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Zuridah Merican

We start by reflecting on the higher supply over demand for global shrimp. Recall that 2022 was the revenge year for shrimp consumption post lockdown and China was expected to recover its appetite for shrimp in 2023. This did not happen. Ecuador continued to increase supply with its technification to an average of 23PL/m². At the recent CFSE 2023 in Qingdao, an industry source said there was lukewarm response for shrimp, even among China's buyers. The strategy to produce larger shrimp for better prices, both for vannamei and black tiger seems to have been replaced by a new demand for smaller black tiger shrimp disrupting the large size niche market. To balance the demand-supply equilibrium there were proposals to set a long-term global shrimp marketing campaign at the Shrimp Summit in Vietnam and Global Shrimp Forum (GSF) in The Netherlands to boost consumption. The Chinese market remains a target of most producers – from Ecuador, Saudi Arabia, Madagascar, India to Southeast Asia.

For marine fish, interest in RAS continues. To overcome scale-drop disease in Singapore's waters, Barramundi Group plans to move its production to RAS in Brunei.

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2023: The Year That Was

Vietnam wants to grow its marine fish aquaculture but knows that it needs to push for industrialisation. Salmon prices reached the highest level with good margins despite threats of sea lice. However, we cannot say the same with tropical marine fish. We know that the market must lead the supply chain. The live market is the only strategy that producers are familiar with, despite economic uncertainty and reduced dining out in Asia.

The two major Asian freshwater fish- tilapia and pangasius, still face cyclical fluctuations of supply and prices in markets. The major market for the tilapia is the US, which is now dominated by producers in Latin America. With poor domestic demand in China, buyer offtake has been slow, leading to higher costs as farmers keep their fish in ponds for longer, said Dr Yufan Zhang (issue July/August). The low margins cascaded along the supply chain. The reopening of China in March helped raise ex-farm prices for Vietnam's pangasius, but farming remained unprofitable with high production cost, despite the use of local feed ingredients. There are reports of farms downsizing.

Whether shrimp or fish, disease featured as the main threat everywhere. While shrimp producers struggle with WSSV, AHPND, WFS and EHP, the latest threat was shown in a recent article by Feng Yang et al (2023) with post larvae mortality from a highly virulent *Vibrio parahaemolyticus*. Nevertheless, the Shrimp Summit projected more shrimp production, as catastrophic disease losses are no longer correcting global production.

Feed prices continue to remain high despite the easing of prices of major feed ingredients. This gives feed companies some breathing room after a very difficult 12 months. Fishmeal prices are now facing upward pressure after a fishing season in Peru was cancelled, adding to costs in aquaculture feeds. Fish oil prices have increased 10X to USD9,200/tonne, 107% up y-o-y. This situation is paving the way for algal oils. El Niño has arrived and it is

expected to have its maximum effect towards the end of the year when the warming of the Eastern Pacific oceans results in lower fish stocks. This provides an opportunity for novel feed ingredients. Calysta's 20,000 tonnes/year single cell protein plant in China has been commissioned while industrial insect meal producers are in expansion mode. However, the industry realises that these volumes are supplemental and not replacements due to the significant increase in aquafeed production and hence demand. New players in the single cell protein ecosystem are coming on board.

A major theme at GSF was the increasing pressure by certification bodies such as ASC in promoting sustainable feed and feed ingredients. This will come at a cost premium and two major questions were asked. The first is the timing of the implementation when the shrimp industry is already facing margin pressures due to the low product prices. The second is if this cost can be spread along the supply chain since it would be impossible for the feed company or the farmer to bear this alone. Another question was raised if this would advantage the integrated multinational companies and disadvantage smaller local feed producers which could result in an unlevel playing field.



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CARE FOR
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Young Thai shrimp farmers meet their Indonesian counterparts



USGC's Caleb Wurth (right) with speakers and participants. From left, Sookkasame Jarupong, AquaBiz, Thailand; Suphawit Suklim, Petsinat Farm, Trang, Thailand; Daniel Trisno, Alphatrio, Singapore; Benedict Tan, Hatch Blue, Singapore; Christopher Tan, Mida Trade Ventures, Singapore; PMI's Denny Leonardo and Rizky Darmawan, Indonesia and Daranee Seguin, Thailand.

An exchange of ideas on shrimp farming in Thailand and Indonesia was facilitated by the US Grains Council (USGC) in Bangkok on October 31 at the Thai Next-Gen Aquaculturist Seminar in Bangkok. The criterion for farmer participation was under 40 years old and this applied to the presenters as well.

Thai participants were mainly next generation farmers, comprising those helping their parents run farms, as well as those who have already taken over the total farm management. They came from all over the country - Surat Thani, Krabi, Trang, Pattani, Chonburi, Chumporn, Chachoengsao and Chanthaburi. Among the 72 participants and speakers were newbies to the industry, startups, researchers from BIOTEC-NSTDA, NGOs and investors.

USGC, aided by Thai consultant Dr Vinij Tansakul, curated this agenda to catalyse farming amidst market challenges. The Young Shrimp Farmers of Indonesia (or their acronym in Bahasa Indonesia, Petambak Muda Indonesia-PMI) recounted on how they have come together as one voice to shape the future of shrimp aquaculture in Indonesia.

"The mandate of USGC is to develop markets, enabling trade and improving lives. The shrimp farming industry in Asia has reached almost 50 years old. The founders are in the midst of passing the baton to the next generation. Over this period there has been questions on change and continuity. In this seminar, we want my generation to integrate well in shrimp aquaculture and learn from each other. We have taken up this mission to provide a platform for the young shrimp farmers to seize opportunities to grow," said **Caleb Wurth**, USGC Regional Director for Southeast Asia and Oceania, who is also part of the younger generation.

Market challenges for Thai shrimp

The Department of Fisheries Thailand has forecasted shrimp production in 2023 at 294,000 tonnes which was 14% higher than that in 2022. Thailand remains one of the primary producers in the global shrimp markets with 80% of the production exported. "Thailand has a good reputation for quality," said **Christopher Tan**, Mida Trade Ventures, Singapore, in his presentation on "The global shrimp markets and where does Thailand fit in". "More than half (~52%) its shrimp is exported frozen, 30% is value added such as tempura and breaded shrimp, while the rest are consumed locally. Shrimp exports, valued at USD1.52 billion represents 1% of the national economy. Therefore, this industry deserves attention."

Some 32% of exports go to the US, followed by 24.4% to Japan and 13.6% to China. While producers face a competitive commodity market in the US, the Chinese market buys niche Thai products like live frozen shrimp. "Unfortunately, as other producing countries copy, it is likely that Thailand's exports will suffer. In the US market, Thailand's volumes have stabilised over 2019-2021 but other producers such as India, Ecuador, Indonesia and Vietnam have increased their market share. Peeled shrimp used to be the forte of Thai exports, but this has been taken over by India and Ecuador.

The outlook does not look good. Thai shrimp is expensive from high feed and labour costs. The country does not have any free trade agreements (FTAs) except with ASEAN and it has lost its Generalised System of Preferences (GSP) in Europe in 2014 and has import tariffs at 12% as compared to 3.5% for shrimp from India." On the next steps for Thai shrimp, Tan suggested a collective voice on marketing, with focus on Asean markets where there is an FTA and to look inwards to the local market.

Feedback from the audience showed that there is ongoing consolidation in the industry and that Thai farmers are producing large sizes (8-12 and 13-15/kg) to get better prices.

Indonesian shrimp aquaculture

Representing PMI were second generation shrimp entrepreneurs, **Rizky Darmawan**, CEO of PT Delta Marine and **Denny Leonardo**, Business Development Manager at PT Tequisa. "We see an attractive and profitable business and wish for collective prosperity in the future. In 2012, Indonesia's production was 140,000 tonnes and in 2022, it was 241,000 tonnes.

In Indonesia, some 80% of culture systems is semi-intensive, stocking less than 20 PL/m² but 80% of the production comes from 20% of land dedicated for shrimp farms and where stocking is 130-200 PL/m². There are major challenges: disease problems - the latest being AHPND; environmental concerns (mangrove deforestation and water pollution), market fluctuations and the fact that Indonesian exporters are US centric, labour and social issues and regulations. There is no organisation to develop exports and local markets."

Rizky had a grand vision of gathering young shrimp farmers together. "In 2015, we were new to the industry and needed discussion amongst the young generation." This group of 6 morphed into PMI with 250 members in 2022 of under 40s. In 2023, the number was reduced following a reorganisation limiting members to only farmers.

PMI's agenda is to ensure sustainability and succession of the industry, to solve problems, form solidarity between farmers, focus on education of young farmers and give them the correct mindset on farming and bring investments into the industry. It helps new entrants in shrimp farming, bring innovation and progressive ideas for industry adoption and strive for a unified voice on the future of the industry. Part of the funding effort is an annual international event called Shrimp Aquaculture Conference. "The message for the Thai farmers is to form a similar club and be selective on membership."

"Margins have dropped to 20%. This means that our generation has to look for novel production systems and precision farming," said Denny. "The younger generation is less concerned about competition between countries. It is more against chicken and meat producers. In this age of startups, we are more collaborative."

SWOT on industry in Thailand

Chodpipat Limlertvatee is Chief Farming Officer at the family's LK Farm of 200 ponds in 9 farms in different locations in Chumphon province. In his SWOT analysis of the industry, Thailand's strength is its location. Thai farmers have showed strong resilience and adaptability, amidst a range of challenges. Productivity/acre/year of 6 tonnes is high as the farming area is limited. Thailand has the fastest growth genetics line able to achieve size 20-25/kg in 3 months. "Our weaknesses include poor support for the industry as we have only 25 farms with ASC certification as compared to more than 100 in Vietnam and Ecuador. The financial sector is highly cautious with shrimp farming which it deems as too risky. Tariffs are high for exports as Thailand has lost the GSP. There is poor relationship between farmers and processors."

Opportunities exist with regional and local markets for large size and quality black tiger shrimp as well as freshwater prawn, where demand is high in China. Examples of threats include a shifting national policy, and high production costs. "Producers need the government to support, elevate interest of young generation with innovations and push for sustainable production."

Chodpipat called for all shrimp producers to collaborate to exchange information and ideas. "Shrimp prices depend on destiny but costs depend on us."

Investing in sustainable aquaculture

Investments in technology are required for industry's growth. **Benedict Tan**, Program Director said Hatch Blue has a portfolio of 47 investments across the aquaculture and seafood ecosystem. As an aquaculture accelerator, it scales up impactful businesses by investing in early-stage technology companies along the value chain and preparing them from the stage when they have an interesting innovation to funding by venture capital stage. It runs startup cohorts in Singapore, Ireland and Norway, annually. Each cohort comprises 8-10 companies and the duration is 3.5 months during which there is active mentorship, access to a network of industry investors and grant providers, and regular 1-1 interactions with industry members. Hatch seeks companies focusing on aquaculture as the main initial market and an important criterion that the company should have is an excellent management team with at least two active founders.



Chodpipat Limlertvatee, LK Farm (centre) with from left, Raksit Sumanus, Raksit Farm, Thailand; Niran Warin, AquaSpark, Thailand; Denny Leonardo and Rizky Darmawan, PMI, Indonesia; Benedict Tan, Hatch Blue, Singapore and Christopher Tan, Mida Trade Ventures, Singapore.



The audience of mainly young farmers from Thailand

Aqua Spark is an evergreen fund focusing on sustainable aquaculture. **Niran Warin** who is Community Manager for Thailand, said Aqua Spark invests in startups across the entire aquaculture value chain. These include Tepbac and eFishery which provide hardware solutions and smart farming management platforms to give farmers access to inputs and markets. He complimented some young Thai leaders already advancing sustainable shrimp aquaculture. "Khun Keang, Raksit Farm has an environmentally friendly approach which led to farm expansion, while Khun Hemm, Meenasup Farm and Khun Cann, both have a focus on quality and promising farm performances. By coming together, we should commit to making a difference and innovate to meet challenges."



Suphawit Suklim, Petsinat Farm, Trang (left) and Pathama In-Ong, PK Farm Group, Trang.



Chutima Limpanawanakul, Chacheongsao province (left) and Khemika Klomsuwan, Krabi province.



Jakkpat Nuklin, Suratthani province.

In Brief

Petitions for antidumping duties

In October, the American Shrimp Processors Association (ASPA) filed trade petitions seeking antidumping duties on imported frozen warmwater shrimp from Ecuador and Indonesia and countervailing duties on imported shrimp from Ecuador, India, Indonesia and Vietnam.

Imports from the four countries were valued at over USD6.6 billion in 2022, accounting for over 90% of all imported frozen warmwater shrimp. ASPA estimates dumping margins for Ecuador ranging as high as 111% and dumping margins for Indonesia ranging as high as 37%.

In addition, ASPA documented government subsidy programs for shrimp farmers and processors in Ecuador, India, Indonesia, and Vietnam, including subsidised loans, tax concessions, grants, export credits and the provision of land, water and other inputs.

