonnes of black tiger shrimp. The full year's production estimate by industry may show a 26% decline in total production from 317,839 tonnes in 2019 (DOF, Thailand). A difference from the production in 2019 would be the production of larger size shrimp in 2020.

According to Olivier Decamp, INVE Aquaculture, the industry's new endeavour is to maintain dissolved oxygen in culture environment at 5-6ppm from the earlier 4ppm, and the preferred stocking density is 80-100PL/m^2 (SAP, 2021).

Malaysia
Production is expected to go down by 8-12%, possibly at only 42,000 tonnes of both vannamei (70%) and monodon shrimp (30%), according to industry. To compensate for downtime losses in Q2, production has extended to Q4. Production in East Malaysia was significantly affected by Covid-19, since it is entirely dependent on the export market. While most of the vannamei shrimp farms survived with local market demand picking up almost all the production, farms producing large monodon shrimp, for the food service segment had reduced sales. In 2020, there were more outbreaks of EHP than AHPND.

Philippines
Chingling Tanco, MIDA Trade Ventures, said that in 2020, with flight disruptions, larger farms in the Visayas and Mindanao could not reach the main market in Manila. Usually, the shrimp industry focusses on the export market in the first half of the year and the local market with better prices in the second half. But demand was low for both segments in 2020 (USSEC, 2020). Therefore, it was likely that farmers had reduced their production. The estimate by McIntosh was 57,000 tonnes (UCN, 2020) However, production could be less at 48,000 tonnes, based on lower imports of broodstocks in 2020.

Bangladesh
In Bangladesh, stocking of farms was probably lower due to Covid-19 and Cyclone Amphan which came in May 2020. Industry in Bangladesh expects production to be similar to previous years but these developments suggest that monodon shrimp production may go down this year, as will prices. In 2020, prices were weak; medium size black tiger shrimp (size 21-44/kg) was BDT895/kg (USD10.5/kg) in February and dropped to BDT695/kg (USD 7.6/kg) in June.

Diseases in vannamei shrimp farming
The situation with WFS, AHPND and EHP in Vietnam, India, Indonesia and Thailand was explained by industry leaders during the virtual TARS Leading Conversations on managing AHPND, EHP and WFS (see pages 50-54). Loc Tran highlighted muscle necrosis (see box). Recently, AHPND is a serious problem in Indonesia with about 30% of farms infected, mostly in the older areas of Lampung, Medan and on Java island. In India, there was a higher virulence of WSSV and tests indicated a new strain (SAP, 2021).

"Although prevalent in China, DIV1 has yet to be detected in Thailand and elsewhere," said Dr Kallaya Sritunyalucksana, BIOTEC, Thailand (WAS, 2020). But with the possibility of transfer across species, especially in polyculture, she recommended other countries to start testing on *Penaeus vannamei* and *Macrobrachium* sp. using the primer developed. Routine PCR testing of polychaetes including for DIV1 and use of only pathogen-free polychaetes were recommended. There are SPF polychaetes in Thailand.

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Muscle necrosis

This bacterial disease is usually associated with intensive farming and it can cause mortality as well. This could be 0.5% of mortality every day, but the cumulative mortality in the pond could be very high. There is a possibility of farmers misdiagnosing the affected animals when they see opaque muscles. Besides that, IMNV could be responsible for muscle necrosis. Based on some literature review and research, it was concluded that muscle necrosis can be caused by *Vibrio harveyi* and it is linked to thick algal bloom, low dissolved oxygen, low alkalinity and stress."

The ShrimpVet lab carried out histological analyses where researchers examined the necrotic muscle and found many Vibrios They could isolate the Vibrio from the necrotic muscle, conduct the infection and easily replicate the disease in the laboratory. To manage muscle necrosis, there is a need for more sanitation, more water exchange, better algae control and improvement in shrimp health in general. "You can apply disinfectants such as iodine to reduce the pressure of a Vibrio attack on the shrimp," advised Loc Tran.

Subsequent challenge studies using both immersion and injection of Vibrio harveyi could induce identical lesions as of field specimens.

GOAL 2020: Global farmed shrimp supply

Over the decade, global farmed shrimp production grew at only 4.6% CAGR. While forecasted production in 2020 was down, there is optimism for an increase of 8.4% in 2021.

The Global Aquaculture Alliance (GAA)'s annual aquaculture production forecasts for shrimp are usually anticipated by most stakeholders, using the information for planning and marketing as well as to stay ahead of the curve on emerging challenges and solutions. In presenting results from the annual GOAL survey on the global shrimp industry, Gorjan Nikolik, Senior Analyst at Rabobank reported on the FAO CAGR for 2010-2018 period and analysed forecasted data for 2020 and 2021.

The Americas

Within the Americas, the focus was on Ecuador where shrimp production grew at a CAGR of almost 11% with no single year of decline during 2010-2018. Ecuador has risen to be the largest contributor at 60% in Latin America. "The Ecuadorian farmed shrimp industry had an excellent 2019 at 600,000 tonnes and a surprisingly small increase of 1.4% in 2020 over that in 2019, possibly because it had a strong first half in 2020," said Nikolik. Production is expected to grow at 1.9% in 2021. The other leading producers are Mexico, Brazil and Peru. In 2020 or even in 2021, Mexico is not expected to reach the previous high volume of 160,000 tonnes achieved in 2019. While Brazil had declining growth at a CAGR of -1.4%, it showed a remarkable growth in 2019 to around 80,000 tonnes and a bullish 2020 with 9.1% growth and 2021 with 15.6% growth to more than 100,000 tonnes expected.

Asian production

Over the years, production forecasts for China used government data provided to FAO. Industry have had doubts as there have been disease outbreaks and production has suffered. The situation is similar for Indonesia. Using industry estimates developed with the help of CPF's Robins McIntosh, Nikolik showed that China's CAGR was in fact -4.8% (Figure 2) rather than CAGR 4.9% using FAO figures. In 2018 production was under 550,000 tonnes, four times less than FAO's data of 2 million tonnes, according to Nikolik. In contrast, Indonesia's volume in 2018 was corrected to less than 350,000 tonnes, which was three times less than FAO's data.

India is the region's leading producer and has been increasing production at a fantastic 27% CAGR (Figure 1). "The leap in 2019 with 800,000 tonnes was more than was expected," said Nikolik. However, the drop in production in 2020 showed the harshest decline of 26.5%. A small recovery is expected at 4.3% in 2021. The estimated data on **China's** production showed a decline in 2019 (-3.2%), a further decline (-14.8%) in 2020 and optimism in 2021 at 12.4% but bringing back production to 500,000 tonnes only (Figure 2).

Within Southeast Asia, **Vietnam** is the leading producer, growing at an impressive CAGR of 11.3% from 2010 to 2018 (Figure 3). The focus was on its vannamei shrimp production, which continued to increase at the expense of monodon shrimp farming. "But monodon shrimp farming remains relevant," said Nikolik. Data from the GAA survey gave a total production of vannamei and monodon at just below 650,000 tonnes. CAGR for only vannamei shrimp production was 21.6%, to over 450,000 tonnes in 2018. Total shrimp production was down 11.4% in 2019 and then a further decline (-6.9%) in 2020; the recovery at 7.4% in 2021 should result in a volume equal to that in 2019.

Indonesia is the next leading producer in Southeast Asia after Thailand's production dropped massively because of AHPND/EMS. In this discussion, Nikolik said that they have decided to use the estimated data from industry. CAGR remained high at 12% and 2018 production was less than 350,000 tonnes. Data showed a 13.8% rise in production in 2019 versus 2018 but subsequently, a drop (-7.8%) in 2020. A rise in production by 7.9% in 2021 will bring production volume close to that in 2019.

Thailand's vannamei shrimp production has been hovering around 300,000-350,000 tonnes since 2013. Production in 2019 dropped by 12.6% as compared to 2018. After a further decline in 2020 (at 9.6%) before a small recovery in 2021 (+3.1%) is expected. Growth has been flat for the industry in **Philippines** at a CAGR of 0.8% and then a sharp increase to around 70,000 tonnes in 2019 and remaining at this range in 2020 and 2021. FAO's CAGR for **Malaysia's** production was -7.7% for the years 2010-2018. The estimates in 2019-2020 hovered around the 50,000 tonnes mark or below.

As a region, Southeast Asia's production declined by 5.5% in 2019 as compared to close to 1.2 million tonnes in 2018. The GOAL survey showed production down at 8.2% in 2020 and will marginally increase by 7.7% in 2021." The survey data shows the importance of Vietnam and how it has become, by far, the largest player in Southeast Asia."

There was also the impressive growth in shrimp production in Saudi Arabia and Iran, with a FAO CAGR (2010-2018) of 13.8% and 28.7%, respectively. For Saudi Arabia, the introduction of the vannamei shrimp increased production to more than 65,000 tonnes in 2018. In Iran, it was more than 45,000 tonnes. In both countries, the survey showed that growth was halted in 2019, production declined in 2020 and may recover in 2021. "However, the growth in production is still impressive, with strong sectors in a relatively short period," said Nikolik.

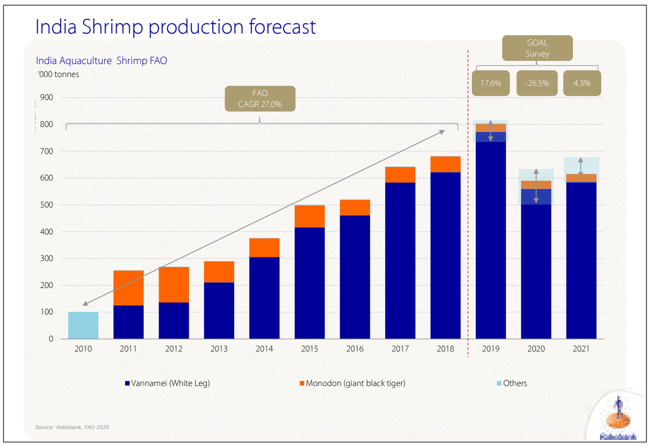


Figure 1. India shrimp production. Goal survey data forecasts a small recovery in 2021.

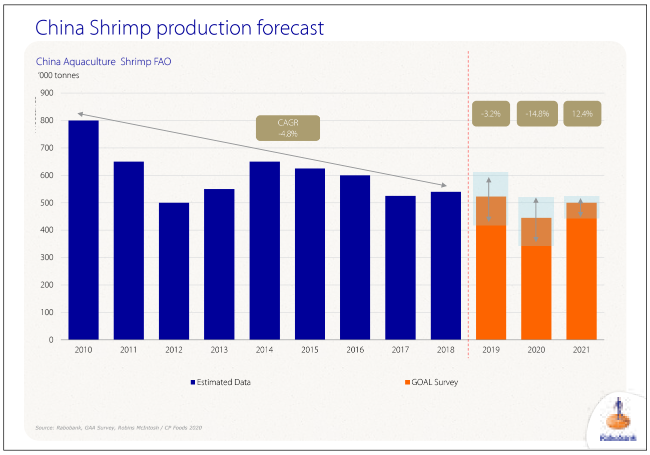


Figure 2. China shrimp production using estimated data. Goal survey data forecasts production declines in 2019, 2020 and a small recovery in 2021.

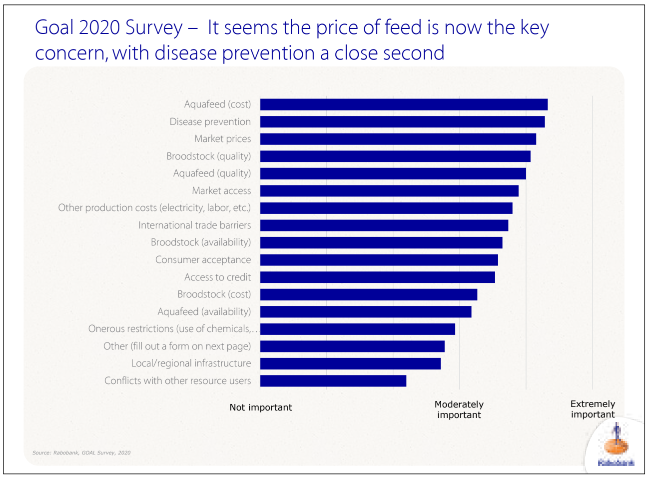


Figure 5. Results from the GOAL Survey in 2020.

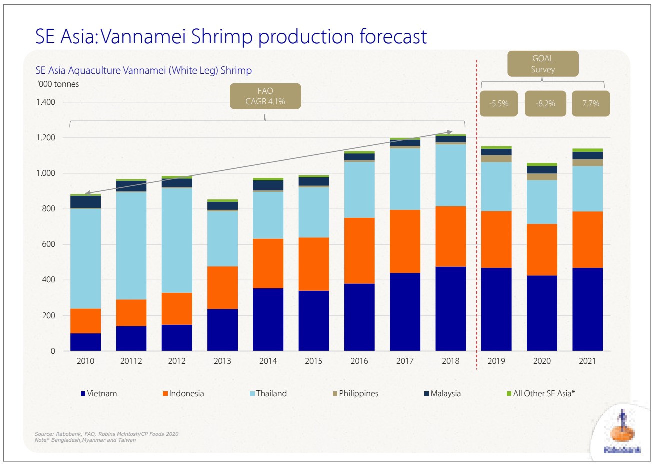


Figure 3. Southeast Asia vannamei shrimp production

“In 2021, industry is hopeful and the total market grow back will be at 8.4%.”
– Gorjan Nikolik

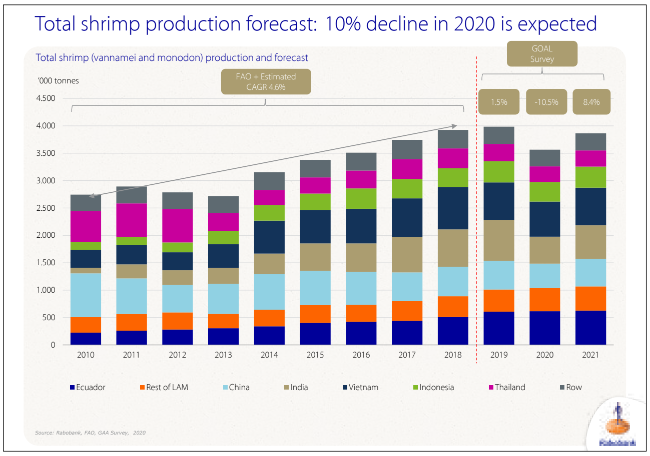


Figure 4. Global shrimp production (with estimated data for China and Indonesia).

The global overview from this survey, with estimates for Indonesia and China is given in Figure 4. The survey indicated a global growth of 4.6% up to 2018, a drop in production of >10.5% to 3.5 million tonnes 3.5 million tonnes in 2020 given the low prices producers are expecting and the adverse impacts of coronavirus on the demand-supply situation . “In 2021, industry is hopeful and the total market grow back will be at 8.4%.” said Nikolik.