ASPA filed the petitions on behalf of the domestic shrimp harvesting and processing sectors, garnering support from hundreds of shrimp boats representing the majority of domestic warmwater shrimp landings and from processors representing over 85% domestic shrimp processing. More details on web: <https://shorturl.at/ksMRZ>

Full-cycle of the Japanese eel

Kindai University in Osaka prefecture has succeeded in complete farming the full cycle of Japanese eels. This is a world's first feat of its kind by a university. Kindai used similar methods to those of the state-run Japan Fisheries Research and Education Agency, which in 2010 became the first in the world to achieve full-cycle eel farming, a process that involves incubating and cultivating eels, so they produce offspring.

The university removed the eggs from a female eel for artificial insemination and then allowed the hatchlings to reach maturity before repeating the process to establish a full breeding cycle. Kindai says that the juvenile eels or glass eels, take time to mature and maintaining them can be complicated as their eating habits often make their tanks dirty.

Furthermore, while it has achieved a "full-cycle" for the eels and hopes are high to commercialise the technology, the university said it has struggled to sustain a large population of young eels due to the many mysteries surrounding their biology.

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Farmers x Tech

Technology providers pitch to farmers from Ecuador, Guatemala, India and Indonesia



Anton Immink (standing) led the session where the technology providers, from second left, Fabian Reusch, Fernando Pino and Pavan Kosaraju pitch to the farmers (from right) Denny Leonardo, Issac Kokkiligadda, Alex de Wind and Gabriel Biguria, how their innovations can help the latter in their farming operations.

The Global Shrimp Forum in 2023 included a breakout session: Farmers x Tech. Here, four farmers from different regions (LATAM, India and Indonesia) and of different scales of production (extensive versus intensive) were on stage as three Founder-CEOs from three countries - India, Ecuador and Thailand, pitch their IoT and AI innovations for more efficient and science-based shrimp farming. After each pitch, session chair Anton Immink of ThinkAqua engaged them in a discussion on the value of the technology offered for industry uptake. This second Global Shrimp Forum was held from September 5-7 in Utrecht, The Netherlands.

The farmers

Issac Kokkiligadda, Owner of Patnam Fisheries, handles farmers covering 80ha in Bapatla District in south Andhra Pradesh, India. The culture technology is probiotic-based extensive culture, stocking 10-15 post larvae (PL)/m² and production is 200 tonnes per year of black tiger shrimp. A part of his own farm is ASC-certified for the black tiger shrimp. Issac said that he is the first farmer to adopt and farm specific pathogen free (SPF) black tiger shrimp in Andhra Pradesh and is also at the forefront of adoption of the latest technology.

Alex de Wind, Owner and General Manager of Pesquera Industrial Bravito S.A is a third-generation farmer and grew up in one of the oldest shrimp farms in Ecuador, built in 1968. His current farm dates back to the 1970s. Alex said that he likes to innovate and has been using technology efficiently. The culture goal at the ASC certified farm is to keep production sustainable. The farming model is extensive, stocking of post larvae at 12 PL/m² and with short cycles of 4 times/year. Production is 9.5 tonnes/ha/year. Some technology used is algae bioreactors for Artemia and rotifer production, XpertSea for biomass biometrics and feeders are calibrated to move around the pond area.

Denny Leonardo, CEO at Pandora Aquatech represented Shrimp Club Indonesia (SCI) and Petambak Muda Indonesia (PMI or Young Shrimp Farmers of Indonesia). SCI members contribute almost 70% to the national production. The production model is intensive stocking at 130-200 PL/m² with aeration.

According to Denny, "On average, we produce 2.5 cycles per year. Almost 80% of farms practise a flow through system,

taking advantage of the direct access to the ocean with high water exchange. This means that the trend is for farms to move far away to the eastern part of the archipelago with better farming conditions."

Gabriel Biguria, CEO at Acuamaya is a second generation farmer in Guatemala. The farm was started 40 years ago by his father. Some 2-3 years ago, due to the high land cost, an intensive culture technology based on three systems was adopted with stocking of 40-60 PL/m² in lined ponds with aeration and automatic feeders with acoustics. Annual production in the 400ha farm is 5,000 tonnes/ha. The farm is ASC certified 5 years ago, and is Guatemala's leading producer and exporter of sustainable, farm-raised shrimp, as well as shrimp post-larvae and nauplii. Gabriel said that technification is ongoing, and slowly he has been testing and adopting several different solutions.

The technology providers

In his introduction, Anton said, "The solutions proposed by the following three technology companies are quite similar yet very different; it is an indication of the different state of shrimp aquaculture in every country and that for each farmer, needs are different."

Services, farming, marketing to finance

AquaExchange Agritech has a full stack of services. **Pavan Kosaraju**, CEO and Co-Founder began his pitch with this statement, "Farmers should view technology adoption as a contributor to savings and not to the cost of farming. Our IoT solutions help farmers daily. We have 3,000 farmers using our technology, covering more than 40,000 acres (16,187ha). Together, our farmers save more than USD1,000,000 using the technology."

The flagship product is the Power Mon, which monitors the farm's activities and aeration continuously, and providing control to the farmer. "With declining shrimp prices, the farmer needs to reduce costs. Most shrimp farms in India use aeration all the time and are with the grid; solar power can save energy costs. The AquaBot is a solar powered IoT remotely controlled (via mobile phone) moving feeder available on lease basis which is 1/6 the cost of manual feeding."

Pavan wants this technology to benefit and create an impact for farmers. "As the farmer scales up, he needs to ensure



nutrition through innovation

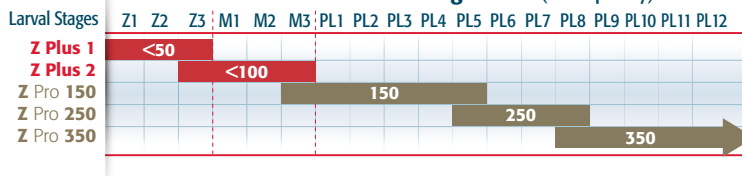
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In the audience, the Contractor Family runs a range of aquaculture related business in Gujarat, India, and works with Moana Technologies in a *Penaeus monodon* broodstock multiplication centre.



Denny Leonardo (left) and Indonesian participants (from right) Abung Maruli, dsm-firmenich; Harry Yuli Susanto, PT Alter Trade Indonesia and Leonardo Tiro, PT Tri Karta Pratama, Indonesia.

that the processes he has set out are followed properly by his employees. We bring all the data from ponds together at a central monitoring station and on a big screen dashboard for the farmer to make the right decisions. AquaExchange is GDPR (General Data Protection Regulation) certified which ensures data is very secure with the farm."

The full stack of services includes technology, finance and inputs at low cost. Based on its technology for an efficient and science-based farming, AquaExchange was selected by the State Bank of India to provide loans to aquaculture farmers. With this, Pavan expects input costs to come down by 9% with lower interest rates. Another service is to connect farmers directly with exporters to help them get the best price for the harvest by cutting out the middleman.

Pavan said, "Today, 90% of our entire customer base is small farmers with 1-2 acres (0.4 to 0.8ha) of ponds. We show how technology benefits small farmers and it works when farms expand. We calculated a savings of 1.5 million tonnes of CO₂."

Adapting human resources to technology

Shrimp farming in Ecuador is moving fast with adoption of technology but with this comes the need to have the right human capital. Alex says that there is a need for personnel to be ready to use technology and to be trained for analysing data from feeders and crunching data for fast decisions. Pavan commented that expansion requires the same level

of attention. This is where technology helps. "Actually, it involves scaling down problems to get all the related data from ponds to the right person for quick decision making. Some innovations provided include *Vibrio* screening and automated weighing of feeds. In the former, an adapter allows the unskilled pond staff to video images from a microscope and relay them to an expert for analysis; in the latter, feed measurements are added to the system for the farmer to monitor."

More than a smart acoustic feed technology with Big Data

In his pitch, **Fernando Pino**, CEO and Co-Founder, Biofeeder said that whatever technology is proposed, it needs to help industry to lower costs and produce shrimp more efficiently. In Ecuador, the first step with automation was with auto feeders, aerators and sensors. Feed companies adopted the strategy of introducing feeds combined with feed technology, which resulted in a huge productivity impact, although Fernando believed that good feed results were a consequence of the feed technology.

Since 2022, advanced automation utilises acoustics feeding which is now the norm. These are smart feeders with acoustics coupled with algorithms for feeding at the right time and reducing feed usage when shrimp demand less feed. This leads to better survival rate, feed conversion ratio (FCR) and growth, which are the KPIs for farmers.



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Fernado explained that in general, benefits of autofeeders are time-based. Today at breakeven point when farmers can make or lose money, getting 0.1 extra feed conversion is critical. "With our latest version of acoustic feeder with real-time accurate data, we can measure exactly the amount dispensed. A smart feeding tray goes up automatically, takes a picture and sends to the internet for image analytics and determines if the feeding tray has too much feed and when connected to our acoustic system, can direct the feeder to be faster or slower."

Combined with the biomatic end to end software connected to an accounting software, the farmer can manage operations from farm all the way to invoicing. It will calculate all costs per hectare per day with real-time information from the accounting system.

Issac expressed concern with ammonia levels from high faecal accumulation around an area of 3-5m when the feeder is static. Admittedly Fernando said that it is difficult to move acoustic feeders, but feeders will not dispense feeds when shrimp are not demanding feed. In acoustic feeding, there is interference from aerators which means that the latter must be 30-40m away.

With the financial model to estimate cost of production, there is a cloud software and web, Apple and Google applications which works well offline, explained Fernando. However, field data combined with weight samplings are added manually for the calculation.

IT based smart phone farm management system

Fabian Reusch, Director and Founder, HydroNeo Smart works mainly with small scale farmers in Thailand to make farming more data-driven and science-based using the IT based smart phone farm management system. Data are sent to the cloud every two minutes. "The approach is having all data insights in one place. We provide additional tools and features so that the farmer can remotely view what is happening in his ponds or farm," said Fabian.

He listed the benefits which include risk management with 24/7 remote monitoring especially of water quality and remote alerts and energy savings by controlling aerators on a demand basis and switching off to save energy whenever the dissolved oxygen (DO) level is high. The system pays for itself in the first production cycle. In June alone, the team sent out 2,000 critically low DO alerts because farmers underestimated how quickly DO levels can change which is not only related to biomass and sunshine but also the impact of adding probiotics and plankton blooms.

He cited cost savings of 30%, +13% productivity and +95% higher profitability.

"But the challenge is scaling up. Data are used to look for patterns, point out issues and provide recommendations on how the farmer can solve these problems himself. This way we are trying to make the farming more scalable," said

Fabian. There is integration of CCTV and an application to streamline data in one place. These include data on shrimp sizes, digitised feed logs and photos taken by farm workers every couple of hours for the farmer or the farm manager to analyse.

Adoption of technology

Technology adoption has been faster with small farmers, operating from 1 to 10-20 ponds. "This is because the farmer as the owner, profits immediately and directly from the savings. This means that the incentives for small scale farmers to adopt technology is much higher compared to farm managers," said Fabian.

Farmers: Top parameters

What are the top parameters important for the farmers? According to Alex, the most critical is weekly feed conversion ratio. "We measure shrimp size using a picture twice a week and on weekly basis, how much tissue is formed and project growth based on feeding."

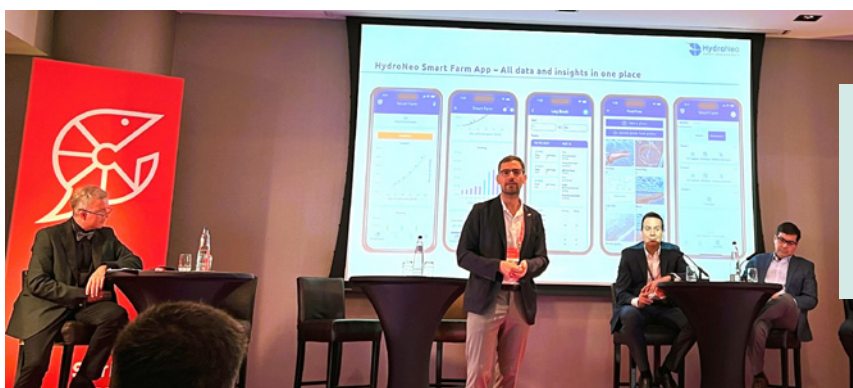
While the advancements discussed are appreciated, Issac believes that there are traditional practices to continue while assessing weekly growth, such as touching shrimp to know the stage of shrimp, pre moulting or post moulting and deviations such as necrosis or issues with moulting.

With smaller and more intensive farms in Indonesia, Denny said, farmers record visually or with sensors, the condition of sludge in the central grid and the need to exchange water. Micromanaging pond carrying capacity almost daily is important for Gabriel. Ponds are of different sizes and it is a back to basics approach, to understand the carrying capacity of each pond and not to cross the threshold. Concurring with Gabriel, Issac added, that carrying capacity is the parameter which he gives wide publicity, especially to small scale farmers. Ponds may be close together, but water and soil conditions can differ.

As a technology supplier, Fabian would like farmers to speak openly and to their peers about how technology is helping them in their operations. "We have saved so many crops; it will be good if farmers can talk about the benefits they gained with technological adoptions."