Concerns in 2020

“It is always interesting to look at our questions to industry. In 2019, we asked whether the global shrimp market will strengthen in 2020. In hindsight, we know that it did not strengthen but was worse. Whereas in 2020, there was optimism among producers in Asia and some from the Americas for 2021 that the shrimp market will strengthen.”

The GAA survey is especially important in estimating key issues affecting shrimp production for the year (Figure 5). The 2020 survey gave a surprising list with aquafeed cost and quality a major concern. Disease prevention came second, in contrast with disease being the leading concern in previous surveys. “It is interesting how aquafeed cost became the biggest concern. This is understandable as many respondents in 2020 came from developing countries and currencies have devalued against the US dollar, bringing up costs of feed production. Again, with lower prices, feed costs look more expensive. Other concerns were disease prevention, market prices and broodstock quality.

Nikolik concluded, “The decade has been difficult; with EMS crisis bringing down shrimp production from 2010, and ten years later the shrimp industry is faced with this human coronavirus. The shrimp sector grew at a respectable 4.6% (Figure 4) CAGR over the last decade, with India, Vietnam and Ecuador the biggest gainers. Most players are positive on the industry with recovery predicted in 2021.”

Empowering the shrimp sector through digital transformation

How an advanced production management software can be the first step towards production optimisation and sustainability.

By Konstantinos Bovolis

Aquaculture is an expanding industry that has great potential to address the demand for high quality protein along with the increasing global population and income. However, while the biomass produced from aquaculture has already surpassed that of fisheries for direct human consumption there is a feeling that the industry is slow to adopt technology and reap its benefits, especially in comparison with other segments of food production, such as poultry. While large strides and technological breakthroughs have been made in the past decades, especially in salmon farming, some sectors, such as shrimp farming are still lagging in terms of adoption of technology. Although having a long history and tradition, shrimp producers, regardless of whether they are small local farms or huge multinational companies, are still relying on experience and instinct, when it comes to decision making and daily operations.

In an everchanging environment and in a world that is constantly evolving, the need for control, innovation, standardisation, automation and sustainability is more profound than ever. The Covid-19 pandemic, accompanied by the initial market shocks, have demonstrated the urgency to address these needs.

Making the right decisions in terms of production cost, -quality, and -scheduling can make the difference between profit and loss. This is especially the case in the shrimp industry, characterised by short production cycles, considerable product price sensitivity, and reliance on optimal environmental conditions for shrimp growth and survival. The daily challenge of controlling shrimp production in real time for maximum profitability and environmental sustainability, can be overcome if supported by a dedicated production management software.

Functionalities adapted to the company's needs

The recording and interpretation of various parameters, such as stocking density, feed conversion ratios, health status and survival rates, may differ from farm to farm and can be unique among different production systems and producers. For instance, some production units might register their data in kilogram per hectare, while others would work with data in square meters or even cubic meters. Also, managers might have different preferences on how data and reports are presented, analysed and visualised.

An advanced management software allows users to personalise and customise all its functionalities to reflect the production reality of each farm and perfectly align the program's functionalities with the company's objectives and needs.

Feed management and evaluation of daily operations using mobile devices

The use of sinking feeds and subjective survival estimation pose many challenges for efficient pond management. At the same time, the short production cycle demands very frequent (weekly, in most cases) survival estimations and weight sampling, together with continuous biomass and feeding regime adaptations and updates. Tools to support rapid and accurate adjustments to the daily feeding and continuous fine-tuning of the optimal feeding regimes are a must and should be readily available to the farm manager.

Nowadays, shrimp farms rely mainly on hand-written feed registration and control systems. Although this practice might seem handy, cheap and fitting the level of education of the farm's workforce, it is not befitting the shrimp company's continuous drive for better controls in search of profitability and quality certifications. Handwritten data collection is prone to errors and puts a huge burden on the farm manager's shoulders as he is not able to see all required information in a consolidated format. Processing the data can be very time consuming and poses difficulties in demonstrating conformity during the ever more frequent audits.

Figure 1. Accurate data collection and reporting through mobile applications provide accesible information in a consolidated format.

With most of the work force familiar with smartphones and with the help of user friendly dedicated mobile applications and considerably basic training, the farm operators are able to register critical information directly on the field. Feeding, mortalities, water quality and issues in specific ponds or the whole farm can be accurately registered in real time, reducing errors and assuring that the system is always updated, providing total traceability at all times (Figure 1).

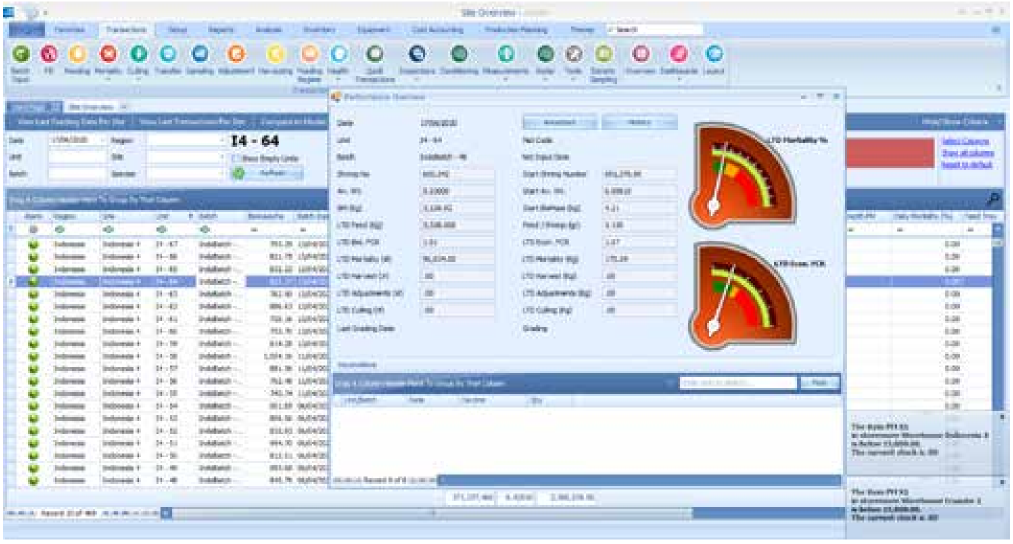


Figure 2. Farm and pond production overview screen

Production overview

Managers can monitor what is happening in real time and evaluate the performance of the personnel or even make spontaneous adjustments. Through powerful overview screens (Figure 2) that mirror the reality in the field, the managers have a "cockpit" in front of them to make the best-informed decisions.

The use of mobile devices with production management software has already changed the way shrimp companies in several countries are working. Farm technicians can perform the daily tasks in a faster and more efficient way, while managers have more time to focus on important tasks and production optimisation.

Even the most advanced software will never replace a good manager, in fact, it merely becomes his/her "best friend", as it empowers both the management and the personnel, by providing tools to assist the decision-making process in real time and to clearly demonstrate the results. Real time notification to the supervisors in case of a problem and the ability to generate management reports immediately, allow production managers to save time, reduce paperwork and increase efficiency.

Data Reliability and Modelling

Average shrimp weight samplings and pond density estimations are quite common in shrimp production. An accurate dataset consisting of production information between a period of any two samplings can be valuable in terms of a descriptive analysis of the production and further predictive analysis through accurate modelling. And here is where things get interesting! Each datum is unique and processes tremendous power when combined and analysed alongside other data.

A production management system ensures data validity, integrity and accessibility. This data can be used to engineer models, such as growth models or survival and feeding tables based on the actual data from the specific farm, tailored to the local conditions and production systems (Figure 3). These are not generic models or ones that are based on intuition, but accurate and personalised models that can even be used on the fly to run multiple production plans. Thus, the production manager can optimise future production, while at the same time reduce feed- and operational costs.

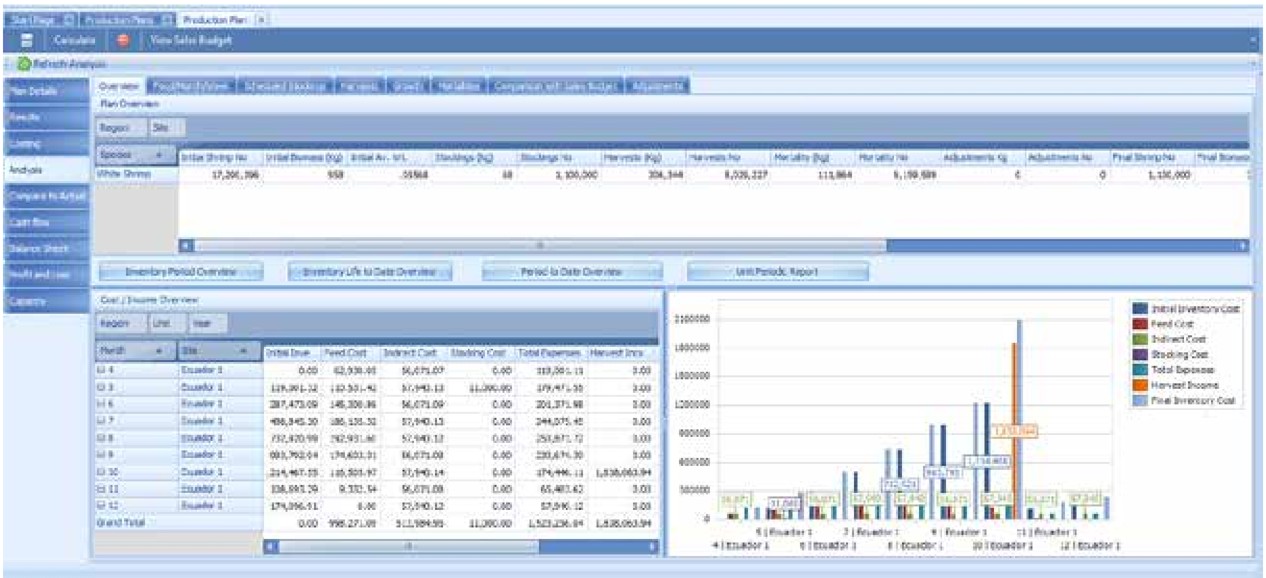


Figure 3. Tools for accurate production planning, cost overviews and budgeting

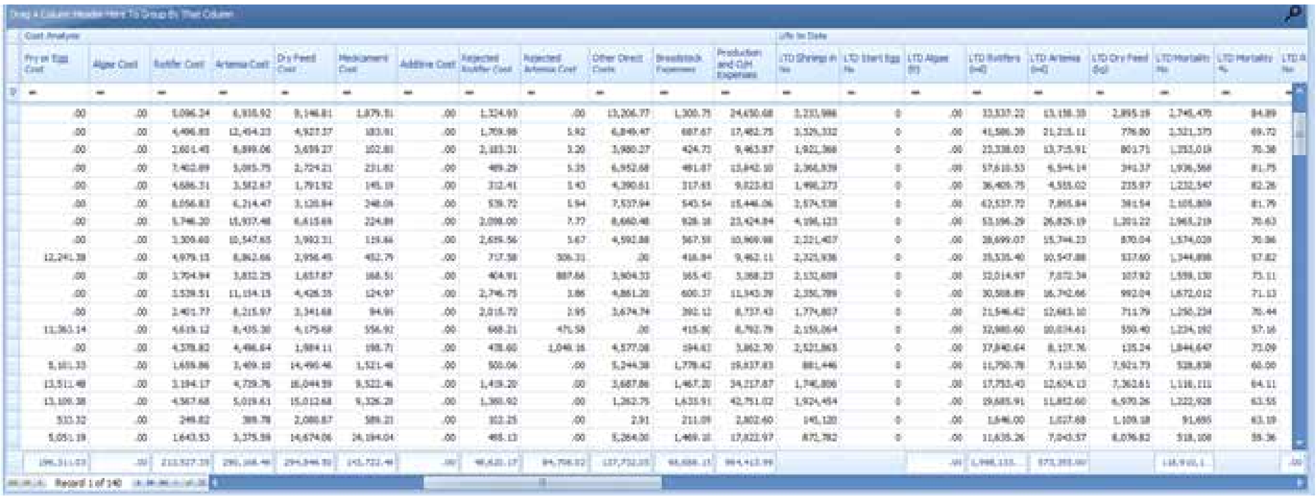


Figure 4. Hatchery Module showing costs breakdown.

Hatchery Module - traceability

Production control, traceability and cost analysis can go all the way back to the broodstock, through a dedicated hatchery module. A hatchery software module consists of specific departments for broodstock, hatching and incubation, live feed (algae and artemia) all the way to shrimp post larvae that are ready to be moved to nursery and grow out (Figure 4). Full traceability of both consumptions and population transfers in all departments can be achieved seamlessly.

For companies that operate both hatcheries and grow-out farms, the “Grow-out module” is automatically integrated with the “Hatchery Module”, assuring that every piece of information throughout the shrimp life is easily accessible and secured. Certification bodies are focusing more and more on details to ensure product quality and full traceability. By using management software, documented and accurate replies to queries, as well as accurate post larvae costs, are just a couple of mouse clicks away.

Cost analysis

Data reliability, error prevention mechanisms, traceability and inventory/storeroom management, not only reinforce production control but also allow a very accurate and automatic cost allocation.

Besides the direct costs, such as feed, probiotics, fertiliser etc., other production expenses and overheads (chart of accounts) can be either registered directly on the system or automatically imported through an integration with an enterprise resource planning (ERP) or accounting system.

A production software can allocate those costs on shrimp number basis, biomass or other more advanced ways. The result is an analytical breakdown of the cost into multiple components, i.e. total cost, remaining cost, post larvae cost, feed cost, harvest cost, mortality cost, cost of goods sold, adjustment cost and many more.

Additional benefits

Data integrity minimises the uncertainty and contributes to more accurate production and financial plans. The quality and validity of the collected data, whether they are registered at the field through mobile devices, or collected through integration of IoT devices, such as continuous water quality monitoring probes or feeding equipment, is ensured (Figure 5). A robust management software enables fraud detection and identification of false data (outliers). This minimises the uncertainty and contributes to a more accurate biological and financial planning.

Figure 5. Real time water quality measurements with IoT devices.

Visualisation of data and easily accessible analysis can assist in problem Identification and prevention of issues before they escalate. Timely identification of trends and patterns in production can make a huge difference and ensure profitability, especially when dealing with the short production cycles in shrimp. The success of shrimp production is affected by a multitude of factors of varying scope and impact, from the stocking density to feed composition, production practices, people and more.

A production management software allows producers to identify systematic relationships between the variables that affect production and dramatically improve sustainable production (Figure 6). Without a system in place, it is nearly impossible to quantify those relationships and focus on the areas that could potentially bring performance improvement. Feed and hatchery evaluation capabilities make it easier to select the best feeds and post larvae quality.

Operational efficiency through the establishment of workflows is one of the biggest advantages that can come with IT. Easier communication across all production levels and a better organised way of working can have a positive effect on the motivation and performance of the staff.

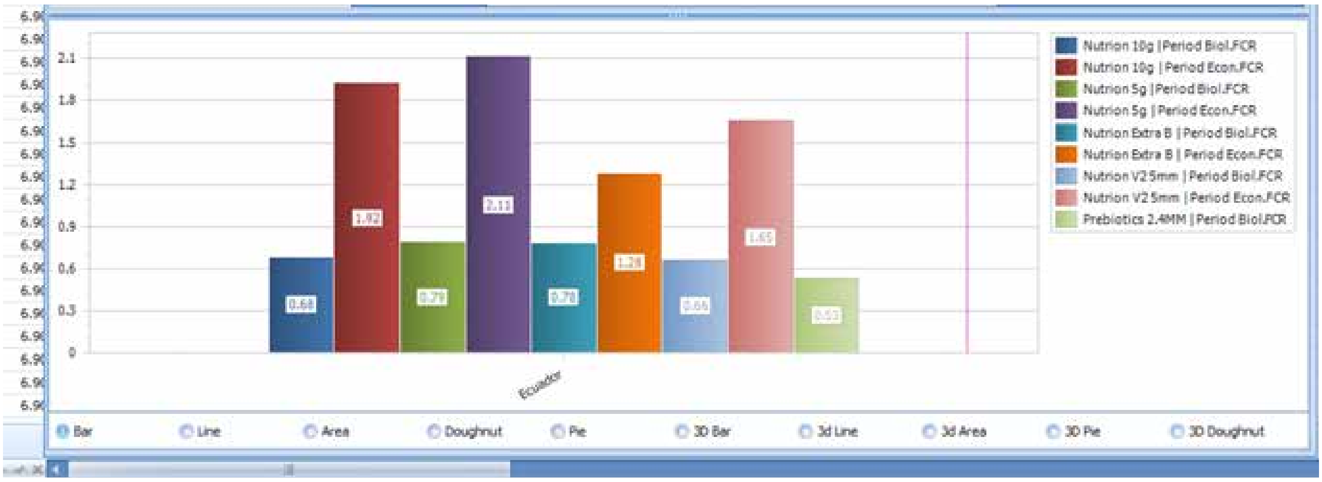


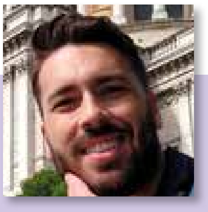
Figure 6. Feed performance comparison chart

Next day

Accurate data analysis and predictive modelling can provide each individual farm and the entire sector the capability to better understand the knowledge that can be extracted from a huge amount of data (environmental parameters, feed types, feed composition, feeding rates and practices, production management practices, etc.). From this data, educated assessments will influence the decision-making process and lead to greater efficiency and subsequently result in a faster return on investments (Figure 7). If one registers all the information, some significantly relevant results may emerge when comparing, for example, average water temperature, pond soil type, probiotics and moon phase with the prevalence of diseases. Once data are registered in a system it is possible to quickly and with very little effort evaluate a whole range of data and scenario, in search of knowledge that is both local and accurate.

The shrimp sector is still in its technological infancy. The tools and the capacity to empower shrimp producers are already available and the digital transformation is inevitable and part of our new reality. Making those tools accessible to everybody still demands some investment in IT infrastructure in many regions around the world, but solutions are evolving and getting cheaper rapidly.

What lies ahead is the challenge of educating shrimp farm owners, management and technical personnel, as well as the farm workers, on how investments made to control production can generate knowledge. This knowledge can be applied to bring higher returns and sustainable growth for the industry.



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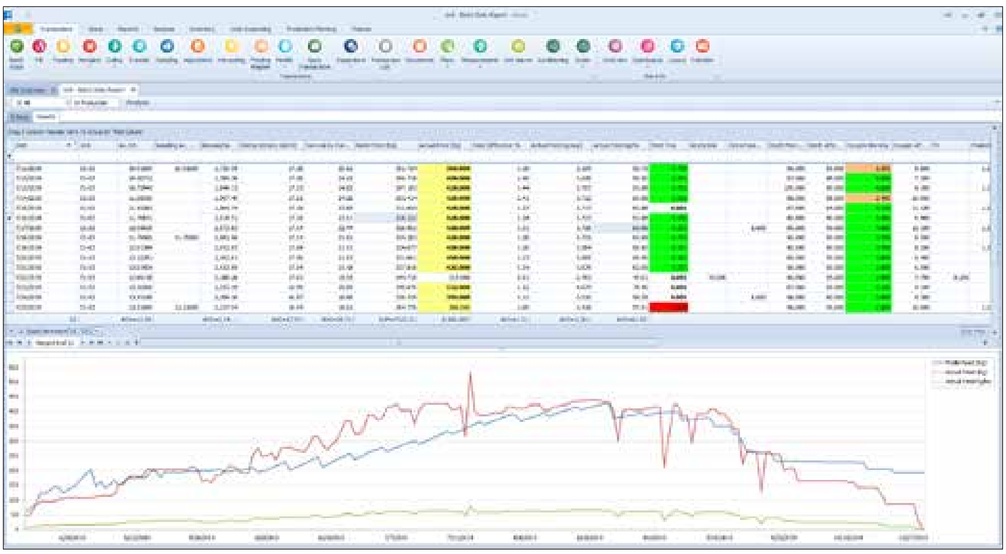

Figure 7. Tools for optimal feeding and feeding strategy evaluation.

Innovation opportunities on shrimp farms

New technology and innovations can have tangible, lasting impact on an industry trending towards energy and cost efficiency with less risks.

By Benedict Tan and Dylan Howell

Much like the algae-enriched water of many a shrimp pond limits visibility, the fragmentation and limited information in the global shrimp industry also hides the numerous challenges faced by shrimp farmers. The sheer scale of the USD70 billion global shrimp market warrants more attention to solve these issues. The species with the highest value and the largest volume traded is *Litopenaeus vannamei*. Valued at USD 30.2 billion, this species, commonly known as whiteleg shrimp, was traded in 2018, at more than twice the total value of the next most traded crustacean red swamp crawfish. At an average USD7.5/kg, 5 million tonnes of whiteleg shrimp were traded in 2018.

Between January and May 2019, three HATCH team members travelled to the top six leading shrimp producing countries to conduct an in-field survey of equipment and technology usage in grow-out shrimp farms. These were China, Ecuador, India, Indonesia, Thailand and Vietnam. HATCH has vested interests in shrimp because it is a business accelerator and venture platform launched to fuel innovation in the aquaculture industry. It helps startups become investment and market ready, thereby bridging the gap between innovative ideas and their commercialisation. The full report is available at www.shrimpfarm.tech

With support of the Walton Family Foundation, the study had three main goals: compare the 10 technology areas across the six regions, identify technology gaps, and highlight innovation opportunities. Entrepreneurs could gain better visibility of the challenges in the industry and potentially engage HATCH. The report could also facilitate learnings across different countries. In total, the team visited 86 farms wherein 81 verbal interviews were conducted.

This article summarises findings of the study and the potential solutions to address existing challenges.

Infrastructure

Modern farmers are gradually preferring lined ponds to substantially increase biomass carrying capacity, but these liners are expensive and not always as durable as claimed. In lined ponds, water and waste may leak through tears in the lining and remain stagnant under the pond lining on top of soil. The stagnant water and moist soil become anoxic, producing toxic gases. Subsequently, these toxic gases diffuse back into the shrimp pond though the damaged lining and trigger shrimp stress and mortality. Already working on thin margins, farmers face additional costs of removing the anoxic soil and replacing/repairing liners between crop cycles.

As a solution, the new woven and flexible geomembrane plastic liners, though available for purchase, are logistically or financially inaccessible to most. This is a new material in the market which farmers, especially in China, are adopting. The material is stronger, more durable and easier to fix, according to farmers using them. Thus, there is an opportunity of wider distribution of affordable and durable liners. New technology to monitor the liquid and gas below their pond linings could also help farmers plan for repairs.

Separately, improvements in nursery practices and any technological advancement will increase inclusion of on-site nurseries in farm infrastructure. Innovations that help more farmers to add nursery systems to their current operations will overall be beneficial.

Before and after photo of the construction of Mayank Aquaculture's shrimp hatchery and nursery facility in Surat, Gujarat state, India. Farms on the West coast in Surat, now can get post larvae locally from Dr Manoj Sharma's facility instead of having to buy from hatcheries in the East coast.

Operations and communication

Various opportunities for innovation in farm operations and communications systems exist. Cheap, user-friendly, smartphone-compatible and reliable applications can empower farmers to make informed decisions and forecast production. Integrated mobile apps could monitor shrimp behaviour, health and nutritional requirements, while tracking environmental conditions and farm inventory.

Currently, operational information is shared via text or verbally. Solutions to organise historical data records could standardise production protocols and image analysis of photos of written information can automate the digitalisation of farm records. With better management, farmers may track performance parameters, which in turn is useful for financial and insurance products to be introduced to the sector. Any one or a combination of the above will help farmers to better plan, manage, and communicate tasks for successful farm operations and harvests.

Power supply, control and consumption

Farmers do not actively measure their electricity consumption in general. A solution for widespread monitoring of power would likely come in the form of mobile applications. Farmers could forecast the monthly energy costs and even be prepared to deal with power failures. This mitigates the risks associated with power failures, chief of which is increased mortality due to reduced aeration.

More advanced apps would grant farmers the ability to control and regulate the power usage of individual devices (e.g. aerators) remotely. Farmers could optimise device use and schedule maintenance according to the device usage to avoid expensive repairs or replacements. Overall, greater cost savings would be achieved through lower energy use, currently a significant operational cost in intensive farms.

Water logistics

There are a few opportunities to improve water supply and water logistics technology. Improved pump efficiency is needed by farmers as pumps contribute significantly to energy costs. Making pumps more cost efficient, affordable and durable is a priority. Additionally, there is a need for enhanced monitoring and control systems. Pumps controlled by timers and built-in sensors for flow rate and water levels can mitigate the risk of pump failure during critical production periods.

Farmers on large and remote farms would especially benefit from remote-controlled pumps and make changes according to real-time feedback of pond levels and tidal regimes. Thai farmers use pond recirculation systems to recycle and reuse production pond water. If more farmers capitalise on unused ponds for on-farm water recycling, the water footprint of shrimp farming will be lowered substantially.

Aeration

Along with water pumps, aerators consume the most energy on shrimp farms. Aerators that are both cost-efficient and effective at increasing dissolved oxygen are welcomed by farmers. Sensors monitoring energy consumption of aerators and dissolved oxygen concentration will enable farmers to optimise energy use.

A young farmer in Chanthaburi, Thailand inspects his post larvae in his indoor nursery controlled by auto feeders, aeration and monitored by CCTV cameras.

The primary issue with aerators is corrosion of motors and moving components due to saline conditions. Corrosion-resistant motors or aerators in general would solve the problem of constant expenditure on repairing or replacing aerator parts. With remote monitoring of the mechanical performance of aerators, farms can also plan adequate maintenance schedules.

New aerators on the market have gearless motors with few moving parts and promise to be long lasting. However, farmers still prefer to repair and refurbish old motors until they are presented with a proven, cost-effective solution. There is huge potential for innovations to support farmers' needs in this regard.

Feed

Feed is the highest cost for shrimp farmers. Optimising for feed consumption is thus crucial, not only to save costs but to limit excess nutrients in ponds. Observation of feeding behaviour and shrimp gut manually using check trays is to understand feed consumption. Some companies have integrated acoustic sensors with auto-feeders to ascertain when the shrimp feed and then time feeding accordingly. Still, costs of these auto-feeders are prohibitive. As such, affordable and accessible innovation options for farmers would be immensely beneficial for farmers.

Existing non-remote auto-feeders are challenging to operate for staff because of the need to predict feeding rates in a day. Ineffective communication among staff can lead to incorrect feeding amounts. Improved auto-feeders would further streamline farm operations and mitigate ineffective feeding.

User-friendly sensors that measure shrimp biomass, movement, and feeding behaviour, can be integrated with management platforms to aid farmers in planning feed volumes and schedules. These tools should be simple to use, easy to install, durable in corrosive saline conditions and compatible with smartphones.

A woven HDPE lined grow-out pond with a custom central drain in Zhanjiang, China (Photo credit: Guang Jin)

Water quality and shrimp health monitoring

Multiple physical and chemical parameters influence physiological processes of the shrimp. Farmers need accurate, real-time information on water quality and shrimp health to make operational decisions. Most farmers rely on manual colorimetric test kits to measure water parameters and are unable to obtain quick results.

Currently, newer methods are needed for faster, more accurate and more frequent data measurements along with information collection, storage and analysis. New technology should automate the collection, storage, and analysis of environmental and health data as farmers lack the capacity to maintain their monitoring records. Several mobile apps and sensors with integrated water and health monitoring exist, but these solutions need to be further optimised for user experience.

New diagnostic tools for health monitoring should be user-friendly, re-usable and ideally allow the simultaneous measurement and quantification of a range of different algae, pathogenic bacteria and viruses.

Monitoring growth

Measuring growth rate of shrimp directly predicts multiple financial outcomes as farmers can determine the amount of feed required and the ultimate value of their current production cycle (the higher the count, the higher the price of the harvest). This is an immense opportunity for innovation.

Image recognition tools are already used in the production of other species in clearer water, but the limited visibility of turbid water used in shrimp farming restricts the use of existing technology.

One startup, XpertSea, has a device that analyses images of live shrimp to inform farmers on shrimp sizes, weight, growth rates and size distributions. However, this device is currently not used insitu so new innovations that conduct real-time underwater monitoring of shrimp would reduce the labour required to collect growth data. Naturally, this technology could also predict appropriate harvesting times for each production cycle.

Market size and harvesting

As mentioned in the previous section, there is great potential for digital insitu monitoring of shrimp biomass to predict harvest volumes and sizes. This also allows for more accurate feeding in terms of timing and feed quantity. Processing companies can receive information in advance to plan their operations and farmers will have higher negotiation power in price discussions with buyers. As market demand for different shrimp size classes fluctuates, knowing the size distribution of a particular crop allows farmers to set harvest dates that optimise for selling price. In-situ monitoring also negates the need for collectors to move sampling gear from farm-to-farm, thereby removing the risk of cross-contamination.

Faster methods to harvest shrimp are highly desirable for it reduces stress to the animal during harvesting and can hence improve flesh quality. Mechanical harvest pumps can gather up to 10 tonnes per hour and produce better margins potentially. This typically requires 4 to 5 hours if done manually with more manpower. On a separate note, large drainage pumps will likely be more available for farms that do not have sluice gates to drain ponds. This is already commonly used in Thailand.

Biosecurity

In general, backyard and small-scale farmers practise poor biosecurity. The primary source of pathogens originates from shared water supply sources, so farmers need better solutions to filter, treat, and eliminate harmful pathogens from contaminating their grow-out ponds.