Alex provides the same data to several technology providers and would like them to use a common interface and avoid repetition of data input across different providers. "Second is benchmarking. This is not about comparing ourselves, but to understand the process and standardise small details like harvesting, manpower usage etc."

Anton said that it has been tricky for CEOs to make direct sales pitch to farmers. "These farmers who are early adopters of technology, have shared their thoughts and lessons learnt. The takeaway today is that while continuing to innovate, technology companies should keep listening to farmers. Definitely, there are regional variations."



Fabian Reusch (standing) says that HydroNeo Smart works mainly with small scale farmers in Thailand. The system sends out alerts because farmers underestimate how quickly DO levels can change.

Making shrimp farming sexy

The next generation is bullish on shrimp farming



The panel of five under 40 young entrepreneurs from the Asian aquaculture industry, from second left, Guntur Mallarangeng, Cynthia Darmawan, Bettina Valerie Lim, Kim Tran and Benny Ng Thiam Hau. On extreme left is the moderator, Ronnie Tan.

The industry dialogue at TARS 2023 on shrimp aquaculture focussed on the second interpretation of regeneration i.e., the succession plan for the next generation of players in Asia's shrimp farming industry. Commercial shrimp farming in most of Asia reaches half a century old and the pioneers have either retired or passed the business to the next generation. TARS 2023 was held from August 16-17 in Bali, Indonesia.

They were five under 40 young entrepreneurs from the Asian aquaculture industry coming together to discuss the future of shrimp farming and shed light on the strengths, weaknesses, opportunities and threats facing the Asian shrimp industry. The participants were:

Guntur Mallarangeng (GM) is Co-founder and CEO, DELOS Aqua, an Indonesian shrimp aquaculture startup assisting shrimp farmers in achieving optimal productivity and profitability. Guntur is also CEO at Dewi Laut Aquaculture in Cikelet, a 10ha shrimp farm which he started in 2016.

Cynthia Darmawan is COO at PT Delta Marine Group, one of Indonesia's leading aquaculture companies. Currently she is responsible for the management of the company's aquaculture farm ventures, spanning Surabaya to Sumbawa Island. Cynthia is chair of Petambak Muda Indonesia (PMI) or Indonesia Young Shrimp Farmers Association.

Bettina Valerie Lim, Business Development Executive at Hoc Po Feeds Corporation, Philippines oversees product development, innovation and enhancement of consumer relations. Hoc Po started as a fry producer and later ventured to produce aquafeeds. It also owns and manages various shrimp farms.

Kim Tran is Head of Formulation, Grobest Vietnam, which is a leading shrimp aquafeed company. Kim has been focussing on the development of scientific methods for fish gut health management, feed additive evaluation in fish/shrimp diets and nutrient requirements of aqua species.

Benny Ng Thiam Hau is a Senior Hatchery and Farm Manager at KS Pekan, Malaysia which is a leading supplier



Guntur Mallarangeng commented on new entrants into shrimp farming in Indonesia, "How can you make sure that these new guys with a lot of optimism figure out how to make their harvest work?"

of black tiger shrimp post larvae. Benny manages a technical team of 14 at the hatchery and farm and is responsible for staff training.

The objective of this dialogue session was to discuss the limitations of the current shrimp aquaculture models and strategies such as focussing on marketing ahead of production. "The difference between the older and the younger generation is that the latter gives frank and brutal answers; we do need their interpretation on the shrimp farming business and where the industry is heading," said Ronnie Tan, US Grains Council, Malaysia, as he introduced the dialogue members.

What are the strengths, weaknesses, opportunities and threats facing shrimp aquaculture today?

GM: Whether we are the younger or the older generation, we are aligned. Shrimp prices are going down, costs are increasing, assets are being offloaded in this wave of uncertainty especially in Indonesia, where there's no formal education or formal training on what it's like to manage or own a shrimp farm.

Our strength, at least for Indonesia, is that we have communities and organisations gathering people together and pushing each other to figure out how the young can work with the older generation to make our industry stronger. There is also a lot of funding pouring into companies like JALA and eFishery to solve the issues in Indonesian aquaculture. The teams that can hold on and stay alive will come out stronger.



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Referring to low survival rates in farming, Benny Ng said, “The situation of farmers being afraid of diseases and harvesting small sizes of 10g does not arise as farmers are concerned with pricing and prefer to produce large size shrimp.”

BVL: In the Philippines, domestic consumption is robust, shielding the industry from the crisis affecting our neighbours. However, we need to work on transition planning. Traditionally in the Philippines, shrimp farming is very intuitive. I am happy that nowadays we see a lot of data and analytics are coming in. Slowly science is coming into aquaculture. The older generation can transfer knowledge to the next generation and can mentor and teach us while we integrate along with science and technology.

With the current uncertainties in the market, can there be consolidation and who will survive?

GM: Macroeconomically we cannot control what is happening and we must figure out how to adapt. We cannot control feed and shrimp prices as well as demand. Those who will survive have a competitive advantage as they know how to control their costs, exercise a lot of discipline and can go back to fundamentals. They are also the ones that know how to run a shrimp farm as a business. They will also know how to make hard decisions on who to partner with, whether that's for consolidation or close partnerships.

As an industry, we need to figure out how to grow it professionally. In Indonesia, we still do not know how to leverage and work with our government, and to get their help to grow the industry.

With a lot of commonalities between all of you in terms of the younger generation across the ASEAN countries, is it possible to share information across countries?

BVL: Recently more professionals have been sharing information and debating. Of course, with every shrimp farm, water quality is different, post larvae and feed are different. So, although information is shared, we cannot just automatically apply without that deeper assessment, as conditions differ from pond to pond and from farm to farm.

Some say here in Asia we are very much production oriented. How do we put market demands ahead of production, such as the 4Ps- product, price, place and promotion instead?

CD: I disagree but perhaps this is because often we see gatherings discussing the science of production. In Indonesia, I do not think we are product oriented, but I do find it hard to put all stakeholders in one room to share insights and focus on the 4Ps. There is also the mistrust

which exists in the industry. Collaboration is important in the industry's evolution. When we can create a place where they can meet and discuss issues and move them forward to gain diverse perspectives, that would help.

KT: Vietnam is among the top-three shrimp exporters worldwide. However, the market is very competitive and we realise that we need to focus on innovative product forms- live, peeled, frozen as well as shrimp with high omega-3s. This is the direction industry is now aiming at and trying to give more choices for the customers. If we can find readily acceptable products for potential customers, that will be the future.

However, we also recognise the importance of sustainability, consistency in quality and certification in shaping Vietnam's image as a responsible producer of farmed shrimp. We must consider how we develop good sustainable quality products not just for today but also for tomorrow. We must understand ASC certification, legal issues etc. There is a commitment to be a sustainable and high-quality producer at the same time.



Cynthia Darmawan said, “In Indonesia, I do not think we are product oriented, but I do find it hard to actually put all of the stakeholders all in one room to share insights and focus on the 4Ps.”

BN: In Malaysia, we are production oriented but as most of the country's production is sold in local markets, we do not need to worry too much about prices. Farmers plan for stocking and consistency in production. But this year, we had a pricing issue, which disrupted the trend. Farms had to plan to grow shrimp to larger sizes to have a pricing advantage.

Our current model with 55-60% survival rates is not economically sustainable. How can we improve?

BN: Profitability depends on the culture systems, whether they are earthen or HDPE lined ponds. In the latter system, some farms push for larger sizes (30 to 20/kg) to match the pricing factor to be profitable. Farmers are not worried about diseases and harvesting small sizes of 10g does not arise as they are concerned with pricing and prefer to produce large size shrimp.

CD: For us 50% survival rate is not that bad as we practice high density farming. I refer to what Robins McIntosh said on pond mismanagement. For example, we had a couple of ponds affected with AHPND and survival was only 25-30%. But we managed to stave off losses, with better control of farm management. We are not expecting everyone to build indoor farms but it is always the little things that you can control - pond construction without cracks, feed management and human resources.



With new technologies and models in Vietnam, Kim Tran said, “Whatever the model, we need to find the balance to be profitable as well as sustainable.”

KT: We may have 60% survival which is not profitable but then if we have higher survival, it may not be sustainable. Higher survival coupled with higher stocking density will use a lot of water and may not be sustainable. Finding the balance is key.

Whether the Vietnamese farmers prefer to go for large sizes and then risk lower survival rates or they prefer to have small sizes and have higher survival rates is dependent on markets. When farmers stock, they do not decide on harvest sizes. The decision is made after two or three months and depends on the market. It can be risky for farmers as the technique to produce size 30/kg is different from that for size 100/kg. So, they will prefer the more profitable option.

What new technologies or models can we adopt to improve survival rate?

KT: In Vietnam, farmers opt for high technology models because they want to stock at high density. This comes together with water treatment and high-quality feeds as part of the culture regime. There are many factors to consider before we say whether the intensive models like round tanks will work. Whatever the model, we need to find the balance to be profitable as well as sustainable.

Farmers and processors are fighting all the time over price. How do we get both parties to be on the same page and work together?

The conversation also moved to the trust factor between parties in the supply chain and the possibility of long-term contracts between farmers and processors on prices.

CD: Farmers have selective hearing on the problems they face. When prices drop, they disregard faults in farm management and price becomes the problem. They do not want to hear why the prices are going down or what’s going on in the farms. I find it hard to have processors and farmers in the same room; each party is not interested in listening to the other party. Older farmers prefer to talk to my parents rather than me. Whether young or old, farmers do not want to believe that prices are going down. I look forward to a strategic plan that works for every stakeholder so that the industry can benefit.

BVL: My example is in the feed segment. Whenever, we talk to customers, trust is lacking on data from the farm, such as feed conversion ratio when the farmer is asking for lower feed prices. Technicians working closely with farmers know the actual production and we have farmers working synergistically with us, a win-win situation which allows us to help them with appropriate feed prices. More transparency, better communication, a commitment towards long term relationships and not short term results, so we can achieve more together with long term goals.

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GM: When you are in a country where the legal infrastructure and contract laws are weak, people are weary of any sort of legal contract. It is well-known that private contracts are very difficult to enforce. Trust between individuals becomes more important. At the end of the day, if a contract is broken, taking legal actions is a complex process without a clear outcome.

How can we align incentives between two different parties? As a farmer, I want to make sure I grow the biggest size to get the best price. But the processor pays the lowest price to get the largest margin when he exports. Production costs are higher for larger shrimp, but is there a middle ground, the best size for the farmer and the best margin for the processor?

How do we make shrimp aquaculture sexy again since the young deem farming as a dirty, difficult and dangerous job?

This includes attracting investors and a new generation of graduates.

GM: Risks are high in shrimp farming, but rewards are high. It is dirty and dangerous, so it has always been sexy. As a farmer, there is the joy and satisfaction when you get a successful harvest, especially when prices are high. Earlier we talked about some farmers disposing assets, but surprisingly in Indonesia, a lot of younger Indonesians, some generation 2 or 3 of family-owned companies, returning after their studies, are asking me how to start a farm, as they have money to invest. I do not think it is the appeal or the interest in the industry that is missing right now.

It is a matter of when they commit, and whether they can stick around for more than 2 years. How can you make sure that these new guys with a lot of optimism figure out how to make their harvests work? How do you ensure that they're not a bunch of headless chickens running around burning a lot of money?

CD: I do not think it's a sunset industry. It is not hard to get into. I find that a lot of people are approaching me with interest to invest money. I am more worried about whether we are creating a bubble.



Bettina Valerie Lim on how to make shrimp aquaculture sexy in the Philippines, "I think the new generation can be nurtured, maybe with better mentorship and incentivisation."

BVL: Most in shrimp farming in the Philippines are from the boomer generation, so a lot of the young generation are hesitant to enter aquaculture. But once you slowly learn, you get more interested and when you understand the art inside it, it becomes very interesting. Food is needed everywhere so with the growing population I do believe it is a sunrise industry. I think the new generation can be nurtured, maybe with better mentorship and incentivisation.

KT: Many students wonder if working as a farmer is more lucrative financially compared to being a tik tok influencer. If you can make the shrimp industry more profitable, grow its reputation, adopt more high technology using digital platforms, satellite images or other productivity solutions, that could attract the young. We want people to understand that shrimp is nutritious and healthy. This type of education will help create interest in seafood production.

BN: To attract graduates, we need to improve the remuneration package for the hard work. We need to make the staff professional. Secondly, it is how well we train our younger generation. Attracting and retaining staff is a challenge. So, we must give them confidence alongside incentives that are linked to higher production.

GM: In Indonesia, the saying is that you are not only culturing shrimp but also taking care of communities. I am trying to figure out how to do that within the local culture; the farm managers, the technicians and farmhands can be trained to be professionals. We need to make them better and smarter.



Benny Ng with participants from Malaysia; Bryan Lee, QL Aquamarine (left) and Eric Lee, Kembang Subur (middle).



Alex Farthing, DELOS, Aqua (middle), Christopher Tan, MIDA Trade Ventures (left) and Rizky Darmawan, PT Delta Marine posed questions on upscaling production practices, managing changing times and Asian family business culture.