The practice of inoculating ponds with probiotics to generate beneficial microbial communities that outcompetes harmful bacteria is a growing trend. However, farmers still cannot measure the microbial conditions of grow-out ponds. A solution to monitor this would enable farmers to take necessary actions, such as pumping, filtering, treating or recirculating between ponds, to optimise pond conditions prior to production.

Final thoughts

Though the full report describes the differences across the 6 countries, only data from farms believed to be representative of the most advanced or the most productive in each country are discussed. But this information remains salient regardless.

The impact of COVID-19 on the shrimp sector cannot be overstated. The shrimp trade has declined significantly, leading to the largest declines in the farm-gate and export prices in the past decade. This disruption, however, could be the impetus for farmers to overhaul production methods and incorporate new innovations. Operating effectively and efficiently is arguably more important now for shrimp farmers and the industry at large.

Importantly, solution providers must understand how farmers work with service providers from a supply chain perspective to effectively engage and provide value for farmers in each country.

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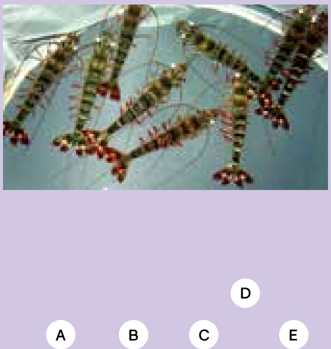
Managing AHPND, EHP and WFS

Industry leaders debate on the different challenges faced by farmers in Vietnam, India, Indonesia and Thailand at the virtual TARS Leading Conversations.



These five shrimp were originally from one batch of post larvae and were subjected to different pathogens.

A: White spot syndrome virus-infected shrimp;
B: Shrimp that was experimentally affected with white faeces disease;
C: A typical EMS affected shrimp;
D: Shrimp infected with EHP with some abnormality in the hepatopancreas and the midgut;
E: Specific pathogen free shrimp.

Figure 1. Transmission route for *Enterocytozoon hepatopenaei* (EHP)

Credit: ShrimpVet Lab, Vietnam

Figure 2. Size comparison of specific pathogen free (SPF) shrimp and four *Enterocytozoon hepatopenaei* or EHP-infected shrimp after two weeks of infection.

For the most part of 2020, Covid-19 took centre stage. The immediate and medium-term problems revolved around disruptions in the production chain affecting global shrimp supply and demand. Shrimp aquaculture's long-term problem is still the ongoing threat of disease and decreasing survival rates, which result in lower productivity and increasing costs of production.

During this pandemic, prices have fallen but with higher cost of production and lower survival rates impacted by disease problems. In general, management of the diseases, acute hepatopancreatic necrosis disease (AHPND) or early mortality syndrome (EMS), *Enterocytozoon hepatopenaei* (EHP) and white faeces syndrome (WFS) continues to be difficult for many farms while there have been success in some.

In this virtual conversation held on October 21, the focus was on the three major diseases; AHPND, EHP and WFS. Industry leaders: **Dr Loc Tran**, Founder and Director of ShrimpVet Laboratory, Vietnam; **Haris Muhtadi**, Chairman of Indonesia's Feedmill Association and Associate Director at PT CJ Feed and Livestock Indonesia; **Ravikumar Bangarusamy**, General Manager – Technical, Growel Feeds, India and **Soraphat Panakorn**, Commercial Development Manager, Aquaculture-Asia Pacific, Novozymes Biologicals, Thailand, were tasked to elucidate the current situation and debate on the different challenges faced by shrimp farmers in Vietnam, Indonesia, India and Thailand, respectively. They also contributed with suggestions on some of the best practices in managing these three diseases.

AHPND, EHP and WFS

Loc summarised the current knowledge on the three diseases:

- EHP is a major problem now in Asia causing severe slow growth in farmed shrimp and economic losses.
- AHPND which began in 2009, had quickly spread to several countries across Asia and it is still a major concern for shrimp farming across the world.
- WFS has become a growing problem, causing significant damage, during the culture period in several shrimp farming countries, including Southeast Asia and India. There are two types of WFS, one is recoverable caused by *Vibrio* or other bacteria, and the other with WFS in combination with EHP. Since the hepatopancreas will be permanently damaged, shrimp will suffer from many infections without being able to recover or resume growth.
- Alongside, these three diseases, white spot syndrome virus (WSSV) is still a major disease in Asia as well as globally.

EHP microsporidia form spores within the hepatopancreas cells, and absorb nutrients. "In laboratory co-habitation studies, we could induce EHP transmission via faeces of infected shrimp. Here we placed the infected shrimp inside a net suspended in a tank, with healthy shrimp in the tank.

After 24 hours, the healthy shrimp became infected and once infected, the shrimp will stop growing by about 70%," said Loc. For example, the average daily growth (ADG) of vannamei shrimp is about 0.3 - 0.35g/day; it may be reduced to 0.1g/day with an EHP infection.

A survey of post larvae, grow-out shrimp in ponds as well as broodstock feed (including bloodworm, oyster and squid) and broodstock faeces found that both EMS and EHP pathogens originated from the feed. Pathogens in live feed were transferred to the broodstock and then infected eggs, nauplii, post larvae and finally transferred to grow-out shrimp.

"A growing infection rate in both post larvae and juveniles was observed, indicating that pathogens can accumulate in the system which includes hatchery and shrimp ponds."

Additional Loc added that the systemic infection of *Vibrio* (such as *Vibrio harveyi* causing muscle necrosis) seems to increase (see box on page 39).

Controversy on pathogens of WFS

Typically, WFS affects shrimp at 30+ days of culture (DOC) and has been closely associated with eutrophication, algal bloom/crash and bad feeding management. "There is a lot of controversy about the causes of WFS," said Loc when presenting what his team has discovered so far.

"We worked hard on a bacterial etiology theory and isolated different types of bacteria from the gut of WFS-infected shrimp. We enriched and cultured the bacteria, and then soaked the bacteria in shrimp feed before feeding the feed to experimental shrimp. WFS was observed at a certain level and it was clear that bacteria at high density, is the direct cause of WFS.

Interestingly, we also found that shrimp affected with EHP will likely also have white faeces. So, what is the real cause of white faeces?"

"Subsequently, in an EHP infection study in a very clean environment where shrimp was fed with feed containing antibiotics to intentionally kill the bacteria, white faeces was not seen much.

However, pre-infection of EHP may result in white faeces in a later *Vibrio* challenge because the EHP infection causes damage to the hepatopancreas, allowing for any secondary bacterial infection. This is the reason why there are shrimp with WFS in EHP-infected ponds."

Loc underlined that typically, if samples were collected from shrimp grow-out ponds and tested for EHP, it is very likely that there is a 60% chance of a positive result.

The above is the general scenario with diseases in many shrimp farms. However, what is the situation in India, Thailand and Indonesia, going back to 2014 when AHPND first came onto the scene in most of Asia?

RB: Both WFS and EHP are widespread across India with outbreaks increasing at 10-15% yearly, since 2014. This year, 60% of farms are affected by WFS and I can divide this up as 40% of farms with infections at DOC 50-60 and 20% after DOC 20-30. In the latter, EHP was transmitted to WFS infected post larvae. EHP could be transmitted through untested post larvae. Poor sampling of post larvae and transport methods could affect accuracy of results.

Feed conversion ratio (FCR) as well as production costs, are increasing while survival rates are declining. When I compare shrimp productivity per billion of post larvae, both productivity and the percentage of the crop success rates are declining year by year. Since 2016, we see that irrespective of the stocking density, there is a drop in survival rate.

SP: Thailand has seen less outbreaks of AHPND and it does not create huge damage to production as before. However, cases of WFS and EHP are increasing and they come together. We not only see an increase in the number of WFS cases, but they are detected earlier; detections used to be at DOC 60-70, but now it is as early as DOC 35.

We also found that most WFS-infected shrimp were previously infected with EHP. The infections may have come together with the post larvae or shrimp infected after stocking in EHP infected-ponds in the last crop. EHP or WFS infections will be higher and occur earlier in ponds which have not been cleaned properly. The estimated increase of these diseases is 5-10% each year.

HM: Since 2014, we are noticing that WFS and EHP are affecting more farms in Indonesia. Farmers find WFS difficult to handle as compared to WSSV. WFS does not kill all of the shrimp. Farmers keep feeding them with no significant increase in ADG, resulting in increases in FCR and the shrimp sizes are not as good as expected. Unlike Thailand and Vietnam, AHPND is a new disease, reported in Indonesia in 2019. There is no official data but AHPND is now becoming a very serious problem and it is increasing from area to area.

"We have to think about disease management in terms of a big picture, not as a single pathogen."

Loc Tran

Among these three diseases which one comes first? If shrimp is infected with one, how predisposed are they with the rest?

LT: We are not dealing with a single pathogen, but multiple pathogens and we see a lot of co-infections. The effect is lowering the animal's immunity and making them more susceptible to other diseases. For example, I thought WSSV was linked to temperature, but I found that more cases were caused by fluctuations in bacteria in ponds or algal crash. We also found that shrimp pre-exposed to *Vibrio* are more likely to suffer from EHP later and vice versa. We must think about disease management in terms of a big picture, not as a single pathogen.

RB: *Vibrio* and EHP are pathogens associated with WFS. If a disease is caused by *Vibrio*, then it is treatable. An EHP infection has three levels: stage 1, stage 2 and stage 3. EHP stage 1 is reversible but stages 2 and 3 are difficult to treat even with good management practices, functional feeds and probiotics.

HM: Yes, I agree. It is almost impossible to find only one disease in our shrimp ponds.

Farmers strongly believe that some diseases and *Vibrio* like those causing AHPND come from the post larvae. From our experience, the same batch of SPF post larvae from a hatchery cannot guarantee the ponds' success during harvest; some may succeed while others fail. Most farmers know how to identify algal crash and bacteria that will trigger all kinds of diseases.

SP: A cocktail of the diseases happens everywhere, including Thailand. In most cases, EHP comes with the post larvae. EHP-infected shrimp are more vulnerable to other diseases (EMS, AHPND, WSSV) or adverse conditions such as heavy rain or plankton crash.

In Thai farms, WFS has been increasing especially during the rainy season, and my investigations show that it has doubled from the previous year's heavy rain or monsoon season. EHP has been increasing in recent years too.

However, suppose shrimp is infected with AHPND, chances for an EHP infection may be less because the shrimp dies first before the EHP symptoms show up. If shrimp is weak from WSSV, it will die before it can show the symptoms of WFS, AHPND or EHP. Today, our first step is to ensure that post larvae are EHP-free to prevent infectious diseases.

" In Thai farms, WFS has been increasing especially during the rainy season. EHP has been increasing in recent years too. "

Soraphat Panakorn

In India, are WFS-infected shrimp predisposed to RMS?
RB: Most ponds have a combination of both WFS and running mortality syndrome (RMS). However, the difference is that RMS starts when the shrimp reaches more than 25g.

After 20-30 days, it is difficult to continue the culture even up to 10g because survivals are low and the farmer will experience losses. RMS is related to poor pond bottom and water conditions, pond carrying capacity etc.

In Indonesia, is IMNV still very prevalent?
HM: Shrimp can be infected with WFS and infectious myonecrosis virus (IMNV) but farmers are more concerned with WFS because the mortality is faster and worse than IMNV. Now, farmers are struggling to control WFS and AHPND compared to IMNV, the disease that used to be a huge issue for Indonesia in the past.

Among these three diseases, which is of most concern for Thai farmers?
SP: Farmers worry more on EHP as he needs a microscope to look for spores in the hepatopancreas. But for WFS, over 1-3 weeks, he can see the white faeces floating on the water surface.

All three diseases have lowered survival rates, increased forced harvests and culling of ponds as well. What are the real survival rates in your country (discounting the bonus post larvae given by hatcheries) and changes in cost of production?
HM: Today, the average survival rate is only 50%, from 70% in the past. Even one or two diseases affect survival.

Production costs have increased from around IDR46,000/kg (USD3.26/kg) to more than IDR55,000/kg (USD3.90/kg) for size 45-50/kg. This is because WFS requires constant feeding and increases FCR to 1.8 from 1.4, while EHP causes low growth rates.

RB: Based on data collected from more than 800 ponds across India, most incidences of WFS were observed at DOC 50-60, while some were at DOC 20-30. When the shrimp sizes reach 30, 40 and 60/kg, the survival rate declines. Mortalities are slow and unnoticed, the survival rate at harvest is low as well. This causes farmers to harvest the shrimp when they see the onset of WFS and loose-shell (Table 1).

SP: For many years, our survival rates have been 80% and above, even when we discount the bonus post larvae. Now, some can reach 70-80% while others can only get 30%; on average, it is about 50-55%.

Both production costs and FCR are increasing as well. This year, we get smaller-sized shrimp that are sold with a lower price and farmers are suffering from production costs that exceed the selling price.

Prior to 2014, India is known for large size shrimp. Do you think that today, farmers target smaller shrimp and lower prices because survival rates drop so much after DOC 90?
RB: At 10-15g shrimp, I would say that the risk is very low. They do not have problems with survival. When it goes up to the 30-40/kg sizes, there is a drop of 20-30% in survival rates.

The cost of production in a normal pond for size 100/kg is USD2.27, while the pond with WFS has a slightly higher production cost.

At 30% survival rate, what would be the cost of production in Thailand?
SP: The number of farms with 30% survival rate is small but you can see that if production cost is THB100/kg, they can sell only 30% of the harvest. For sure, they lose three times of the production cost!

But it will also depend on the time of harvest. When shrimp sizes are only 200/kg which is the smallest size the market can accept, they can lose 3 the times cost of production. If they continue to grow shrimp and growth is good, they can reduce losses or even cover the production cost or even have some profit margins.

"..Most incidences of WFS were observed at DOC 50-60, while some were at DOC 20-30. When the shrimp sizes reach 30, 40 and 60/kg, the survival rate declines."

Ravikumar Bangarusamy

With increases in cost of production, are farmers hesitant to go back into farming or are they just skipping cycles to reduce losses?

RB: No, farmers are slowly implementing better management practices and the use of probiotics. Over the past three years, with Loc Tran, we are developing and fine-tuning the SOP. In our R&D farm, we also follow the regular application of probiotics at 2 to 3-day intervals and we found 20-30/kg size shrimp with no WFS, but with RMS.

The trick is to keep the *Vibrio* load under control throughout the culture period.

SP: Yes, some farmers skip cycles but many just reduce the stocking density. Ten years ago, it was regular practice to manage the harsh condition at the end of each year and the monsoon season by fallowing, reducing stocking density or number of the ponds stocked. But over the past 3-4 years, with new technology and confidence in feed and post larvae quality, many continue farming.

This year, Thai farmers have decided to return to the past practices and even let some ponds or farms fallow because prices are not very encouraging. They prefer to wait and see. With this Covid-19 pandemic, they are also uncertain of the future.

HM: There is no choice but to go ahead. But farmers have become more realistic, stocking 100-125 PL/m^2 instead of the usual, 150-200 PL/m^2. Another change is feeding. Prior to EHP and WFS, farmers push feeding with using automatic feeders or manually to get the maximum ADG. Today, it is lowering the amount of feed to control water quality. They focus on water treatment in reservoirs instead of treating pond water directly.

There have been reports of farmers managing by living with all these diseases. What mitigation procedures have worked for them?

RB: During pond preparation, we need to address the problem of EHP. Water treatment must change according to farm location. Probiotics application starts at 10-14 days prior to stocking. We have to continue throughout the crop. For example, over the DOC 100, we use water probiotic after fermentation up to DOC 50, i.e. 2X water probiotics: 1X soil probiotics. When feed input is high after DOC 50, it is 2X soil: 1X water probiotics. This is at regular intervals of 3 days. For each application, we only use 100-200g of probiotic after fermentation.

My recommendation is to use anaerobic fermentation and night application for soil probiotic. For water probiotic, the protocol is to use aerobic fermentation and application at 9-10 am.

Here in India, farmers do the first screening with PCR for viruses, but my advice is to do a *Vibrio* test first. Stress test should follow. We have been practising these in the past 2 years and do not have any problem with WFS and EHP in almost six crops in our R&D and customers' ponds.

SP: First, the diseases must be identified before they can be treated. In Thailand, we can roughly assume that there is a chance of the eight root trigger factors of WFS: from *Vibrio*, hydrogen sulphide, plankton crash, EHP, antibiotics (if used more than 10 days), some groups of bacteria and gregarine.

These may come as a combination of 2-4 factors and to manage or reduce WFS, identify and fix these factors one by one. With AHPND, when shrimp are molting and are in the sludge area, *Vibrio* will enter the empty stomach, colonise and destroy the hepatopancreas (Figure 3).

Farmers use these methods for shrimp health: select post larvae, nurse shrimp before stocking, lower saline water to avoid AHPND, use good probiotics and frequently monitor the water for bacteria count. Additionally, they remove sludge, use polyethylene (PE) lining and improve dissolved oxygen to ensure a clean pond bottom.

In cases of severe EHP infection, it would be better to harvest when prices are good. When shrimp size is small, farmers mix some easy-to-digest protein like fermented fish into the feed and add trace minerals, vitamins, sugar, salt and probiotics into the soluble feed to improve shrimp health. This makes the shrimp ready for a good size harvest.

"Farmers realise that most incidences are mostly triggered by the blooms, abundance of *Vibrio* and other bacteria caused by overabundance of organic material,"

Haris Muhtadi

HM: Indonesian farmers realise that disease is a combination of the animal and the environment. All hatcheries in Indonesia are using the PCR test as a mandatory test before releasing the fry to the farmer. Farmers realise that most incidences are mostly triggered by the blooms, abundance of *Vibrio* and other bacteria caused by overabundance of organic material. The management practice is to reduce the organic matter loads by chlorination, more water exchange to reduce plankton blooms and more siphoning. In the past, farmers siphon pond bottom after 35 or 40 days, but now they start from 20 days. We are also starting nursery culture (although this is still not popular), to have stronger post larvae after 20-25 days. Stocking density is lower and during blind feeding, farmers have cut back to only 60-70% of the ration.

LT: We can detect EHP in various samples, including broodstock feed, broodstock faeces, nauplii and post larvae. I recommend choosing large-size post larvae for sampling as there are difficulties in detection limits of methods when we sample small post larvae. They should request the laboratory to conduct real-time diagnostic or nested PCR.

If a shrimp is infected with EHP at below size 100/kg, what is the average growth rate?

SP: The ADG would be 0.2g-0.1g. Normal ADG would be about 0.25g up to 0.3g/per day.

If polychaetes fed to the broodstock carry EHP and AHPND pathogens, why do hatcheries still use them?

LT: Since we do not have a complete artificial diet for broodstock, we still have to rely on locally sourced fresh feed. But often farms discharge water into estuaries, and will contaminate the food chain which includes bloodworms etc. To reduce disease risks in oyster, we can remove the viscera and the feed contents inside, wash well, chop and refrigerate at least overnight. Freezing will kill EHP spores.

One way to reduce the density of pathogens, including bacteria and potential EHP in live polychaetes, is to keep them in flow-through water for at least 12 hours. EHP-positive polychaetes cannot be fed to shrimp but they may be frozen overnight. This can quite successfully control EHP and has been the practice in our hatchery over the last few years. It is laborious but is worth the while.

Do functional feeds work and if they do, why are they not used often?

RB: Functional feeds offer a solution and combining them with stringent feed management practices and the use of probiotics will produce excellent results. The amino acids and protein content are slightly higher than regular feeds.

The farmer should look at the unit cost instead of the cost of the functional feed/kg only. For 10g shrimp, we recommend the feeding rate for 100,000 shrimp at 24-25kg for regular feed and only 18kg for our functional feed. This means that the unit cost for functional feed is much lower.

HM: Functional feeds are about 15-20% more expensive than regular feeds in Indonesia, but over a crop cycle, the farmer can apportion into half functional feed and half regular feed. The increase in feed cost is insignificant when using a mix of functional feed and regular feed. More feed millers in Indonesia are introducing functional feeds targeted at various diseases.

Is there an association between WFS and soybean meal rich feeds?

HM: I do not believe so. However, phytase or any kind of antinutritional factor in soybean is meal, is suspected to affect the ability of the shrimp's hepatopancreas to digest feed that contains a lot of soybean meal.

SP: We found that the most important factor is not soybean meal, but it is the nutrient profile of the feed. Suppose that the nutrition profile is good enough with soybean meal added into the feed, the shrimp can grow significantly. Until now, it has not been proven to be true.

LT: We have worked with different formulations and high inclusion of soybean meal in the lab, but we have not seen any indication that it is associated with WFS. Whether we can formulate the diet well or not, it will affect the shrimp's performance in terms of growth rate. When we start seeing WFS caused by bacteria, our protocol is to produce fermented soybean and use it as a treatment for gut bacterial disease. Using a lot of soybean will make it difficult for the shrimp to digest the feed, so that is why I see more feed mills using fermented soybean meal in their feed instead.

Are there any remedial actions against AHPND?

LT: What farmers can do every day is to check the shrimp very carefully, such as during siphoning. If you detect any shrimp mortality, throw a cast net and collect at least 100 shrimp and put them into a bucket with some water where you check the digestive tract, including the hepatopancreas, stomach and midgut, for any abnormalities.

If you find any shrimp with an empty gut and atrophied hepatopancreas, do a simple dissection and crush the hepatopancreas to see if the content within the hepatopancreas turns white. If yes, this is a strong indication that the shrimp might be suffering from AHPND. Next is to follow all appropriate procedures to stop mortality, including reduced feeding, water exchange and application of some prophylaxis.

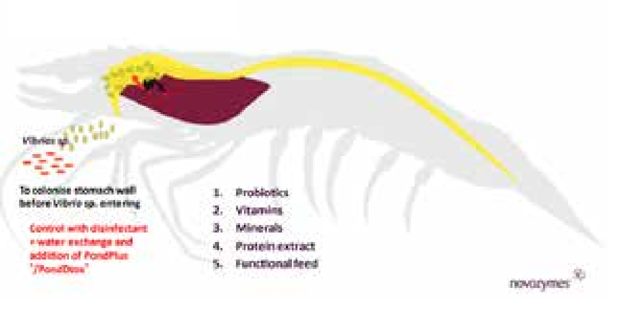
SP: The normal practice in Thailand for identifying infected shrimp is to drop an empty check tray at the edge of the sludge area in the middle of the pond and check it frequently for weak and infected shrimp on the tray.

Specific to Vietnam, what are the successful farmers doing right which you can share with the other countries

LT: Today in Vietnam, we understand that the disease pressure is very high. We can no longer continue with traditional farming methods. Many farmers are more consolidated and have invested in farm engineering, better farm design, water treatment system and ponds which allow them to have multiple phases.

First, they split farming into nursery and grow-out. They then divide the cycle into four phases, when they see problems. The nursery stage is 25-30 days starting with PL10 and harvesting 1g shrimp. In the nursery, the stocking density could be as high as 2,500-3,000 PL/m². Next, they farm at 300-500 PL/m² for another 30 days. In phase 3, stocking is at 150-200 shrimp/m².

Colonisation post molting



Courtesy, Sorapat Panakorn, Novozymes

Figure 3. The addition of probiotic should help to prevent attachment of pathogenic bacteria.

After completing phase 2, the shrimp is already about 8-10g and after another 30-35 days, the shrimp will reach around 25-30g. They will start partial harvests and continue to 30-40g, 50g or larger or they may transfer the shrimp to a very large pond, an earthen pond and farm shrimp at 50-70 shrimp/m² and allow the animal to reach 40g to more than 50g. By doing so, they can significantly reduce the risk of disease, nitrite toxicity (which sets in after 30 days) and *vibriosis*. We can reduce the damage from EHP and increase growth by transferring shrimp to a larger environment and reducing density.

In earthen pond culture, we follow Ravikumar's protocol. We reduce stocking density from 100PL/m^2 down to 40-50 PL/m^2. Farmers prepare the ponds properly and some send sludge samples to our lab to test for EHP. If the pond is contaminated, they either line the pond or have a crop holiday. Probiotics are applied regularly.

These are practices by some successful farmers but we still have to spread the success stories to more farmers. It is still a long way to go, but we are seeing a lot of successful farmers in Vietnam nowadays.

In conclusion, there are several takeaway messages from this conversation.

- There is no one major disease problem. It is always a combination of diseases that causes the mortality such as AHPND, WFS and EHP. EHP remains the most challenging at the moment. EHP could occur without co-infections with WFS and if shrimp are infected with WFS, there is high probability of EHP infections too.
- Multiple phases and adapting suitable stocking densities are mitigation strategies. Reduce stocking densities during stressful weather conditions.
- Detect diseases early with continuous sampling and monitoring. Do not wait for mortality or slow growth to set in.
- Functional feeds are not a silver bullet. It can only work in a holistic manner with good pond management practices.
- Evidently, the presence of WFS is linked to pond environment; disease management must be in terms of a big picture, not just for individual pathogens.

The video on the complete conversation is available at www.tarsaquaculture.com

Normal Ponds					
Shrimp size/kg at harvest	**100**	**80**	**60**	**40**	**30**
Average Survival Rate (%)					
Andhra Pradesh	93	90	82	75	66
Rest of India	90	87	78	73	65
Average	**92**	**89**	**80**	**74**	**66**
Feed Conversion Ratio					
Andhra Pradesh	1.00	1.13	1.26	1.41	1.60
Rest of India	1.00	1.19	1.31	1.52	1.67
Average	**1.00**	**1.16**	**1.29**	**1.47**	**1.64**
Cost of Production (USD)					
Andhra Pradesh	2.27	2.49	2.72	3.17	3.68
Rest of India	3.04	3.25	3.47	3.81	4.22
Average	**2.66**	**2.87**	**3.10**	**3.49**	**3.95**
Average DOC in Normal Ponds	**65**	**74**	**88**	**116**	**143**

	WFS Ponds				
Shrimp size/kg at harvest	**100**	**80**	**60**	**40**	**30**
Average Survival Rate (%)					
Andhra Pradesh	91	82	69	59	54
Rest of India	82	78	63	54	46
Average	**87**	**80**	**66**	**57**	**50**
Feed Conversion Ratio					
Andhra Pradesh	1.15	1.28	1.50	1.80	2.05
Rest of India	1.16	1.32	1.56	1.90	2.19
Average	**1.16**	**1.30**	**1.53**	**1.85**	**2.12**
Cost of Production (USD)					
Andhra Pradesh	2.63	2.97	3.44	4.04	4.51
Rest of India	3.43	3.58	3.95	4.25	4.74
Average	**3.03**	**3.28**	**3.70**	**4.15**	**4.63**
Average DOC in WFS Ponds	**74**	**86**	**105**	**133**	**160**

Table 1. Summary of crop analysis conducted by the Growel Feeds team. Stocking density ranged from 30 to 43PL/m^2
Copyright Growel Feeds Pvt Ltd, India.

Results from the three poll questions at the TARS Leading Conversations

Poll 1: Which is the biggest threat to your business?	
AHPND	36%
WFS	31%
EHP	33%

Poll 2: Would farmers use functional feeds? If so, how much premium price would they be willing to pay?	
0%	9%
1-5%	48%
5-10%	43%

Poll 3: Due to diseases, how much has your costs of production increased?	
0-10%	10%
10-20%	33%
>20%	57%

Nursery culture in 2020

Farmers recognise the advantages of on-farm 1 or 2 stage nursery systems in Vietnam and India.

Dr Manoj Sharma, Mayank Aquaculture recently completed a multiphase crop with two nursery stages which allows him to have two crops/year.

Adding an intermediate phase, between hatchery and grow-out is more commonly practised in Vietnam than in other countries. Here, the majority of nurseries are on-farm where small ponds or tanks are used. Dr Loc Tran, ShrimpVet Lab, gave reasons for the rather fast adoption. "These generally helps to increase the number of crops, improve farm production efficiency, lower production cost and reduce risks. Nurseries help in disease and culture management, from reducing vibriosis and nitrite levels, to minimising water exchange. Generally, nursery culture is 20-30 days to produce 0.5-1g shrimp for stocking in grow-out ponds. Farms in Vietnam have developed several versions of multiple phase farming, incorporating 1 or 2 stages of nursery phase."

Some large farms and farming groups in India have been adopting this trend with success. Dr Manoj Sharma, Mayank Aquaculture Pvt Ltd has recently completed a multiphase crop with two nursery stages. The first stage involved culturing postlarvae (PL4) to PL15, while the second nursery stage raised PL16 to PL35. This was followed by the third phase, the grow-out phase of farming over 60-80 days.

"My target harvest is size 40/kg, and we had an excellent crop of size 40-50/kg with 85% survival. Feed conversion ratio went down to 1.15. We achieved a 45-day reduction in the grow-out duration, disease prevention and reduction in operational costs (electricity, labour and feed). I can now do two crops a year which was not possible before. More importantly is that for the first 45 days, the culture is carried out indoors which gives me full control of the major pathogens; EHP and WSSV will be ruled out. At the pond level, I just need only to manage *Vibrio* loads. Once the basics are followed, I can get a good crop."

Other farms in India have caught up on this trend with mixed success. With vannamei shrimp farming, the push is to strive for 3- 4 crops over the year. To overcome the issue of transfer of juvenile shrimp, the recommendation is to construct a small pond in between the grow-out ponds, or alternatively, quick transfers can be carried out in small aerated tanks.