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Unmasking vannamei shrimp production in China

This insight into Chinese domestic production provides a connection between imports and consumption and the potential to increase production in the near future.

By Fu-Ci Guo

There has always been a mystery surrounding the actual marine shrimp production in China. This was before and during the pandemic. Whilst some sources estimate Chinese production at around 800,000 tonnes, the Chinese government claims numbers at above 2 million tonnes. A challenge is getting realistic data on its shrimp production.

Between October/November 2022 and March/April 2023, I spent five weeks visiting feed mills and shrimp farms and interacting with relevant stakeholders. This gave me the opportunity to gather data on shrimp farming in China. During the seminar on Shrimp Production at the Global Shrimp Forum, held from September 5-7 in Utrecht, The Netherlands, I presented some insights on shrimp farming in China and unveiled China's shrimp production figures for 2021-2022 and its potential to increase production.

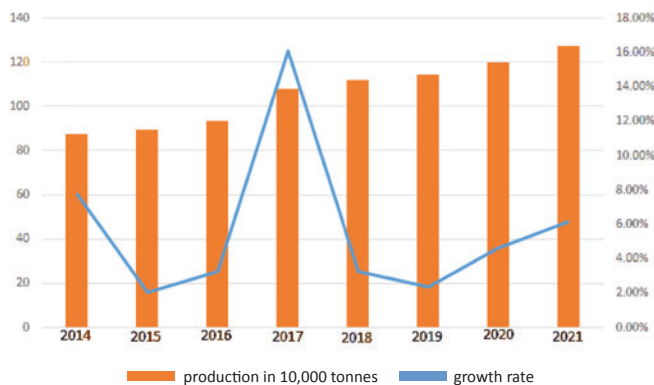


Figure 1. Seawater white shrimp *Penaeus vannamei* production in China from 2014 to 2021. According to the China Fishery Statistical Yearbook, the total output of *Penaeus vannamei* in 2021 was 1.99 million tonnes, an increase of 6.15% compared with 2020, of which 1.27 million tonnes was produced from seawater (SW) culture and 703,800 tonnes from freshwater (FW) culture.

Vannamei shrimp production China

Official data from the Fishery Statistical Yearbook on the production of Pacific white shrimp *Penaeus vannamei* in marine environments was 900,000 tonnes in 2014 and increased to 1.3 million tonnes in 2021. The top five provinces were: Guangdong, Guangxi, Shandong, Fujian and Jiangsu, which in total produced 1.6 million tonnes in 2021. This included vannamei shrimp grown in waters of less than 5ppt which China's industry categorises as freshwater systems. This is sizeable, contributing about 300,000 tonnes in 2021 (Figures 1 and 2).

The latest China Fishery Statistical Yearbook did not have the numbers for 2022, but according to reliable WeChat media, the eleven provinces and regions in 2022 produced 1.49 million tonnes of the white shrimp from seawater farms. Assuming another 300,000 tonnes from freshwater farms, the total production in 2022 was estimated at over 1.8 million tonnes.

In China, shrimp farms spread from Hainan province in the south to Liaoning province in the north. At least eleven

provinces and regions are engaged in farming marine shrimp along the 14,500km long coastline. Summer temperatures are hot and humid, but winter temperatures vary from tropical in Hainan, Guangxi, Guangdong, to temperate in Fujian, Zhejiang, Jiangsu and to cold winters in Shandong, Hebei and Liaoning (Figure 3).

Culture systems

China's culture systems can be categorised into four types: earthen ponds, elevated ponds, large and small greenhouses and shrimp factories (recirculating aquaculture system, RAS).

Earthen ponds

These account for half of the annual production volume. Pond sizes range from 0.5-3ha without any pond liners; water intake is usually through tidal exchange with no pumping, and stocking density ranges from 10-30 post larvae (PL)/m². Usually there are a few paddle wheels or aerators, and with no heating during the winter months. Production is 1-2 crops/year and ranges from 4.5-11 tonnes/crop/ha. All ponds are open systems, low in biosecurity and are prone to weather changes, such as temperature fluctuations, rains, floods, and typhoons.

Elevated ponds

These account for about 15% of annual production. The ponds are lined or have concrete walls and bricks, pumps are used for water intake, and stocking density is 50-120 PL/m² with paddle wheels and aerators. There are 1-2 crops/year. Productivity ranges from 11-26 tonnes/crop/ha. Shrimp in these open systems have a high risk of infection. Ponds are prone to water temperature fluctuations, typhoons, and floods.

Greenhouses

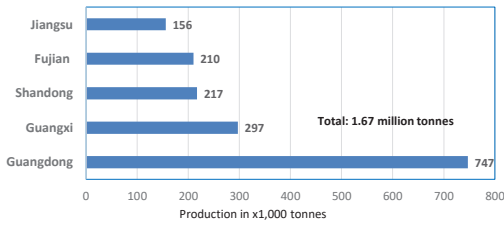
Some 30% of production is from this system. Based on the sizes of ponds, they can be further divided into large and small greenhouses.

The **large greenhouse system** is basically an earthen pond covered with plastic. Here, ponds are small (0.4-1ha) and stocking density is high at (50-80 PL/m²) as compared to earthen ponds. Production ranges from 9-23 tonnes/crop/ha. The plastic covering shields the pond from birds, pests and rain and stabilises water temperature by retaining warm conditions when water heaters are applied. However, it is still exposed to typhoon damage due to its vast size.



Inside the greenhouse with farm owner Chen Zhongfa at Xiaoshan, Hangzhou, Zhejiang province. Photo by Fu-Ci Guo.

Shrimp production systems



Source: China Fishery Statistical Yearbook



Figure 2. Production of white shrimp *Penaeus vannamei* in both seawater and freshwater by China's top five provinces in 2021 (x 1,000 tonnes). Adapted from China Fishery Statistical Yearbook.



Figure 3. Shrimp production in China. China Map adapted to display farming conditions from <https://www.thoughtco.com/china-provinces-4158617>

The **small greenhouses** are typically 10mx40m (0.04ha) in size with no plastic lining. Pond stocking density is from 75-100 PL/m² and production of 12-30 tonnes/crop/ha. Usually there are 2-3 crops/year. The plastic covering shields the pond from the outside environment and stabilises temperatures when using heaters. These small greenhouses are less prone to damage by typhoons.

The small greenhouse model started in Rudong, Jiangsu province about a decade ago. The number of greenhouses has now exceeded 200,000 units in Jiangsu province

alone. Recently this model has moved south to Guangxi, Guangdong and Fujian provinces. It was estimated that 450,000 greenhouses are currently in operation countrywide, producing approximately half a million tonnes of shrimp. The small size makes it easier to manage and turnaround. However, because of its rectangular pond shape, there is no central drainage and aeration is compressed air via nano aeration tubes. It is a bio-floc system which relies on probiotics for water treatment and other animal health products.



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Greenhouses in Xiaoshan, Hangzhou, Zhejiang province. Photo by Fu-Ci Guo.



A bird's eye view of an industrialised indoor farm.



A bird's eye view of small greenhouses in Jiangsu province. Source: <https://sdwx.iqilu.com/share/YSOyMS0xMzZM2OTk2Mw==.html>



Harvesting shrimp in a small greenhouse. Source: www.fishfirst.cn

Shrimp factories (RAS)

In China, this is called **industrialised indoor farms (IIF)**. This system contributes to only 3% of total production, but it is now a megatrend. News reports indicated that Charoen Pokphand (CP) has invested USD31 million in Dongying, Shandong province. Near to the CP site, Tongwei has invested CNY1.2 billion (about USD170 million), targeting to produce 10,000 tonnes in 2023 and a million tonnes in 5 to 10 years. Evergreen and Haida are also investing heavily in southern China. Shrimp factories are high-tech smart farms; they can do up to five crops/year and the production per unit is 4-10 times higher than small greenhouse farms.

Will China continue to import shrimp?

The question asked at the Chinese industry panel following the presentation was, "Will such a high domestic supply become a threat to Chinese shrimp imports and in the next 5 years, would China need to import shrimp?"

The gap between local production and consumption is about one million tonnes. Many industry experts predict that China will continue to import a million tonnes of shrimp each year in the next few years. Since local production is around 2 million tonnes, plus a million tonnes of imports, the

consumption is 3 million tonnes. When we divide this supply by its 1.4 billion population, the per capita consumption is 2.1kg per year. This is on par with USA which had a 2.13kg per capita/year consumption in 2019 (SeafoodSource.com).

In conclusion, the above gave an insight into China's domestic shrimp production. However, will this high production compete with imports from Ecuador and other Asian countries? The best option is to ensure both supply channels will continue to grow hand in hand to meet the annual demand for three million tonnes.

Acknowledgment

The author appreciates the assistance of Lauren Guo, a University of Guelph graduate in Agri-Food Economy and Andrew Guo, a second-year Biological Science student at University of Calgary, Canada in preparation of this article.



Fu-Ci Guo (second left) at the Chinese Industry Panel, during the Global Shrimp Forum 2023, with from right, Fang-Qing, General Manager, Aquaculture Stewardship Council (ASC), China; Ronnie Jin, Senior Partner and Vice General Manager, Aqua-One and Chief Consultant of Aqua-Drive and Fred Kao, CEO, SyAqua Group, Thailand. The panel was chaired by Sander Visch, Kontali (left). Photo credit, Pierre-Banoori-Photography.



Fu-Ci Guo, PhD is the Global Category Manager Aquaculture at Royal Agrifirm, marketing functional feed additives (including aromabiotics as anti-vibrio and a vibrio toxin deactivator) for aquaculture. Email: f.guo@agrifirm.com.

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Phenotype switching in *Vibrio*

A promising method to mitigate AHPND in vannamei shrimp culture

Over the last five years, the team at Ghent University, Belgium has been focussing on phenotype switching in *Vibrio* species. On October 3-4, Phileo by Lesaffre organised several talks for its Microbiota Days and particularly relevant to disease management in shrimp aquaculture, was the presentation on “Phenotype switching in host microbial interactions” by recently retired Professor Peter Bossier at Ghent University.

Bossier began with examples of phenotype switching which were already seen in *Vibrio* species - luminescent *Vibrio campbellii* and the PirA/B toxin producing *Vibrio parahaemolyticus*. “Classically, luminescent bacteria produce light when plated on agar but occasionally, some colonies basically refuse to produce that characteristic light. You might think that you have a non-luminescent colony; when they are placed on a different medium, there is no luminescence but there is the presence of a very dark colour. This is what is termed as a phenotype switch.”

Back in 2019, the team had shown that environmental conditions steer phenotype switching which impacts virulence, antimicrobial resistance and stress resistance (Kumar et al, 2020). This work evaluated the role of fluid shear on phenotypic switch and how it applies to acute hepatopancreatic necrosis disease or AHPND causing *V. parahaemolyticus* M0904.

“Flocules (cellular aggregation) associated with lower shaking speed (110rpm constant speed) attenuated PirA^{VP}/PirB^{VP} toxin production and enhance the production of alkaline phosphatase (ALP PhoX in *V. parahaemolyticus* M0904 culture,” said Bossier, adding that observations showed a strong reduction in virulence towards two crustaceans, *Artemia* and *Macrobrachium*. There is evidence of phenotype switching with two phenotypes – one virulent and the other non-virulent. This was confirmed by protein sequencing and allowed the team to clone the gene and design primers for expression of ALP PhoX gene (Figure 1).

“*Vibrio* in general in aquaculture is almost impossible to eliminate from the production system. But will phenotype switching give us an opportunity to manipulate the environment? We keep this particular pathogen in the non-virulent status, i.e. we have a non-virulent phenotype

around rather than a virulent phenotype. Eventually this is a promising strategy to manage AHPND,” said Bossier.

Bossier recounted work in 2019, where in a biofloc system, microbial biomass of autotrophic or heterotrophic bacteria is stimulated together with the target species. “It was shown that especially in heterotrophic systems, shrimp were apparently protected against AHPND. You could add the AHPND pathogen but the shrimp did not acquire the disease. But during that time, we were uncertain of the mechanism.”

With new markers available, the team revisited this research to unravel the mechanism. A complicated experiment showed that phenotype switching was basically going on in vivo. Shrimp were held in three tanks in a clear water environment and then split into two groups and challenged with AHPND in a clear water environment or in a biofloc environment. The challenge with AHPND at 107 CFU/mL gave a very high and rapid mortality over 24 hours while survival declined to 20-30%. Contrastingly, the best survival at 70% was in the group growing in the biofloc environment. Survival rate was intermediate for shrimp growing in biofloc system transferred to seawater?

Bossier said, “In the biofloc group, there was evidence that phenotype switching was happening. In the control, there was high PirB expression but in the presence of biofloc, there was almost no gene expression. Furthermore, the gene expression in the hepatopancreas of the shrimp showed a very similar picture. When challenged, the seawater group showed the highest expression of PirB gene compared with the lowest expression in challenged shrimp for PirB at either 12 or 24 hours in the biofloc environment.”