In a recent webinar conducted by the Society of Aquaculture Professionals (SAP) on 7 January 2021, farmers presented their success stories. A second generation farmer, Hetal Patel of Mindhola Foods described his two-stage nursery system in his Gokuldham farm; the first stage is in 900m^2 HDPE lined ponds, stocking 1,510 PL/m^2 and growing to 1.35g shrimp in 30 days and the next stage is in 0.2ha ponds stocking 515PL/m^2 and growing to 9.11g in 29 days. Survivals are at 89-91%. Subsequently, the grow-out is in 0.2ha ponds for 51 days growing large sized shrimp of 22.7-31g. At Ramaraju's farm in Vongole, Andhra Pradesh, earthen and lined nursery ponds are used, stocking PL10 at 0.5PL/L and 3-4PL/L respectively to grow 1g juvenile shrimp.

These much lower stocking densities in India contrast with recommended density in Vietnam where 2,000 - 4,000 PL12/m^2 are stocked in stage 1 nursery. In the second stage nursery, stocking is 0.5-0.6g PL, grown over 20-30 days and stocked at 350 – 800 PL/m^2 to reach 1-2g in 25-30 days (Dr Nguyen Thi Hanh Tien, Contom, November 2020).

Juveniles, PL35 at 0.2g

2020 HATCH Cohort

Annually, HATCH, offers a tailor- made accelerator programme to mentor seed or pre-seed startups with innovative and scalable solutions.

"Like business the world over in 2020, the Hatch Accelerator 2020 was decidedly different in how it operated. Eight companies formed Cohort 2020, which features companies from many parts of the world including Australia, Canada, Norway, UK and USA. Regardless of the conditions, the teams worked extremely hard with Hatch and developed a considerable amount in three and a half months, culminating in our first virtual Demo Day in December 2020," said Benedict Tan, Programme Coordinator, Hatch.

Cohort 2020 featured a wider range of companies in terms of their stage of development from previous cohorts. There are companies in early tech development stage such as Blue Lion Labs, ExciPlex, and Sea Warden. There are those with proven products and services looking to expand their sales and production such as Smart Oysters, ANB Sensors, and The Plant Based Seafood Co. Lastly, there are larger companies such as C-Feed and SuSeWi. C-Feed has been in revenue for a few years and is looking to expand internationally to access new markets. C-Feed has currently raised €4 million round. SuSeWi is raising Series B funds currently to build a full scale production module and activate their offtake agreements.

"Most of the Hatch team has yet to meet the participating cohort in-person. Running the programme virtually over 3.5 months was challenging. There was the scheduling of sessions to take into consideration the 21-hour time difference and obtain a common time for all the companies to participate. The 1-1 sessions between the cohort and mentors often had to be split up over a few days, "added Benedict.

With both movement restrictions internationally and domestically, company development was slower. Things such as team expansion, generating investment leads, research and product development occurred at a slower pace. "Still, we believe that the additional time enabled companies to think through important decisions and strategise better. With Hatch's support, Cohort 2020 will emerge from this period with more robust and resilient businesses.

"Our vision of achieving the least-possible footprint for farmed and alternative seafood remains the same, and it is perhaps more important now with more attention placed on aquaculture as a form of food production. We know that Cohort 2020 has a key role to play in this through better farming management, sensor technology, and higher quality feed with lower environmental footprints," said Benedict. www.hatch.com

Calibration-free pH measuring technology

Cambridge, UK based startup **ANB Sensors** has been developing smart, affordable, self-calibrating pH sensing technologies since 2017. Co-founders Kay McGuinness and Nathan Lawrence discovered this niche for calibration free pH sensing technology when they entered the Wendy Schmitt Ocean Heath Xprize. "Now with ten patents filed on the technology, we are ready to commercialise our sensor," said Kay

There are two products: iRef – which is an enabling technology for the glass pH sensor market and the S Series – an all solid-state sensor with novel chemistry. "Our S Series pH sensor is not complex; it essentially is a plug and play device, which is affordable and requires low maintenance. All that is needed is to polish the probe before use, and the sensor will inform the end user when it is time for a repolish, or a replacement."

The innovation was developed for oceanography and therefore, ideal for marine aquaculture. In 2021, the team will look into sensors for freshwater applications, and in contrast to deep sea monitoring which requires pressure resistant housing, ANB is developing cheaper housing for shallow environments.

Competitor products are the fragile glass electrodes which need to be manually calibrated on a regular basis, and do not operate in low buffer media. "This frequent manual calibration to maintain accuracy has a huge impact on maintenance costs and quantity that can be deployed, whilst also having a significant environmental impact. Our S Series sensor is robust and there is no need to have technicians checking and calibrating regularly," said Kay.

Nathan Lawrence with the sensor on a Blue Robotics underwater vehicle.

"The accuracy of the S Series is currently at 0.05 pH unit, although we are continually improving. This accuracy should be sufficient for use in aquaculture where the fluctuations in pH are as critical as are minimum and maximum readings."

ANB Sensors is analysing the demand for pH measurements in aquaculture. While the demands are often to have a multitude of parameters within one device, and indeed the technology roadmap for the team includes other sensing analytes, they presently remain focussed on pH.

Currently data is communicated to the underwater vehicle or stored on an SD card for buoy deployment. In the future, there will be possibilities to link the data using AI and connect wirelessly to mobile phones etc. www.anbsensors.com

Farm management and production software

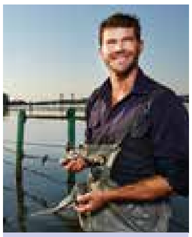
While running his family's oyster farm as well as marketing oysters, Ewan McAsh, found that in large farms, a large part of the time is taken up with data collection and manual recording. Together with James Horton, COO with experience in business and technology, Ewan started **Smart Oysters**, a multi-platform farm management mobile app to transform and optimise oyster farming. The software includes scheduling, communication and reporting on a customisable web-based reporting app using Wi-Fi and GPS. Smart Oysters is already in revenue with the software used by oyster farms in Australia, New Zealand, US, UK and Ireland. The team is looking to expand into Asia.

"In oyster farming, there is a lot of stock movements and many crops with multiple sizes. This software solves the problem of tracking where the stock of a certain size is, when it was last handled, and what has to happen to it next. This is instead of depending on the memory of the farm operator," said Ewan.

"It also helps that the mobile app has a spatial GPS map of the farm for easy tracking. The scheduling function records on the map, and validates that a task has been done and actions to be taken. In our journey with this app, we have managed to solve Ewan's problem but also discovered that the old manual method involved a lot of double entry.

Smart oysters Moana repair Needed Pin

Using SmartOysters has solved that problem," added James.



Ewan McAsh

"Our application system is very much focussed, not only on helping farmers manage farm operations, but doing so in a way that reflects their unique farming practices. Basically, we provide farmers with a map-based mobile phone application that allows them to schedule, record and manage their farm activities. Farmers can quickly alert workers to tasks that need to be done while they are out on the farm, as well as schedule tasks that need to be done in time, in weeks or months. If farmers come across something that needs repairing, they can easily take a photo, capture the location and schedule a maintenance task. It gives them a complete record of their sustainable practices." said Ewan.

According to the team, what they have discovered is that there is a need for versatility. The software is applicable in the farming of other species which needs an operational tool. It is already being trialled on seaweed, mussel, and finfish farms around the world. The app is also suitable for an integrated shrimp farm stocking daily and requiring current stock information for harvesting daily to supply a processing plant. There can be transparency all along the supply chain for managers.

Some future features that are being added include capturing and linking with environmental data, RFID tags and market data, smart certification etc.
www.smartoysters.com

Remote auditing tool

Hawaii based **Sea Warden**, founded by Zack Dinh, CEO/CTO, Shelby Oliver, Head of Product, and David Wang, Head of Engineering, has developed remote auditing and data analytics solutions to reduce the cost and complexity of certifying farmed seafood. This is through satellite observations, image capture and data storage and analytics.

"We are focused on monitoring shrimp production around the world. We see this service as useful throughout the supply chain including feed millers, processors as well as equipment supply companies that are looking to identify regions they should be targeting for their business. Shrimp buyers, such as importers and retailers, can access valuable information for future purchasing decisions. At the farm level, we want to identify production volumes, stocking times etc. We also want to see how our approach can assess the production status across the country," said Shelby.

An interesting aspect is how such technology can help to predict production (and therefore supply) as farmers make decisions on stocking based on projections on prices which may change by the time the crop is completed. Demand generally increases by 1-3% annually. "Our capability can certainly detect production activity and what is happening at the pond level. We use cloud-penetrating technology, enabling year-round monitoring at weekly intervals. We can observe routine pond fallowing, a best practice that reduces disease risk, as well as detect early pond emptying across a region, a potential indicator of disease outbreaks."

Other than certification bodies that may find this tool useful, the team is also targeting financial institutions that need data to be collected to verify production levels and also for risk management. "We are currently working with the Aquaculture Stewardship Council (ASC) on a pilot project. They are looking at ways satellite observations can help in auditing, making certification more accessible as well as increasing level of certification and cutting costs."

Shelby also explained how this remote auditing technology works, "At a general level, satellite observation allows us to track pond activity and some other operational aspects, but we will also need to assess a lot of other things. We have included a photo verification component. The app asks the farmer to submit more data such as photos of activities (e.g. water discharge, proper disposal of sludge etc) according to the requirements for certification."

As they continue to develop the app, Sea Warden is open to working together with farms, certification bodies, or financial/insurance institutions to determine the types of data required and provide data storage, and with certification auditors to test version 1 at the farm level.
https://seawarden.io

Cutting edge diagnostics for mycotoxins

Working out of Michigan, Daryl Staveness, CEO of startup **ExciPlex** wants to redefine how we detect mycotoxins. Daryl founded ExciPlex, Inc. in 2020, inspired by his desire to use his scientific background to develop molecular-level innovations with real-world impact.

ExciPlex has a cutting edge simple photochemical method built from the molecular level up. It is based on an exciplex/excimer principles whereby detection molecules pair with key structures in mycotoxins. The resulting pairs have specific photochemical and photophysical properties which can be detected with simple spectroscopic technologies. This technique is thus a unique blend of photochemical and agricultural sciences.

"Mycotoxin contamination is a persistent problem in all feeds for livestock and aquaculture. The conventional and often expensive methods measure them early in the feed supply chain, while little is known about the ramifications to the fish and shrimp or the impact on farm and profitability," said Daryl. "What we are developing is a completely new way to detect mycotoxins, and it works in finished feeds. This is a much simpler and faster way to detect mycotoxins that works on the farm, which will be much faster and even cheaper than sending a sample for testing with conventional methods using HPLC or even LC-MS."

The testing steps are simply, mixing of sample, filtration and testing. Toxins are identified and quantified with diagnostic signals unique to each mycotoxin, and ExciPlex's on-farm device will allow for detection of these signals with a smartphone. This proprietary technology is new in the field of diagnostics. The team has worked with aflatoxin, deoxynivalenol, zearalenone, and ochratoxin A to date, but they expect that this technology will apply to a multitude of mycotoxins and even other analytes.

"We would like to see farmers or their nutritional consultants testing for mycotoxins in feeds on-site prior to feeding. In addition to the diagnostic technology, we are developing a device that will enable on-site detection with a protocol that will take only 2 minutes or less."

The final product is anticipated to be a stand-alone, smartphone-associated testing device which analyses pre-sold test kits that utilise a simplified water-based extraction procedure.
www.exciplexinc.com

Daryl Staveness

Live copepods in fish and shrimp hatcheries

The CFEED Team

Copepods 10X. Credit: Tora Bardal/NTNU.

As the worlds´ first large scale supplier of industrially farmed copepods, **CFEED** is leading the way in making this superior live feed available for the aquaculture industry. Based on 15 years of R&D at SINTEF Ocean, the company moved into their pilot factory in Vanvikan, Norway, back in 2016. Since then, they have been increasing their production capacity steadily, closing in on an annual production of 200 billion copepods, delivered to hatcheries all around the world.

"A great selling point for us is to provide a bio-secure live feed that can be hatched on demand and fed to the larvae 24 hours later" says Tore Remman, CEO, who has previously held managing positions in business development at both Mowi and Nutrimar. "It is also possible for the hatchery to increase the size of the copepods by feeding them live algae, thereby adjusting the size to the growing fish larvae."

Another great advantage of copepods is their superior nutrition. While Artemia and rotifers undergo enrichment to improve the nutritional value, copepods are inherently high in DHA/EPA. When combined with the high protein content of the copepods of close to 70%, the result is a feed solution that does wonders for larvae of marine species. CFEED has seen numerous benefits on the biological development of the larvae fed copepods, among them faster growth, better survival, less deformities and increased stress tolerance throughout the whole production cycle.

CFEED is already in revenue and its participation in the cohort 2020 is to access potential clients and setting up production facilities in new geographies. "The small size of the copepod, 100 µm in length, upon hatching make it an ideal prey for a variety of warm and cold-water marine species. Successful trials have already been conducted for tiger grouper in Thailand, barramundi in Singapore, and various other species such as Tuna and *Seriola* sp. in Japan and Korea," says Tore.

"The large shrimp market is a target for us, although the challenges are entirely different. There, a pathogen-free status of the live feed is critical. We are regularly monitoring our whole in-house production process and checking for diseases as part of the process to secure SPF-accreditation. For shrimp, we see the zoea and mysis stages as an ideal fit for our product."

CFEED is currently supplying copepods globally. Transported on ice, the product can be stored cold for weeks. Among the challenges expected are import regulations into some countries. "We are looking for hatcheries and research institutes to establish import protocols and conduct trials," added Tore.
www.cfeed.no

Smart aquaculture in pandemic year 2020

At this TIFSS, offline and online services to link international visitors and push for smart sensing and smart control of farming.

Display on R&D at the National Taiwan Ocean University

In 2020, after a two-month postponement, the Taiwan External Trade Development Council (TAITRA) and My Exhibition Co. successfully held the sixth edition of the annual Taiwan International Fisheries Seafood Show (TIFFS) on December 3-5 at the Taipei Nangang Exhibition Centre. Usually, this is an annual event where researchers, academics, farmers, vendors and buyers of seafood products come together to update on the latest innovations in aquaculture and seafood products and to network. In 2019, international exhibitors mainly came from Southeast Asia to learn more on the technological developments in Taiwan's aquaculture. After all, Taiwan has long been recognised globally not only as an important fishing nation but also as one which has developed cutting edge technologies in aquaculture and leads in its commercialisation. There had to be changes in this pandemic year with international travel restricted. Organisers arranged a series of online and offline digital services, including a "2D online 1-on-1 procurement meetings" for international buyers who cannot visit Taiwan. AAP conducted google-meets with selected exhibitors (see pages 63-65).

This year, on-site exhibitors were mainly local Taiwanese companies. There were 150 exhibitors with an estimated 4,000 visitors attending the three-day tradeshow. The one-day "Marine Fish Farming Technology Forum – where formulation meets science" became a hybrid conference covering advanced aquaculture nutrition, innovations in aquafeeds and marine farming technology. Presentations from several international experts were pre-recorded.

SBM and advanced aqua nutrition

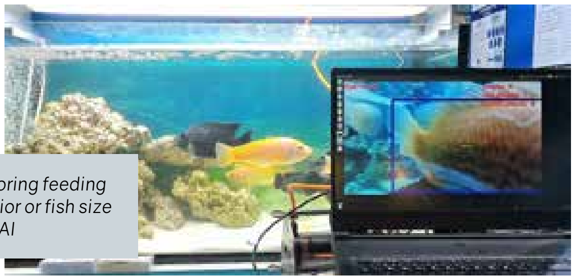
Professor Yu-Hung Lin, National Pingtung University of Science and Technology, Taiwan dealt on the regulation of nutrient utilisation and metabolism in fish fed a plant-based diet. With declining fish meal availability, prices will dramatically increase. However, the use of soybean meal (SBM), the most widely used plant ingredient is limited due to missing nutrients, and that it contains anti-nutritional factors. Lin said that recent studies reported that when fish meal was replaced by SBM in diets, some issues were low nutrient digestibility, poor growth and depressed immunity, resulting in fish being easily susceptible to disease. Other problems were enteritis, fatty liver, high oxidative stress and visceral fat in fish. Through the next generation sequencing (NGS) analysis, fish fed with high SBM-based diet showed up-regulated cholesterol synthesis but down-regulated bile salts synthesis, and poor lipid and protein digestion and absorption when compared with fish fed a fish meal diet. Therefore, in modern aquafeed production, nutritional strategies for fish fed a plant-based diet need to include optimising the feed formula by using functional feed additives and/or bioprocessing feed ingredients. New techniques, such as proteomics, genomics or metabolomics, can be applied to screen for potential problems when plant feed ingredients are used in fish diets.

In his presentation on sustainable ingredients and formulation in aquafeed application and how SBM can do more, **Hsiang Pin Lan**, USSEC Taiwan, pointed out that considerations are methionine, lysine, digestible phosphorus, long chain omega 3 fatty acids and taurine. Attention should also be given to feed attractability and indigestible carbohydrates. The maximum inclusion rates of soy nitrogen free extract (NFE) in feeds for major fish species were listed as 16-17% in carps, tilapia and channel catfish, and 12.5-13.5% in marine shrimp. Results on growth performance of tilapia fed diets containing US origin SBM or SBM from Brazil were presented.

Smart cage aquaculture

On the application of artificial intelligence (AI) in smart cage aquaculture management systems, **Professor Chung-Cheng Chang**, National Taiwan Ocean University (NTOU) said that Taiwan has excellent expertise and application capabilities in aquaculture technology and information technology. The application of AI to optimise aquaculture management, reduce costs and energy consumption, and increase productivity, can help pave the way for a re-emergence of Taiwan's aquaculture industry.

"If we can actively integrate resources to accelerate the development of intelligent aquaculture technology, we can certainly become an international AI aquaculture innovation centre as well as drive our domestic aquaculture and allow us to compete with other countries. Cage culture has great market and business opportunities and can attract international investors. For example, Japan is very keen in breeding black tuna on the east coast of Taiwan. This will contribute to the economic development of Taiwan."



Monitoring feeding behavior or fish size using AI

He presented some research findings such as those applying state-of-the-art AI techniques to implement a practical Smart Cage Aquaculture Management System (SCAMS) useful for minimising cost of farming and maximising yield. "We set up five sub-systems to cater for the following: Omini IoT ; intelligent image behaviour monitoring and analysis; automatic measurement of fish body length and weight; AI smart feeding and automatic submersion of cages; and accident protection.. An AI farming services company will be established upon the completion of this project to provide industry with various technical services" (Figure 1).

A nutritional strategy

The two company presentations were by DaBomb Protein and Sheng Quan Biotechnology Corp. **Jeffrey Jiang**, DaBomb Protein said that in the past two years, the company, has been focussing on a nutritional strategy for antibiotic-free marine aquaculture. The new concept is referred to as "ProbioSynTec", combining the words– probiotics, synthesis and technology. Jiang also elaborated on a fishmeal alternative where the latest research results showed that DaBomb-P could replace

Jeffery Jiang, Manager, DaBomb Protein Corp (right) with CEO, Alice Liu, (middle) and Zong-Da Jiang, Assistant Researcher.

75% fish meal in a low fish meal diet for shrimp, without adverse effect on growth, immunity and health status. To overcome disease problems, the new immuno-plus prebiotic product "DaBomb-LIVE" plays a key role with resistance to *Streptococcus* infection in four finger threadfin fish. In field results, DaBomb-LIVE reduces 75% of antibiotic use and increases survival by10%, leading to economic efficiency for the farmer. Jiang concluded that the company will continue the research on ProbioSynTec to further support the industry.

Free radicals in the water environment

Sheng Quan Biotechnology has been working on this less well- known concept in aquaculture for several years. **Seeker Chen** said prior to this, researchers could not explain why diseases persist although water quality parameters were in the normal range, in terms of dissolved oxygen, nitrate, nitrite, ammonia and ammonia-N, pH, salinity, conductivity, oxidation-reduction potential and total dissolved solids. "Indicators of the water quality before the occurrence of diseases have been addressed often by researchers but according to our study on the environment, free radicals are the pre-indicator of water quality deterioration. Free radicals can cause damage to cells and immune systems."

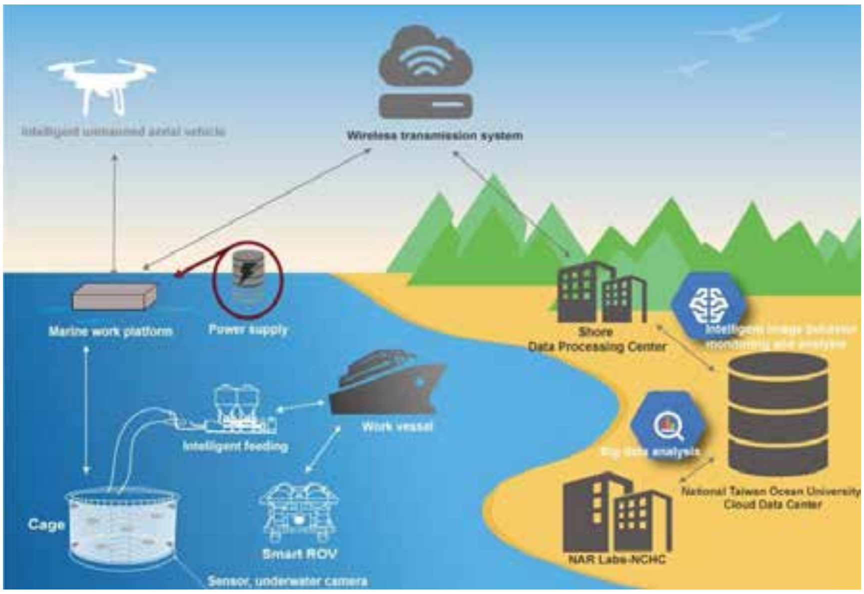


Figure 1. Professor Chung-Cheng Chang, National Taiwan Ocean University (NTOU) showed how AI can optimise aquaculture management, reduce costs and energy consumption, and increase productivity and pave the way for a re-emergence of Taiwan's aquaculture industry.

The formation of free radicals, an unstable state of natural substances in the environment may occur anytime as environmental stimulations to the natural substances can change. For example, oxygen can become superoxide which is both highly toxic and active when receiving environmental stimulations. "The worse the environmental pollutants are, the greater the amount of free radicals in the environment, causing severe damage to the fish or shrimp. The free radicals come from air pollution and the microorganisms in the subsoils," added Chen.

The company has designed a simple, low-cost, and highly accurate free radical detector (FRD) that can quickly determine the concentration of free radicals in water with the naked eye. It has also developed a plant based free radical neutraliser. (see page 64).

DC direct drive paddle wheel aerators

Today, conventional paddle wheel aerators are driven by AC induction motors with low torque combined with a gear box to drive the impellers at ~100 rpm speeds. A transformation from this, is the new long life and quiet DC direct drive paddle wheel aerator from **Dyna Rechi** with energy savings in mind, a no gear reducer and a compatible motor base.

"Getting rid of a gear reducer is a major improvement for a paddle wheel aerator. Our magnet-based brushless DC motor rotor design increases the motor's torque to directly drive impellers and reach 84% motor performance. Essentially what we offer to aqua farmers is a DC aerator which only consume 500~600W/hour," said Lesley Hsiao, specialist at Dyna Rechi, adding that the savings in energy consumption are around 40%~45%, compared to AC driven paddle wheel aerators in the market. DC aerators give flexibility with adjustable speeds– from 60rpm to 105rpm.

"DC aerators are new in the market and most farms still have AC aerators and components (such as aerator frames and impellers), in stock. We want farmers to easily switch from AC induction motors to a BLDC motor without buying other DC special components. Therefore, we designed our BLDC motorbase to be compatible with most AC aerator frames."

"We launched this product in May 2020 and passed the performance test conducted by the Green-Product Certification Division at National Cheng Kung University. Recently, we sold 113 sets to aquafarmers participating in the 50% subsidy program of the Taiwan Fisheries Bureau, to improve farm efficiency. This was an achievement as DC aerators with rotor magnets are more costly than copper

Lesley Hsiao, with the DC direct drive paddle wheel aerator.

made AC driven ones. Customers can further appreciate these aerators when they see the savings in electricity costs. We want to introduce this aerator to markets in Southeast Asia in 2021, especially in the Philippines where electricity costs are three times that of Taiwan. We have an office in Thailand and will look for overseas distributors and partners," said Hsiao.

By April 2021, Dyna Rechi hopes to launch an app with control features like turning-on/off, adjusting speed, scheduling day and night operations of the motor and receiving alerts from mobile devices. The aim is to ease operations, especially for large aquaculture farms. "We want to link sensors on water quality to aerator operations. We are also developing 2HP BLDC motor for 4-6 impellers which are more energy saving than 1HP motors. At Dyna Rechi, we see unlimited possibilities in reducing energy usage and our aim is to become the leading provider of advanced energy saving products. We will keep moving forward including researching and developing techniques to operate aerators automatically, based on the big data," said Hsiao. www.dynarechi.com.tw

Fish health and nutritional solutions

Alltech is a global company providing natural-based products and solutions for animal health and nutrition. In Taiwan, the company celebrated its twentieth anniversary in February 2019. Lillian Chang, Business Support & Marketing Manager, Taiwan, said that aquaculture is a small market in Taiwan, as compared to that for swine, dairy and poultry production. But the sales team is working closely with farmers such as the tilapia farmers in Chiayi, the centre for tilapia farming in Taiwan. "Our products for aquaculture include mineral complexes, nucleotides, mycotoxin binders and yeast-based prebiotics. We have pig farmers who are also farming tilapia and they are now showing interest in Actigen®, our second-generation yeast-based prebiotics to optimise gut health. Their focus is on increasing growth performance and specific shape of the tilapia."

Lillian Chang (right) and tilapia farmer, Huang in Tainan City's Liu Guan area where tilapia is the major fish species. The goal is to produce the high value Taiwan Tilapia brand with specific shapes.

The team in Taiwan is also encouraging fish farmers to shift to the use of organic minerals instead of inorganic minerals. It is also trying to promote the use of Aquate™ Defender, a combination of prebiotics and essential minerals to optimise digestive function, improve feed intake and reduce feed conversion ratio. "Our key players in Taiwan's aquaculture industry are the eel farmers who started using Actigen some 5 years ago. As eels are of high value, we see that these farmers recognised our product," added Chang. Taiwan's aquaculture is a challenging market. "It is not only a small market, but we also need to create awareness and convince farmers to change. The industry is also changing with the second and third generations taking over, where the interest is in smart aquaculture and in product branding which requires more attention to product quality. At TIFSS, we also promoted our global focus on environmental sustainability. With the reduction in the use of fish meal in aquafeeds, we need to support the industry on the use of alternatives to fish meal and ensure feed digestibility without compromising on growth performance."

Chang added that Alltech Taiwan will be launching Viligen, a proprietary and synergistic blend of innovative ingredients, zinc and acidifiers. www.alltech.com

Free radicals in aquaculture

Shengquan Biotechnology Co., Ltd. focuses on toxin removal in agriculture and aquaculture, as well as in various environmental water treatment, testing and maintenance facilities. The company was set up in 2015, after 6 years of research by NTOU on shrimp ponds. The researchers found that despite ideal normal water quality parameters, disease problems persist. Looking at how environmental toxins directly affect aquaculture, they discovered that toxin levels are closely related to the concentration of free radicals, which in turn can determine the health status of the fish and shrimp.

Researchers have developed a free radical detector as well as a free radical neutraliser, both of which were presented at this show. "What we are marketing is the detector. Here we dissolve a tablet which will give fluorescence. The degree of fluorescence will determine the amount of free radicals," said Seeker Chen, General Manager. "We use plant extracts as a free radical neutraliser, to remove free radicals in the water, which will not cause any harm to the organism or the environment. This product is marketed as "Undine" and is available in powder and liquid forms.

Ashley Wu showing the tablet in water during the Google Meet interview with AAP.

"Of course, we can measure the amount of free radicals in other ways, but using fluorescent technology is the cheapest way. Our tablet only costs one US cent/tablet. In terms of market, we are interested in Southeast Asia, the leading region for aquaculture and are looking for distributors. We are also interested in markets in Africa and Latin America. Since this concept of free radicals is new, we need to create awareness first." (see page 58 on free radicals in aquaculture).

Seeker Chen with Karen Kuo, Business Manager at the booth of Shengquan Biotechnology Co., Ltd

Intelligent and portable water quality device

MIC Meter Industrial Company, established in 2010 by Jane Shih, General Manager, produces intelligent aquaculture instruments. Based in Taichung, it is one of Taiwan's leading company for instrumentation. Shih saw potential in the aquaculture industry. On display at TIFSS was its portable water quality device to measure salinity, ORP (redox potential), dissolved oxygen, ammonia, pH and temperature in fish ponds.

The cable-free device is solar powered with the battery on a floater. Readings are sent to the cloud via 4G and WIFI to either a single LED panel or a large screen showing those from many ponds, the latter for large farms. Farmers can receive alerts on smart phones. The price of the device also includes the small NBioT fee (only USD1 per month). The cloud storage is free for the latest 12 months and may automatically send data via set email per month. "The farmer can view data wherever they are," said Shih. "Developed by in-house R&D engineering team, this is the most popular and cost-effective aquaculture water quality monitory device in the market. In the future, we will integrate with weather stations and AI to activate aerators remotely, depending on weather and water quality conditions.

"It is quite important for clam farmers to measure ORP between the water and bottom mud instead of just immersing the probe in the water. Our latest invention is a 1-2m long. This innovation is the first online device in Taiwan. The readings are transmitted via free IOS or Android apps," said Shih.