The take home message is that phenotype switching apparently happens in a biofloc environment. “The very important message for the aquaculture sector is AHPND causing *V. parahaemolyticus* (according to assays carried out most of the time by PCR) and verified by gene expression, is always around, which also implies the presence of PirA/B. Basically, we can say that the mere presence of *V. parahaemolyticus* is not sufficient for AHPND development. The microbial environment will also determine whether there is disease development.”

Shaking condition regulates phenotype status of AHPND strain

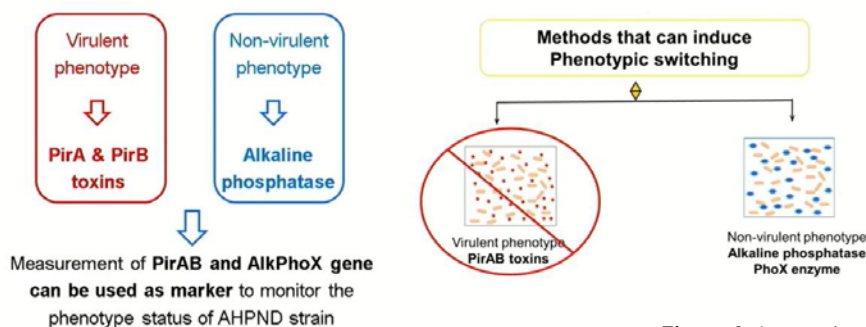


Figure 1. A new phenomenon - phenotype switching in aquaculture systems. Source: Presentation by Peter Bossier, Microbiota Days, October 3-4, 2023, Phileo by Lesaffre.

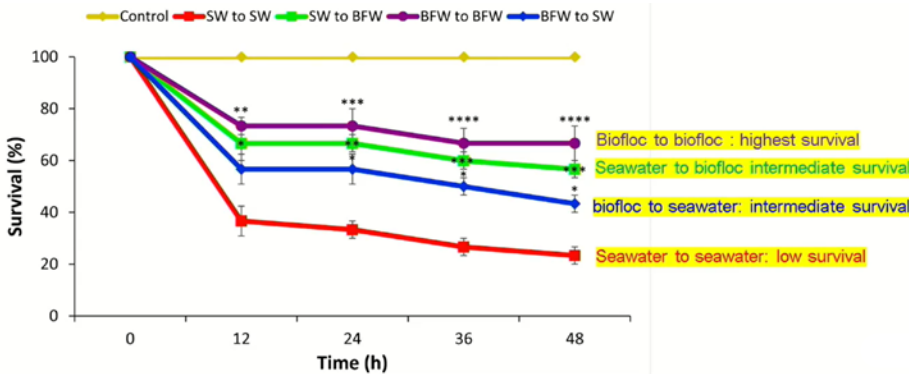


Figure 2. Effect of biofloc on the survival of vannamei postlarvae after 12, 24, 36, and 48h post challenge with *V. parahaemolyticus* M0904 strain. Source: Kumar et al, 2020.

Phenotype switching and AHPND mitigation

Next is how to mitigate the disease by using this phenotypic switching. Bossier went on to discuss the effect of bamboo powder. Bamboo is composed of different polymers and is a rich carbon source used to grow biofilms. The research is to test whether bamboo can influence phenotype switching. "We used 50ppm of bamboo powder and the control was pure cellulose pulp at 50ppm, suspended *in vitro*. We studied the effect on several strains of *V. parahaemolyticus*." In these cultures, the presence of bamboo powder gave a very strong expression of ALP PhoX and low longer expression of PirB. Results also confirmed the marker for the phenotype switching.

"We also checked whether the phenomenon was happening with different strains of *V. parahaemolyticus*. Detected by the ALP PhoX gene and that of the varying profile of secreted protein, we saw that phenotype switching was happening but was strain dependent. The challenge is in interpreting field results. There is a lot of different *V. parahaemolyticus* strains out there," said Bossier.

"Remember that the disease is caused by a plasmid, carrying an operon. This is jumping around from different strains and different families of *V. parahaemolyticus* and also between species of *Vibrio harveyi*. The result from a classical model using *Artemia* cultured by increasing concentrations of bamboo powder in the water, showed that there was a high protection of nauplii against *V. parahaemolyticus*. This was repeated with *Litopenaeus vannamei* with AHPND causing

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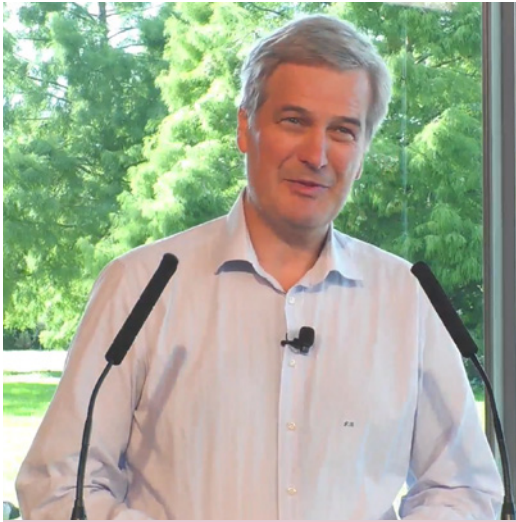
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economical and ecological sustainability



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feed performance and farm productivity



Professor Peter Bossier at Microbiota Days, organised by Phileo by Lessafre.

strains. The bamboo powder showed the same effect as with *Artemia*. The team concluded that 75mg bamboo powder completely protected shrimp against AHPND.

Probiotics for AHPND mitigation

This is not related to phenotype switching. "I want to demonstrate here that we can get protection against *V. parahaemolyticus* for *L. vannamei* by using a mixture of *Bacillus* species. In this particular case we used a mixture of one strain which can degrade the toxin and other species where we could get about 50% protection," said Bossier.

This was done through a toxin degradation assay with different strains of *Bacillus* species. Experiments involved looking at: the chemical stability PirA/B toxins; PirA/B toxins degradation in the presence of *Bacillus* sp strains and supplementation with acetate as a carbon source; and how the supernatant of *Bacillus* strains are handling the PirA/B toxins. Sampling was done at 2,4,6, 24 and 48 hours. The results showed that there were some *Bacillus* strains which can degrade PirA/B toxins but this did not happen with all the strains. Some were not interfering with PirA/B toxins. Degradation was strain dependent. In the negative control there was hardly any degradation.

In his conclusion, Bossier stressed that not necessarily all *V. parahaemolyticus* display two distinct phenotypes. The phenomenon might be strain specific, especially the PirA/B production might not always be regulated in this way in plasmid harbouring *Vibrio* species. The term used was planktonic and virulent phenotype or a biofilm and non-virulent phenotype. This phenotype switching with *V. parahaemolyticus* and also *V. campbellii* might be very common in the genus which means that it is probably an overlooked phenomenon in aquaculture research.

Phenotype switching can be induced in the biofloc environment but also depends on what type of biofloc, heterotrophic or autotrophic, although it was less effective with the latter biofloc. Bamboo powder can induce phenotype switching *in vitro* and *in vivo*. However, the mechanism behind this protection is still unknown. Basically, the target of this research is to develop AHPND mitigation strategies using several combinations of these findings.

References available on request

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Managing productivity with disease mitigation

While classical R&D continues, is using AI the way forward?



Dr Daranee Seguin, Thailand chaired the panel at TARS 2023 with industry players (from left) Dr Loc Tran and Dan Fegan and speakers, Aryo Wiryaman and Dr Kallaya Sritunyalucksana.

Occurring either singly or as co-infections, the current disease threats comprise *Enterocytozoon hepatopenaei* (EHP), acute hepatopancreatic necrosis disease (AHPND), white faeces syndrome (WFS) and white spot syndrome virus (WSSV) remain the scourge of productivity in many farms in Asia. Added to these is infectious myonecrosis virus (IMNV), prevalent in Indonesia. Farmers often ask, what can be done to reduce comorbidities and track disease trigger points, maintain consistency and improve predictability in farming. Is the end game to live with disease and sustain productivity.

Following two presentations covering an update on research on the EHP and using AI and Big Data Analytics to predict disease trigger points, Dr Daranee Seguin, Thailand chaired a panel at TARS 2023 to provide some answers. The industry players at the panel were Dr Loc Tran, Founder and Director, ShrimpVet Laboratory Vietnam and Dan Fegan, Chief Impact Officer, SyAqua Group, Thailand.

Managing EHP

There continues to be a high frequency of outbreaks of the microsporidian *Enterocytozoon hepatopenaei* (EHP) which causes hepatopancreatic microsporidiosis (HPM). Dr Kallaya Sritunyalucksana gave the latest update from the laboratory studies in Thailand with the microsporidian EHP. Kallaya is the Principal Researcher of Aquatic Animal Health Research Team at The National Center for Genetic Engineering and Biotechnology (BIOTEC), National Science and Technology Development Agency (NSTDA). The research team at BIOTEC has been studying the life cycle, transmission route and mechanism of virulence of this shrimp microsporidian since 2009 to make recommendations to shrimp farmers on its control.

A co-habitation model is used to answer several questions from farmers. EHP is transmitted horizontally not vertically. "When we added infected shrimp to a tank of naïve shrimp in the laboratory, infection occurred within 14 days. Spores are in the water and faeces. The infection is transmitted by oral ingestion of spores and initial infection is the gastrointestinal tract. Naturally, high stocking density

accelerates EHP transmission," said Kallaya as she showed EHP spores packed in cell tubules and epithelium.

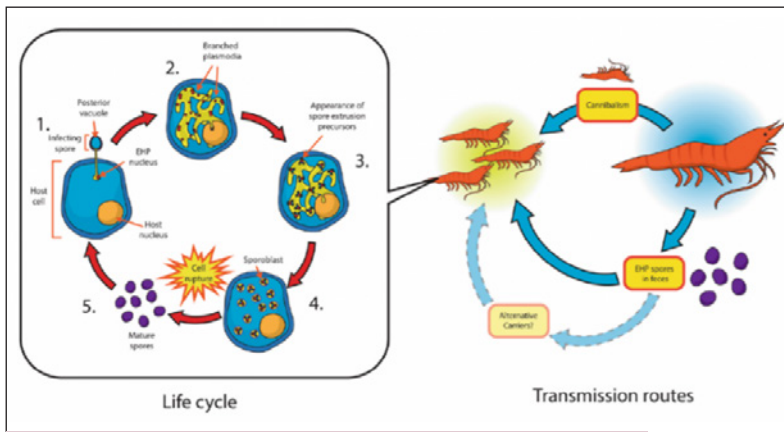
In 2018, the team published a paper on polar tube extrusion which is necessary for EHP infection. If the polar tube is already extruded, there will not be an infection. The results from the co-habitation model and EHP spore purification and polar tube extrusion study led her team to the design of control strategies for EHP such as the use of spore wall protein (SWP)-PCR detection method (Jaroenlak et al., 2016), pond preparation using high pH treatment, low temperature for live feed preparation, and discovery of the mechanical carrier of EHP such as bivalves, etc. This is described in the latest review in Aldama-Cano et al, 2022.

"Together with CEFAS and University of Exeter in UK, we sequenced the whole genome using purified EHP spores and have deposited it in the GenBank (Boakye et al., 2016). We learnt that the EHP genome contains 4 ATP transporter genes but lost 8 of the 10 essential glycolytic genes to generate ATP. With the knock down in the expression of these ATP transport genes, EHP cannot replicate. This implies that this parasite relies entirely on ATP import from its host resulting in the shrimp's slow growth."

Mitigation steps

Disinfectants such as 15ppm KMnO_4 , 40ppm of 60% active chlorine and 20% ethanol inhibited the polar tube extrusion process of EHP spores. The recommendation at post-harvest is to treat contaminated water and allow to rest for at least 10 days to inactivate EHP spores.

Freezing at -20°C can inactivate the spores. This is important when using live feeds such as artemia and polychaetes. Relevant to feed production is that spore infectivity is inhibited at 75°C within 1 minute (Figures 1 and 2). The 75°C -treated and non-treated spores (28°C) were experimentally added into feed pellets and fed to shrimp. It was found that shrimp fed with 75°C -treated spores showed no replication of EHP using qPCR, whereas those fed with non-treated spores revealed high replication of EHP. Considering the heat exposure during feed processing (equal to or exceeding 75°C for



Schematics illustrating the life cycle and transmission routes of EHP. Photo by Chaijarasphong et al., 2020.

EHP carriers

Mechanical carriers of EHP have been identified as mussels, *Mytilopsis leucopheata*. EHP cannot replicate in this mussel but can stay in its digestive tract. A cohabitation model of the shrimp and mussels with spores in their digestive gland showed that after 10-20 days shrimp were infected. Other carriers are artemia, polychaetes and other bivalves. The recommendation is to remove bivalves, and wash artemia and polychaetes excessively before use.

EHP as a component cause of WFS

“Now we know that EHP is not the cause of shrimp white faeces syndrome (WFS) but is a component cause when together with bacteria. EHP-WFS was associated with 6HP (low toxin producing Vp-AHPND). The massive bacterial infection in EHP-infected shrimp can result in shrimp WFS and mortality. Infection of EHP results in a higher susceptibility to 6HP infection” specified Kallaya as shown in Figure 3.

60 seconds) such feeds should be regarded as posing no risk for EHP transmission.