"One major issue is on-site calibration of the probes, requiring visits to some 400 customers all over Taiwan. In 2020, with the pandemic, this was not easy. An easy self-calibration process is essential. We are currently developing a blue tooth and mobile phone app to communicate with the devices and quickly organise calibration. It is important that our customers feel confident and have no doubts on the readings from our devices. We have also started a project on cleaning of the probes.

"Overall, we have been successful in marketing our water quality devices. In April, we sold 200 units and 80 panels to fish, shrimp and clam farmers at 50% cost of equipment under the government's subsidy program. We appreciated this recognition, as otherwise, at USD2000 each, it will be difficult for our small farmers."

The company has sold units to customers in the US, Germany, Japan, Egypt and the Philippines and is seeking distributors for Southeast Asia markets. "We believe potential markets will be China, South Asia and Brazil," said Shih.

Jane Shih displayed; solar powered battery, LED black panel and LED multi pond screen.

Functional additives and enzyme complex

Lytone's booth at TIFSS.

With a history of innovating science-based solutions, data-driven technologies for food production, since 1994, **Lytone Enterprise, Inc.** has now applied some of its products for livestock into aquaculture. One of them is Azofeed which contains around 70 trace elements including rare earth elements extracted from ocean volcanic sediments. In aquaculture, it is a functional additive which can completely supplement the trace elements, helps in enzyme synthesis and improves gut health and growth. With its buffering effect, when added directly into the pond water, it stabilises water conditions and help algae growth.

It has OMRI organic certification, halal certification, GRAS products approved by the US FDA, and meets the Association of American Feed Control Officials (AAFCO) standards for use in animal feed. The product can be used in organic aquaculture. "We have added Azofeed into diets for the white shrimp and crabs and have shown 10% faster growth and 10% higher weight gain. In fish, the benefits have been less fatty liver conditions and therefore, we had more healthy fish with more lipid synthesis," explained Alex Yang, Technical Sales Director, Animal Health Division.

"We started marketing it in aquaculture some 3 years ago. We see that in China, there are many products with the same benefits. As such, we have been working to gather data to demonstrate the special attributes of Azofeed. As this is a cheap product, we focus on the species with large production volumes in China and Taiwan such as white shrimp, freshwater fish, mainly the grass carp, largemouth bass and tilapia and grouper and seabass."

The company is also looking at applications for aquaculture of some of its enzymes and probiotics developed for livestock farming. "Anizyme is an efficient complex of enzymes (among them β-mannanase, β-glucanase, xylanase) which improves digestion in poultry. In aquaculture, we think that it can help in ingredient digestibility, such as corn and soybean meal. It may help in feed gelatinisation. These are some new ideas but we still do not know how the aquafeed market will accept them," said Yang.

"We know that our products can help the farmer improve production and have better profit margins. My job now is to encourage the farmer to try out our products. This is especially important in 2021. In 2020, with the pandemic, we saw that fish prices dropped 20-30% and prices have not improved yet.

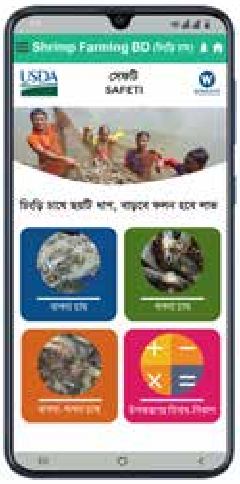
"In Taiwan, we have agencies tasked with the detection of antibiotics in food production. Therefore, another target for Lytone is to look at products that can replace antibiotics used to treat diseases in fish and shrimp farming. It is essential that we find alternatives, but not as prophylactics," added Yang. www.lytone.com

The *"Shrimp Farming BD"* app

Winrock International is implementing a five-year project in Bangladesh to improve production and trade of farmed marine shrimp and freshwater prawns, with 250,000 farmers and other industry businesses targeted. Winrock is a USA not-for-profit development organisation and the Bangladesh project - called "Safe Aqua Farming for Economic and Trade Improvement (SAFETI)" - is funded by the United States Department of Agriculture.

SAFETI is introducing improved farming methods to the country's shrimp and prawn farmers and has developed a mobile phone app as one way to support them. The '*Shrimp Farming BD*' app contains information on the improved technologies - from pond preparation through to harvest - and has a calculator that farmers can use to work out the quantities of chemicals, feeds and other inputs they need for their pond.

Also incorporated is a Frequently Asked Questions (FAQ) page where users can find answers to common questions with a single click: and they can send specific technical questions to SAFETI specialists online and receive an answer back within hours. The app can also be used to post news messages, and a link to market prices is planned.



The app can be downloaded from the Google Play Store and then used online or offline. It is only available in Bengali language, but already has 14,000 users, including some in the neighbouring Indian State of West Bengal. Under the Covid-19 conditions, it has been particularly valuable as a support to Bangladeshi smallholder shrimp and prawn farmers, and will serve them as a remote learning resource well into the future. www.winrock.org

Distributing live SPF polychaetes to India

Florian Renault

SPF Shrimp Feeds, a company co-founded by Stephen Christensen and Florian Renault, specialises in live, fresh, and natural specific pathogen-free (SPF) feeds for shrimp hatcheries. For the last 18 months, SPF Shrimp Feeds has worked closely with Topsy Bait (The Netherlands) to perfect the packaging, transportation, and in-country storage system that allows for live polychaetes to be shipped anywhere in the world and kept alive in-country for daily delivery to shrimp hatcheries.

Prior to coming to market, the two companies worked closely on a three-month trial that fed Topsy Bait's live SPF polychaetes to shrimp broodstock, benchmarking against local, wild caught polychaetes common in Asia, as well as frozen polychaetes. Additional laboratory testing revealed cold-water origin polychaetes have a far superior nutritional profile than tropical worms. The *Nereis virens* polychaete profile include; protein, 13.49 g/100g; hydrolyzed fat, 2.06 g/100g; moisture, 81.40g/100g; DHA, 23mg/100g; EPA, 135.1mg/100g and total fatty acids, 1547.1mg/100g.

The biosecurity benefits cannot be understated. It is 100% farmed in a completely biosecure environment, according to GMP+ and HACCP standards with certifications. The OIE recognises The Netherlands as an aquaculture disease-free country, and further government testing prior to export guarantees the polychaetes to be free of EHP, DIV1 and AHPND.

Live SPF polychaetes as a shrimp broodstock feed will increase the nauplii number per female; increase the mating rate; increase the maturation rate; offer better recovery after each spawning; increase the sperm quality; increase egg quality (higher hatching rate); and offer full traceability from the worms to the final shrimp post larvae. These conclusions are substantiated by data collected over 18 months of sales and customer trials.

India's Coastal Aquaculture Authority (CAA) deserves praise for its role in approving the first ever import license for live polychaetes, a monumental moment for India's shrimp aquaculture industry.

SPF Shrimp Feeds is the exclusive distributor of Topsy Bait's Live SPF polychaetes in Vietnam and India. Topsy Bait also sells SPF polychaetes under the Delta Farms brand, making it the world's biggest and only commercial scale SPF polychaete (*N. virens*) farm. www.SPFshrimpfeeds.com

New fish feed fact ory in Chittavaram

Bharat Luxindo Agrifeeds Pvt. Ltd. inaugurated its new factory in Chittavaram, Narasapur in January. This is the company's 18th year in the aquaculture industry in Andhra Pradesh, India. Bharat Luxindo is instrumental in the use of pelleted feeds in rohu farming.

"This new factory is a testimony of the success we have achieved in our quest to make an impact in the industry with new initiatives and using best practices in aquaculture," said Yeo Keng Joon, Chairman. He thanked all stakeholders for their loyal support over the years, dealers, farmers, suppliers, employees and all their families.

"The Covid-19 pandemic has caused us enormous hardship and restricted our travel to India but our management team have put up this new factory, largely on their own without our directors being present in India for the last twelve months. This is indeed an achievement. Our dealers and customers have great confidence in the capability of our management team."

Yeo also said that the marketing team, led by Kameswara Rao has started the demonstration FFGG (Farm of Future Grow with Grofish) farm in Korukollu in March 2020 using the pelleted Grofish (100%) and broadcasting feeds instead of using the feed bags tied to poles.

"We have excellent results. This is part of our initiative to introduce modern farming practices in rohu farming in Andhra Pradesh that will increase the profitability of our

customers and to reduce pollution and wastage caused by the use of DORB in the fish ponds. We have also initiated another demonstration farm nearby in Palakol where we have used our pelleted Grofish for Rupchand (pacu) fish. We have since started a third FFGG farm in Eluru last month growing rohu."

Bharat Luxindo plans to introduce FFGG farm in each major rohu growing area – to introduce and convince all traditional farmers to use its rohu seedstock, Grofish pellets and broadcasting the feeds.

"There is a big potential for the use of pelleted fish feeds in Andhra Pradesh and this new factory is testimony to our confidence in the growth of our products in the years to come." www.bharatluxindo.com

RAS@EAS: A new element of the EAS Aquaculture Europe events

The European Aquaculture Society AE2020 event is taking place online on April 13-15.

On April 12 (before the conference starts the following day) EAS is organising a full day 'special' event RAS@EAS. To complement the science presented in the parallel sessions of the AE conference, RAS@EAS looks to take a different approach - with the emphasis on bringing together key figures from science and industry to focus on key issues, present the latest knowledge and share experience with different species and systems.

The first RAS@EAS event is entitled **"Creating an Optimal Environment"** and 3 panel discussions will address key questions related to this:

- Session 1: **How do we best approach disinfection?** (Moderated by Jaap van Rijn of The Interuniversity Institute for Marine Sciences in Eilat (IUI), Israel and with introductory presentation by Chris Good of the The Conservation Fund Freshwater Institute, USA.)
- Session 2: **Where are we going with monitoring & autonomy?** (Moderated by Øyvind Fylling-Jensen of Nofima, Norway and with introductory presentation by Bård Skjelstad of ScaleAQ, Norway.)
- Session 3: **What are the most challenging interactions between fish & RAS environment?** (Moderated by Damien Toner of Bord Iascaigh Mhara (BIM), Ireland and with introductory presentation by Jelena Kolarevic of UiT The Arctic University of Norway/ Nofima, Norway.)

More information:

Participation in this online event is included in the AE2020 registration and participants can register https://www.aquaeas.org/Registration/Submit/AE2020

For the RAS@EAS event. Registration is FREE for EAS members and is €100 for non-members.

2021

To have your event included in this section, email details to **zuridah@aquaasiapac.com**

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

April 13-15 (online)
Aquaculture Europe (AE2020 Cork)
Cork, Ireland
https://aquaeas.eu/

June 6-11
ISFNF 2020
Busan, Korea
www.isfnf2020busan.com

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 2021
Melaka
www.livestockmalaysia.com

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

September 7-9
Seafood Expo Global 2021
Barcelona, Spain
https://www.seafoodexpo.com/global/

September 7 - 10
Asian-Pacific Aquaculture 2021
Surabaya, Indonesia
www.was.org

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

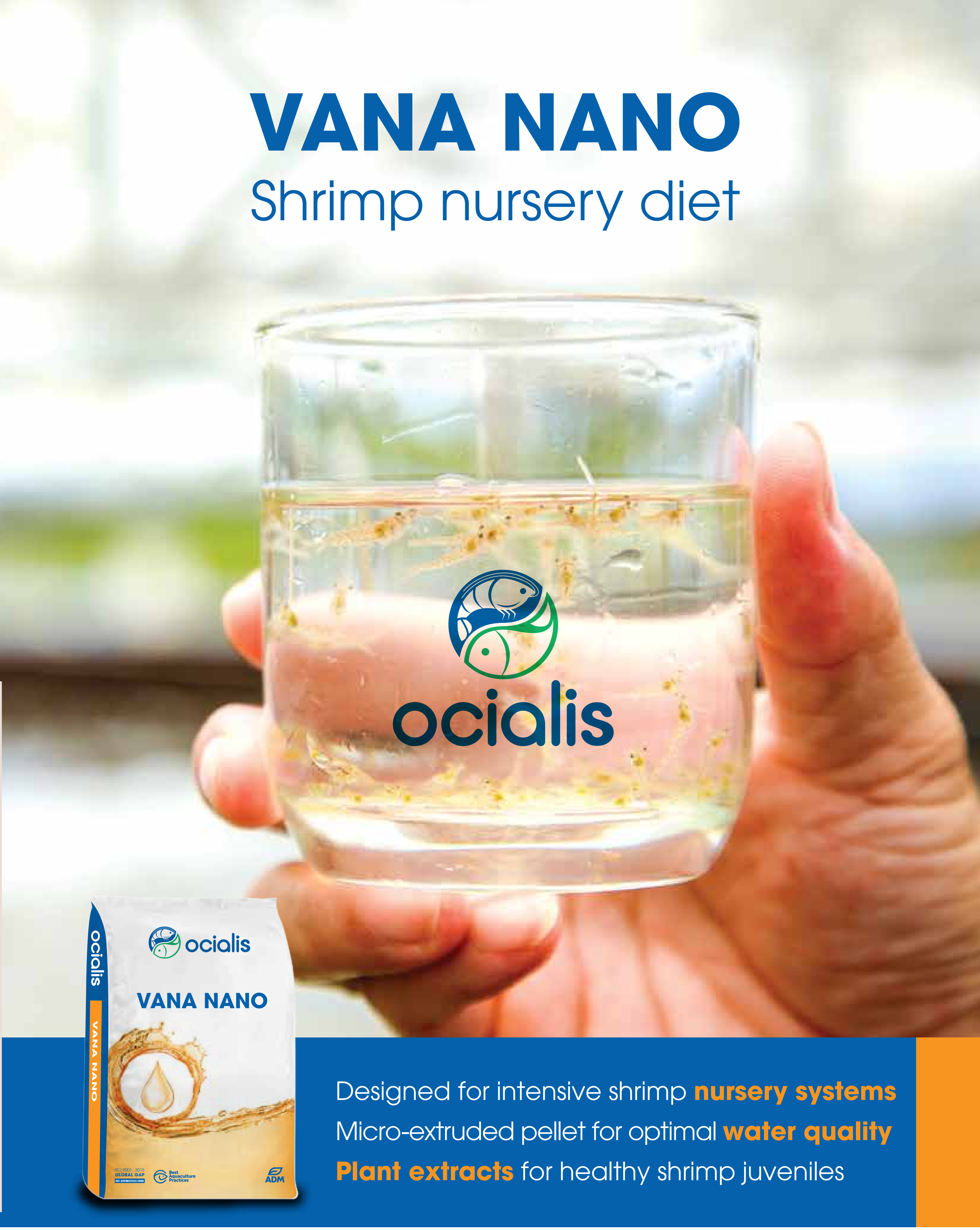
September 22-24
VIV Asia
Bangkok, Thailand
www.viv.net

October 4-7
Aquaculture Europe (AE2021)
Madeira, Portugal
www.aquaeas.org

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

November 15-19
World Aquaculture 2021
Mérida, Mexico
www.was.org

December 10-13
AFRAQ20
Alexandria City, Egypt
www.was.org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