Diagnosis on HPM

Attention was given on this as farmers look for spores in tissues and faeces “HPM has no clear symptoms to facilitate diagnosis. It is suspected when there is growth retardation. Histological diagnosis depends on the presence of spores in the hepatopancreas. The spores are very small and with microscopy, a 100X lens is required. Sometimes spores are present in low numbers, even when the infection is heavy,” said Kallaya. She added that with an in-situ hybridisation technique, a high density of spores in the hepatopancreas indicated a heavy EHP infection.

Arising from the work on the EHP genome, BIOTEC has developed a sensitive and specific nested PCR method for detection of the spore wall protein (SWP) gene of EHP (SWP-PCR). It is recommended for use in the detection of EHP in shrimp, and non-shrimp samples (faeces, feed and environmental samples) for potential EHP carriers together with histology to avoid false positives. A key message was that post larvae should be tested with SWP-PCR at least twice with 7 days interval (PL5 and PL12) before stocking. A portion of the first checked PL5 should be cultured in a stress condition for 7 days to allow EHP replication. Screening should be carried out again at PL12 or before stocking to ensure that the shrimp are EHP free.



A key message from Kallaya Sritunyalucksana is “Post larvae should be tested with SWP-PCR at least twice with 7 days interval (PL5 and PL12) before stocking.”

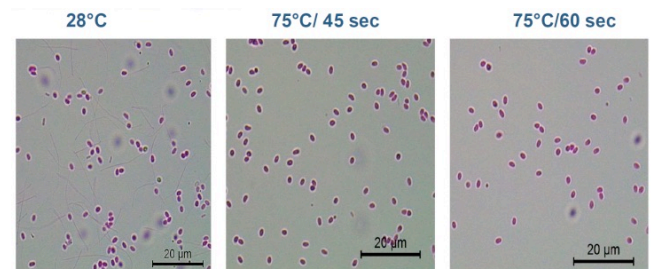


Figure 2. Spore density in cells at 75°C at 45 sec and at 60 sec versus at 28°C.

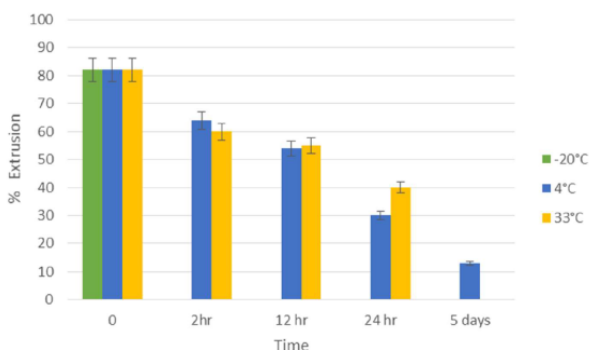


Figure 1. Spore deactivation. At -20°C, there was no spore germination within 2 hours post exposure.

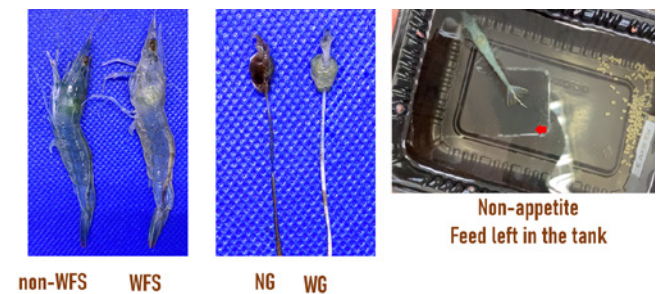


Figure 3. The reproduction of WFS in EHP-WFS laboratory model. Source of figures: Update on shrimp microsporidian, Enterocytozoon hepatopenaei (EHP), presented by By Kallaya Sritunyalucksana, TARS 2023.

AI and Big Data Analytics

AI is already playing a large part in managing shrimp farming. In Indonesia, the team at JALA Tech is proposing using AI and big data analytics in disease prevention and management. Indirectly it will improve the future of shrimp farming.

There is no doubt that with the intensification of culture systems, particularly in Indonesia, farmers are exceeding carrying capacity and diseases are omnipresent.

Aryo Wiryaman, Chairman and Founder of the Indonesian startup JALA Tech knows the challenges in shrimp farming as he has been helping his father run their shrimp farm in Central Java since 2001. Coincidentally, farming in the southern part of Central Java is most challenging with farms close to each other. "Today 60% are no longer farming and so the presence of disease pathogens is impacting the industry," said Aryo.

Predicting disease trigger points

By analysing large volumes of data, AI algorithms can detect patterns and early warning signs of diseases, allowing farmers to take proactive measures. Real-time monitoring systems powered by AI can track water quality parameters, detect anomalies, and in the future trigger automated interventions to maintain optimal conditions for shrimp health.

Aryo presented this work by JALA.. "Basically, big data in shrimp farming is data from daily inputs. We use our apps to record various parameters -from water quality to operational parameters giving them a wide variety of new problem-solving ideas. Big data can be used for predictive analytics, preventive measures for diseases, optimisation of feed and improvement of overall sustainability."

In describing how the farm cultivation data collected are used for big data, Aryo said that in Indonesia, the

water quality measurements (bacteria, plankton, *Vibrio* etc) are laboratory data from weekly monitoring. He emphasised that the data will help the farmers make decisions themselves. "These are the data being used by Jala to predict trigger points for diseases. Disease labs in Indonesia are still very rare. It is common for small farmers never to test shrimp for diseases. They determine the disease type/status by visual observations only."

The predictive model focussed on predicting acute hepatopancreatic necrosis disease (AHPND), infectious myonecrosis virus (IMNV), white faeces disease (WFD) and white spot disease (WSD).

Data sources

Data was collected over three years, from 1,839 crop cycles out of the 4,000 monitored throughout Indonesia. The cycles were managed by 383 farms. Data were from 1,255 ponds. The data covered four physical parameters measured twice daily (in the morning and evening). These parameters were water temperature, dissolved oxygen, salinity and pH. These were then complemented by farming data (stocking density and pond area). The data also covered disease diagnosis but they have not been customised by region.

Data must be collected following a standard protocol. "Therefore, our data has been collected by our technical team using our instruments to avoid inconsistencies in collection methods. We do accept data input by farmers themselves as long as it is fulfilling our Qualified Data Cycle methods."

JALA uses Generative Adversarial Network (GAN) to overcome missing data and Random Forest models. "Applying the algorithms to these crop data, we managed to achieve F1 scores higher than 0.85 for AHPND, WFD and WSD. However, there is a performance issue in prediction of IMNV where we only obtained a 0.78 recall score which indicates a high false negative prediction. Despite this, in this research, we are convinced that disease occurrence can be predicted based on water quality conditions," said Aryo.

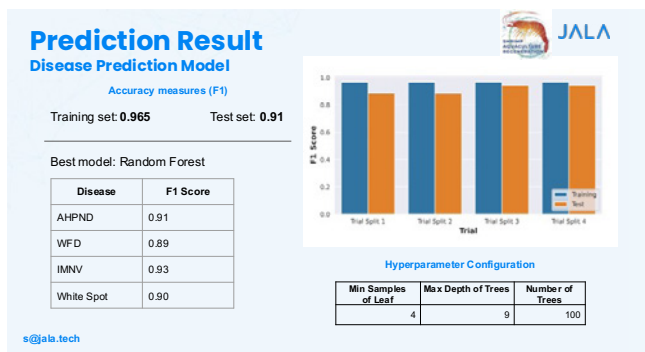


Figure 1. Details on the data sources used in this research.

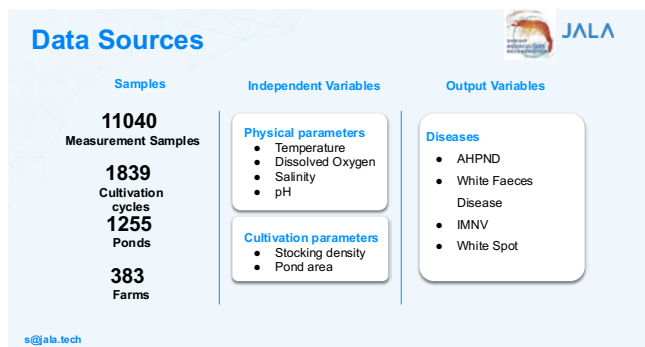


Figure 2. Prediction results from JALA Tech. Source of figures: AI and Big Data Analytics to Predict Trigger Points for AHPND, IMNV, WSSV and WSD, by Aryo Wiryaman, TARS 2023.

"By harnessing the power of these technologies, farmers can proactively manage diseases, optimise resource utilisation and improve operational efficiency..."
said, Aryo Wiryaman.



The integration of AI, big data, and automation presents promising opportunities for mitigating disease risks and increasing sustainability in Asian shrimp farming. By harnessing the power of these technologies, farmers can proactively manage diseases, optimise resource utilisation and improve operational efficiency, leading to a more sustainable and resilient shrimp farming industry.

Aryo clarified that this is still not implemented in the field as the team needs to add more variables and data. "We also want this research to be regional and show regional variations."



Dr Loc Tran (standing) with panel members, from left, Dr Luis Fernando Aranguren; Dr Rajeev Jha, Consultant, India; Chengli Wang, Director of Sales and Service, Genereach, Taiwan; Eduardo Reyes, Production Manager at Grupo Almar, Ecuador; Dr Kallaya Sritunyalucksana, Principal Researcher of Aquatic Animal Health Research Team, BIOTEC-NSTDA, Thailand and Le Van Khoa, Head of Technical Service, Grobest Group.

Shrimp disease management: Asia versus the Americas

At the inaugural Shrimp Summit in Ho Chi Minh City, Vietnam, **Dr Loc Tran**, Founder and Director, ShrimpVet Laboratory, Vietnam led a panel comprising disease experts from the US, India and Thailand, a shrimp producer in Ecuador and disease diagnostics and feed suppliers from Taiwan and Vietnam, to discuss several aspects on managing diseases in Asia and the Americas. The Shrimp Summit, organised by The Center for Responsible Seafood (TCRS) was held on July 24-26.

Dr Luis Fernando Aranguren set the stage for the panel discussion, with a presentation on the history of disease outbreaks in Asia and the Americas. In July, Luis Fernando joined Grupo Almar Ecuador as its Health Manager. Previously he was with the Aquaculture Pathology Laboratory, University of Arizona. He noted that the last outbreak was acute hepatopancreatic necrosis disease (AHPND) in Ecuador in 2015 but production continued the upward trend. In contrast in Asia, the recent outbreaks

of *Enterocytozoon hepatopenaei* (EHP) and white spot syndrome virus (WSSV) brought down production. There is a clear difference in the disease threats in Asia versus Latin America. The top two diseases are EHP/white faeces syndrome (WFS) and WSSV in Asia whereas it is WSSV and AHPND in the Americas.

The difference between HPM or hepatopancreatic microsporidiosis in the Americas and EHP in Asia was discussed. With WFS, the research showed that it is a combination of several primary and secondary pathogens and a susceptible host, aided by triggers such as high stocking, high biomass, mismanagement and surpassing carrying capacity.

OIE and EHP

Luis Fernando suggested that World Organisation for Animal Health (WOAH) policies need to be updated to remove infectious hypodermal and haematopoietic

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necrosis virus (IHHNV) and Taura syndrome virus (TSV) from the list of notifiable pathogens and add EHP and WFS to the list. In his opinion, the listing will compel industry to regulate testing and avoid intra or interregional spread of EHP in broodstock. However, the fear was that markets may use this OIE listing to create trade barriers such as the current practice where countries demand tests for WSSV even in frozen products. An option is to advise OIE to be specific with testing of EHP in live shrimp only.

Based on their research, Kallaya, Loc and Rajeev concurred that EHP is deactivated in frozen shrimp. Nevertheless, it is important to have EHP listed with OIE, to have at least an in-country control on its spread.

Diagnostics and emerging pathogens

The limited understanding of pathogen detection has led to the focus mostly on known pathogens tested by PCR. Diagnostic PCR methods for EHP/HPM detection included conventional, real time and nested. Only the spore wall protein (SWP)-PCR detection method developed in Thailand has sensitivity to EHP.

Despite the importance of histopathology to detect new etiologies or syndromes, its use is declining. The problem of false positive PCR detected from endogenous viral elements (EVE) in the shrimp genome, when shrimp are not infected, was raised. The challenge is to develop primers that are not affected by integrated viral DNA. IHHNV-EVE is a typical example of this phenomenon in monodon shrimp.

The future in diagnostic tools includes next generation sequencing (NGS). The new CRISPR-based diagnostics may provide sensitivity similar to PCR but with much reduced cost and no specialised equipment or training.

There are some emerging pathogens such as covert mortality nodavirus (CMNV) and translucent post larvae disease (TPD) but there is no strong evidence of their presence and impact on the shrimp industry. Nevertheless, it pays to be vigilant. It is crucial to investigate the cause/nature of any mortality.

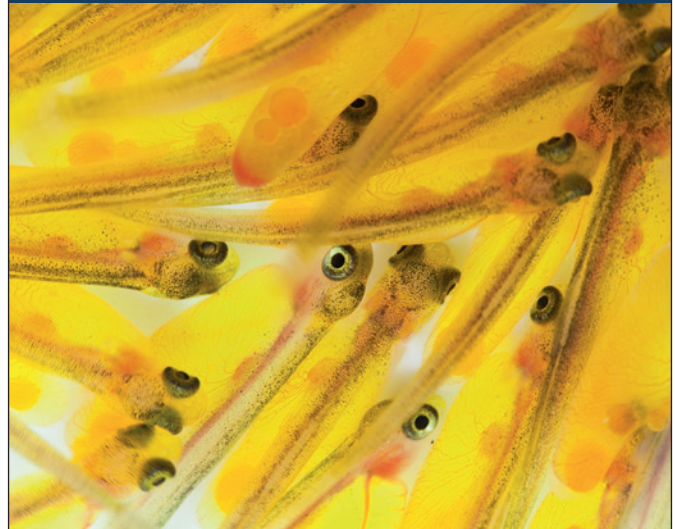
Disease management

The concept of hyperthermia is used to control WSSV. There is also the use of WSSV tolerant lines in the Americas, where survival was 40% compared to 5% with specific pathogen free (SPF) lines or with all pathogens exposed (APE) lines, where survival is 20% compared to 0% with susceptible lines.

AHPND is in the Americas but how the pathogen affects farms is different from that in Asia. Farms in Asia use of SPF/specific pathogen resistant (SPR) broodstock to produce clean post larvae unlike the situation in the Americas. It is perhaps because of the lower stocking and less stressful culture systems in the Americas.

Disease continues to be the single largest issue facing producers worldwide. The challenge is how to build capacity. Should control of some disease be prioritised? Loc suggested that this be based on the risk level posed by each disease. Rajeev offered a perspective that focus be based on the economic loss, whereby EHP adds to high feed conversion ratio while AHPND succumbs to chronic mortality. Source: TCRS www.responsibleseafood.org

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Empowering independent aquaculture

Anton Immink on ThinkAqua's innovative approach to engage independent farmers

By Zuridah Merican

In a candid conversation during Seafood Expo Global in Barcelona, **Anton Immink**, CEO of ThinkAqua, discussed the inception and aspirations of this novel aquaculture-positive non-governmental organisation (NGO). The dialogue sheds light on ThinkAqua's distinctive mission, its ongoing projects, funding sources and its vision for the future.

Immink initiated the conversation by addressing the dearth of small, dynamic NGOs dedicated to aquaculture, which can understand market issues, and able to engage with smallholders. "The big international NGOs and organisations like FAO often run aquaculture as just another program in their overall offering and can be constrained by established working patterns, for example only with government partners. There was a gap in the market and a chance to establish ThinkAqua as a unique organisation dedicated to delivering projects on the ground in a practical and dynamic way - covering all aquaculture species and working with innovative companies; bringing in additional expertise when required," said Immink. He's not alone: ThinkAqua's Board of Trustees includes key figures from academia and industry, including Professor Dave Little (University of Stirling), Dick Jones and Aisla Jones.

The conversation touched upon large organisations that have aquaculture programs. They have their place, but ThinkAqua, aspires to foster sustainable growth in the aquaculture industry without pushing a specific environmental agenda.

"We are not here to push a particular agenda, such as around environmental management, but to find positive solutions for sustainable growth." ThinkAqua is, however, keen to foster partnerships with as many local NGOs as possible. "There is a lot of power, energy and expertise in those NGOs who have been working with communities for years, but who need some international connections to make a step-change in impact."

Specific focus

When asked about Think Aqua's specific focus, Immink elucidated that the organisation aims to empower smallholder independent producers to play a pivotal role in local and global supply chains. Currently, its projects revolve around shrimp in Indonesia and carp in Nepal and Bangladesh. It is working with the Gatsby Foundation on development of the tilapia industry in Kenya and Uganda. These projects are carried out in collaboration with local partners and aim to address diverse challenges within the aquaculture industry, such as disease management and economic sustainability.

"With Gatsby, we are working on a range of issues - spatial planning, the economics of small-scale farming and sustainability of feed ingredients."

He discussed the logistical challenges in Africa, particularly in the context of aquaculture. He highlights that Africa



Anton Immink is the CEO of ThinkAqua. He was previously an Aquaculture Director at the Sustainable Fisheries Partnership, a senior consultant at the University of Stirling, Scotland and a Visiting Scientist at FAO. He has helped pioneer the Aquaculture Improvement Project (AIP) model and shift industry discussion beyond just being farm-focused to proactive landscape-level actions on disease and environment. He has chaired repeated smallholder innovation sessions at several international industry conferences.

has comparatively low population densities, which can make the distribution of essential aquaculture inputs such as feed and seed more challenging and expensive. Feeding black soldier fly larvae whole to tilapia in rural Uganda creates an innovative solution to address this issue. By locally producing black soldier fly larvae using waste products from markets, farmers can provide cost-effective and sustainable feed for their tilapia.

This approach not only addresses the economic challenges faced by farmers but also encourages more frequent and efficient feeding. "These logistical challenges in Africa underscore the importance of finding practical solutions to enable the aquaculture industry to thrive locally," said Immink.

Setting itself apart from other NGOs

The question was how different ThinkAqua is compared with other NGOs. "What sets us apart is that we are still small and dynamic and have a wealth of experience. We can bring in additional partners. As a team, our strength is delivering projects on the ground, understanding challenges, engaging farmers and building trust. We are on the lookout for innovation, new ideas and future

leaders who are keen to engage and find solutions for independent farmers,” said Immink while emphasising his wish to move away from using the term small-scale farmers or smallholders.

Achievements to date

Within its initial year of operations, ThinkAqua’s accomplishments include collaborating with the World Economic Forum to develop a roadmap for sustainable aquaculture, piloting the shrimp improver program in Indonesia in partnership with the Aquaculture Stewardship Council (ASC) and conducting assessments of aquatic health across ten African countries with the support of FAO. Notably, ThinkAqua made a direct donation to a farm in Uganda, enabling the purchase of an ice machine that revolutionised the local fish market.

“In the pilot of ASC’s Improver Program, with our partner, YSAI (Yayasan Sinergi Akuakultur Indonesia), we are getting four farms through the Aquaculture Improvement Project to reach certification with two processing plants, BMI and PT Sekar Bumi, and tech company JALA.”

Funding sources were revealed, including the World Economic Forum, FAO, ASC, Walmart Foundation and Gatsby Africa. While ThinkAqua is keen to grow and replicate its successful models, securing funding remains a challenge.

In the next five years

Regarding the prospects for the next five years, Immink envisaged the NGO expanding to a team of 10, situated in strategic locations across the world. The primary focus will be on promoting aquaculture production in Africa, especially tilapia production in ponds and cages. ThinkAqua also aims to encourage wastewater treatment pond utilisation among shrimp farmers. He emphasised the importance of finding economic incentives for farmers to adopt sustainability practices beyond mere certification requirements.

Immink sees the creation of novel business models and approaches, like some hub and spoke models that can be replicated in many countries with blended finance approaches.

“I just hope that donors out there recognise the value of aquaculture as a low carbon footprint food production system that can feed people locally as well as being part of the international market. We know that our organisation is still small and we are always keen to add value to a consortium.”

While funding remains a challenge, Immink expressed optimism about the future, highlighting the importance of identifying the right individuals to lead the organisation and continue its growth trajectory. Immink wants young, dynamic, creative people taking leadership roles in the aquaculture industry and continuing to reinvigorate the industry.

ThinkAqua is a dynamic and innovative NGO with a mission to support the growth of sustainable aquaculture, particularly in developing regions. While challenges persist, Immink’s vision for the organisation’s future is to expand its impact with their extensive on-the-ground experience, understanding of how to build trust with farmers and knowing what makes them tick.

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Omega-3 futures in aquafeeds

An In focus workshop analysed gaps between science and practices and use of omega-3 stocks more efficiently



The IFFO In Focus workshop was held in Stirling, Scotland. From left, front row: IFFO's Veronique Jamin, Communications and External Relations Director and Petter Johannessen, Director General, Nina Liland and Bente Ruyter. Second row: Philip Calder, Brett Glencross and Richard Newton. Third row: Enrico Bachis and Monica Betancor.

A unique group of academic and industry experts in Aquaculture, fish and human nutrition gathered for an IFFO In Focus workshop on May 31 in Stirling, Scotland to analyse the knowledge gaps in the omega-3 story. They covered its role in fish and human nutrition, to what and where the potential growth is, and how we can use omega-3 stocks more efficiently. Discussions focussed on the gap between science and practice, such as the inclusion rates, which are often determined in laboratory instead of farm conditions.

Opening the event, IFFO's **Dr Brett Glencross** stated that the industry needs to look beyond flesh/fillet omega-3 targets, exploring what the actual requirements are for both fish and humans and how we communicate this.

Mapping the global supply of omega-3s and the potential for more

Looking at the reality and potential omega-3 supplies, **Dr Richard Newton**, University of Stirling presented a systems approach to quantify the global omega-3 production and utilisation pathways, the natural loss in nature and the loss in processing along the path to human consumption. In fisheries, loss can be reduced by improving the natural pathways through fisheries management. However, the greatest potential lies within aquaculture and fish processing, which currently sees a huge loss of potential by-products.

"There are a lot of inefficiencies in the value chain for most species, although in aquaculture, gains are being made in terms of nutrition, feed delivery and genetics, for some species. Only a small fraction of EPA and DHA from net fish

production is actually harvested: seafood trimmings have huge uncaptured value."

Opportunities for by-products vary greatly globally and the industry needs to carefully determine what goes to feed or direct human consumption.

Looking at the potential of by-products across different regions, Newton presented findings from a IFFO development database (2013), looking at pathways, use and waste. The database showed the potential for an additional 2.5 million tonnes of fishmeal globally from by-products and this figure is expected to have increased since the data was last gathered in 2013. If all seafood was processed, the extra potential was calculated at 9.7 million tonnes, which again shows the huge waste level within the current food system. An example of this potential is that retention of omega-3s is lower in the fish fillet, with most being left in the 'waste'.

However, the data does not account for the increasing use of by-products for direct human consumption, or in pet food. More data gathering is needed on this potential and omega-3 retention in various fractions to allow the industry to better map and utilise the various products.

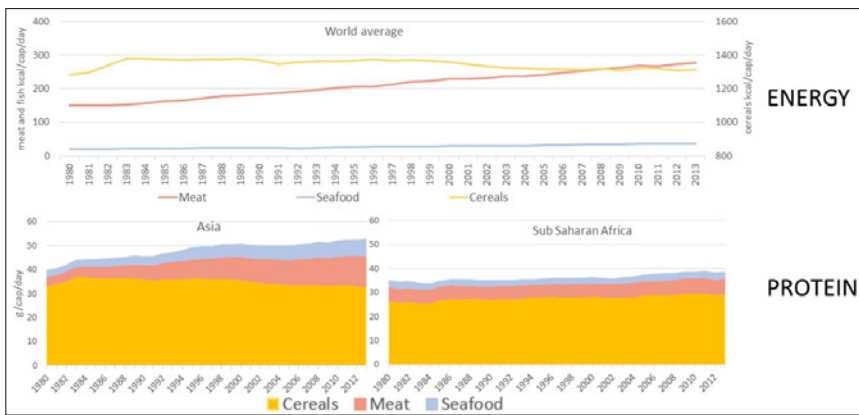
Identifying these marine ingredient sources and reducing loss is essential for the growth of aquaculture, which is accelerating, both in Asia and Africa. In China, seafood consumption is growing with people eating more protein and more energy dense food and reducing consumption of cereals. The market will not always be the best driver to improve nutrition and resources need to be used in a strategic way.

There is potential for species such as tilapia and grass carp, which efficiently convert alpha-linolenic acid (ALA) to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Gains are being made in terms of nutrition, feed delivery and genetics. However, inefficiencies remain across the value chain for most species and more assessments are required to identify the potential and deliver this change.



Dr Richard Newton, University of Stirling noted only a small fraction of EPA and DHA from net fish production is actually harvested.

"There is a push to apply a nutritional index to life cycle assessment as an additional impact category. A big topic presently is how to measure the impacts of food from a nutritional perspective."



People are eating more protein and more energy dense foods.

Where are we with development of novel omega-3 sources?

Exploring the potential new sources of omega-3s, Associate Professor **Monica Betancor**, University of Stirling introduced the range of new omega-3 sources under development, starting with algal biomass, which has a limited inclusion level due to constraints with digestibility, and algal oil, which is higher in price.

EPA and DHA contents vary across the products and data is still being gathered to map environmental impacts to compare with other ingredients. Fish trials have been carried out, showing beneficial results with impacting levels on sea lice with one of the algal oil ingredients. An example of an innovative approach in this area is a DHA only biomass oil produced from pot ale (from whisky distilleries) to create a more sustainable ingredient for the pet and aquafeed markets.



With regards to GM crops, Associate Professor Monica Betancor, University of Stirling said the UK is now differentiating from the EU on the inclusion of GM crops and a new bill may open up this market.

Moving to genetically modified (GM) crops, they can be an EPA and DHA mix and differing commercial crops are available with trials carried out on humans and several fish species. The main plants being used are canola and camelina, but questions remain regarding the varying balance of EPA and DHA, on-going investigations into health benefits and impacts, legal challenges and public acceptance. The UK is now differentiating from the EU on the inclusion of GM crops and a new bill may open up this market.

Betancor showed other areas of innovation including precision fermentation and cell cultivation. She concluded that we need to re-assess these ingredients based on new sustainability indicators and look at direct human consumption rather than just feed inclusion.

How do omega-3 affect fish physiology?

Moving to the role omega-3s play in fish physiology, **Dr Nina Liland** at IMR, Norway presented findings from long-term fish trials, showing that without EPA/DHA, farmed fish are vulnerable to stress and disease. Fish are affected by both their environment and water temperature and the amount of dietary EPA/DHA required depends on both these factors and how they adapt their membrane to the temperature. Diet is more impactful on the fatty acid composition of Atlantic salmon than the water temperature. Fish can handle lower levels but there is a baseline, as too little EPA and DHA changes the fatty acid composition in essential organs.

A study by Hundal et al. (2022) showed the close relationship between omega-3 and omega-6. Given their role in impacting cell membrane structure and gut, bone, gill, and



Dr Nina Liland at IMR, Norway presented findings from long-term fish trials, showing that without EPA/DHA, farmed fish are vulnerable to stress and disease.

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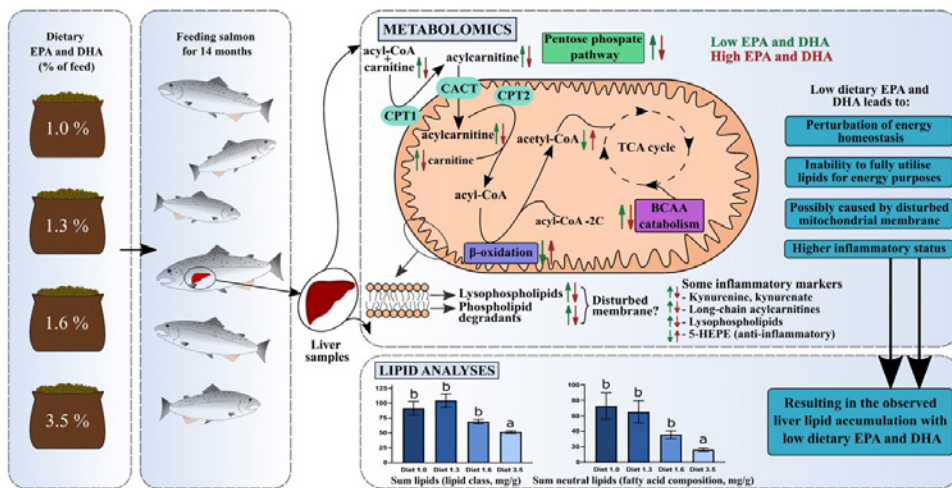
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Source: Hundal BK, Luffi E, Sigholt T, Rosenlund G, Liland NS, Glencross B & Sissener NH (2022) A Piece of the Puzzle-Possible Mechanisms for Why Low Dietary EPA and DHA Cause Hepatic Lipid Accumulation in Atlantic Salmon (*Salmo salar*). *Metabolites*, 12 (2), Art. No.: 159. <https://doi.org/10.3390/metabo12020159>

skin health, the balanced inclusion of EPA and DHA is vital to improving resistance to inflammatory diseases. These positive effects are still being mapped on skin health, which is very important in a farming environment and EPA and DHA have been shown to promote tissue integrity.

Trials have shown that a low EPA and DHA diet impacts astaxanthin deposition and increases fat content in the liver, intestine, and viscera, leading to reduced intervertebral space and caused hyper-vacuolisation of the intestinal cells. Additionally, EPA/DHA impacts corticosteroid regulation. However, there are complex interactions in the synthesis of other steroids. The new sources of EPA and DHA have a huge variation of EPA/DHA ratios, which provides a challenge in feed formulations. The benefits of EPA and DHA are extremely complex and are still being investigated; what is clear is that ensuring a balanced inclusion of both, along with balanced inclusion of omega-6, promotes fish health.

What is the market doing with regards to the omega-3s?

Starting with global production, IFFO's **Enrico Bachis**, noted that supply has remained steady since 2010 of around 5 million tonnes of fishmeal and 1 million tonnes of fish oil. Latin America, most notably Peru, still leads in fishmeal production, whereas fish oil production is led by Asia and then Europe, with the difference due to the variation of fat content to produce fish oil.

The use of by-products continues to rise, with 34% of global fishmeal supply coming from by-products and 53% of global fish oil supply coming from by-products in 2023. The EPA and DHA markets differ from the fish oil markets again due to the variation of EPA and DHA in the raw materials.

In terms of the main sources of crude oil, anchovy (from Peru and Chile) continues to lead, followed by sardine and menhaden (USA). Sources of crude oil are diverset and production of algae-based EPA and DHA is increasing.

Aquaculture is a major consumer of fishoil

In terms of demand for fish oil, looking at 2021 figures, aquaculture consumed 74%, direct human consumption (supplements) consumed 16% and petfood consumed 10% in 2021. Demand for aquafeed continues to increase and marine ingredients are now considered a strategic ingredient with a critical role within a broader raw material basket. Demand is growing fastest with crude oils, with an average growth prediction of 2.5%/year to 2025. In general, market demand for fish oil is diverse and prices have reached record levels, with stock availability especially impacting the pharmaceutical sector. This demand is pushing for further strategic use.

What can we learn from human omega-3 physiology

Moving the focus to humans, Professor **Philip Calder**, University of Southampton explored lessons learned from human omega-3 physiology. EPA and DHA provide special and unique biological properties to humans, changing the physicality of the membrane and its function, changing protein and lipid function and structure in a more optimal way. This changes gene expression patterns, altering when proteins are produced, cell responses and activation and "raft" assembly in the cell membrane, which affects the way in which proteins and cell membranes function. The overall benefit to this is the reduction of inflammation which then benefits different organs throughout the body, including aiding visual function, cognitive function, metabolism,

Evolution of salmon feed formulation

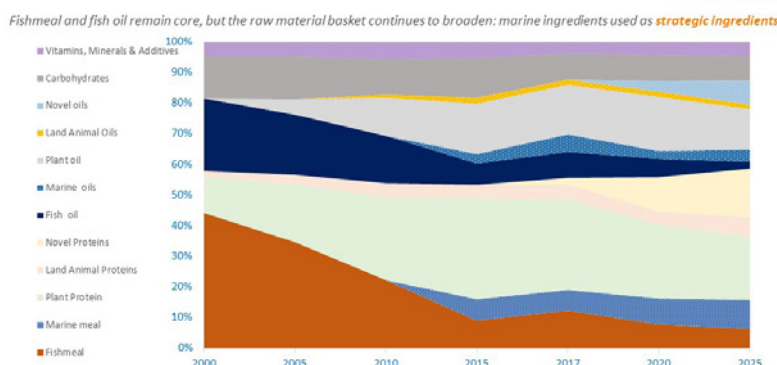


Chart represents an index for a composite global salmon formulation. Local formulations will vary, eg local land animal proteins might be 40% of the diet in some regions. Source: Cargill.



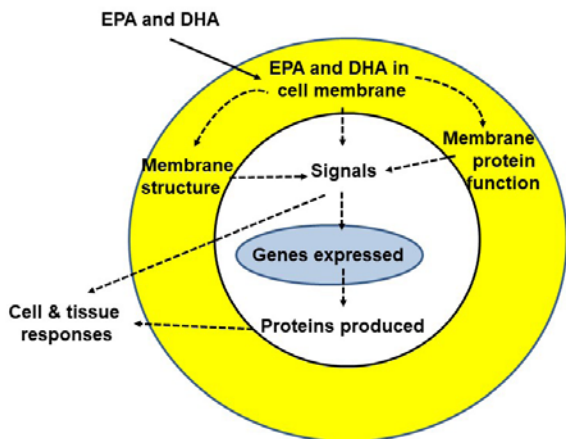
inflammation regulation, immune responses, oxidative stress, blood coagulation, organ function (e.g. heart, liver, lung, muscle) and wound healing.

EPA and DHA are generally poorly synthesised in humans, so their inclusion in our diets is essential. EPA is typically absorbed faster than DHA, but DHA is biologically more stable, so it is retained in the body for longer periods. In terms of dose, short term impacts can be seen with high consistent doses with longer retention, but over longer periods, fluctuating doses are still beneficial.



Professor Philip Calder, University of Southampton said EPA and DHA provide special and unique biological properties to humans, changing the physicality of the membrane.

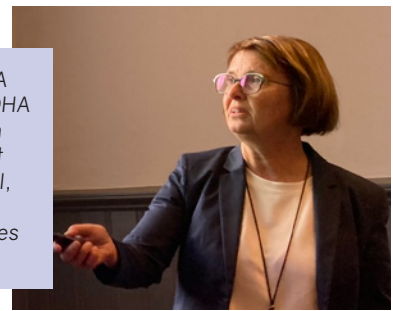
Consumption of EPA and DHA is especially essential during pregnancy and early development, especially with breast feeding. In terms of a hierarchy of anti-inflammatory effects of fatty acids, EPA and DHA are most effective, followed by stearidonic acid (SDA) and ALA, the last being the least involved in anti-inflammatory responses in the body. Highly controlled laboratory experiments have indicated that for some processes (e.g. inflammation) DHA is more potent than EPA and that plant omega-3s have low bioactivity (low conversion to inflammation mediators), although the latter is still being explored.



EPA and DHA influence how cells work.

What do we know about the omega-3 requirements in Atlantic salmon?

Exploring the latest science on omega-3 inclusion in salmon feed, **Dr Bente Ruyter** (NOFIMA) discussed the impacts on growth, health, and quality. Studies have shown that dropping EPA and DHA inclusion in salmon feed below 1% of the diet leads to reduced survival, fatty liver, intestinal pathology, and deformities of vertebrae. Bente presented the results of a trial carried out on Atlantic salmon in sea cages to assess the impacts of varying levels of EPA and DHA, and improvements to growth, welfare, robustness, and fillet quality.



Dr Bente Ruyter, NOFIMA said dropping EPA and DHA inclusion rates in salmon feed below 1% of the diet leads to reduced survival, fatty liver, intestinal pathology and deformities of vertebrae.

Using four diet groups of differing levels of EPA and DHA in the feed (1%, 1.3%, 1.6 and 3.5%), results showed that fish in the high omega-3 group outperformed the others. Growth rates were unaffected at early stages in the trial, but the high EPA and DHA groups grew fastest by the end and had higher EPA and DHA retention rates.

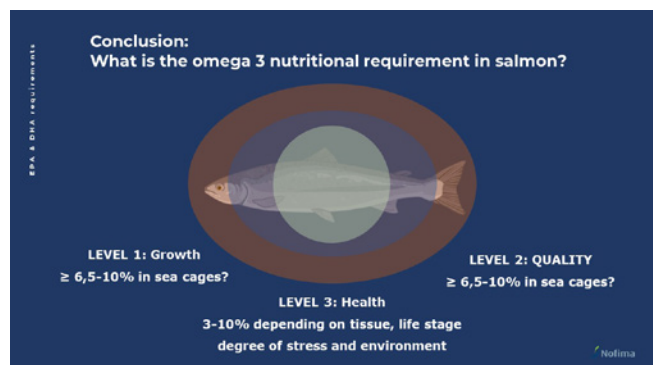
In terms of overall health, benefits of a high EPA and DHA diet were seen in the muscle, liver, hindgut and skin. Other studies showed that lowering the fat content in the diet, along with increasing EPA helped with heart health in fish. Resilience to disease was also higher in fish fed high EPA and DHA diets with lower mortality observed. In terms of rates in mineral uptake, EPA and DHA improved absorption throughout the body, especially of selenium and zinc.

Fillet quality was also improved with this group, including the colour, muscle firmness and incidence of gaping. Overall, studies have shown that the requirement of EPA and DHA in Atlantic salmon diets is higher than previously thought and played an important role in health, growth and quality.

Requirements for essential fatty acids by shrimp

Focussing on shrimp fatty acid requirements, Glencross noted that shrimp metabolism and lipid storage differ substantially from that of fish. The main shrimp species (*Penaeus vannamei* and *Penaeus monodon*) have clear thresholds to dietary lipid levels and are sensitive to fatty acid manipulation with evidence of multiple requirements. There is clear evidence in monodon shrimp of requirements for EPA and DHA, linoleic acid (LOA) and linolenic acid (ALA/LNA), but arachidonic acid (ARA) appears to antagonise fatty acid responses.

EPA and DHA have been observed to enhance growth, and in combination act synergistically whereas the addition of ARA has a negative impact on growth (in juvenile stages). The relationship between omega-3 and omega-6 fatty acids is complex and shows several sub level interactions.



The nutritional requirements of Atlantic salmon for omega-3s.

Evidence is less clear with vannamei shrimp, with some trials showing the addition of LOA or LNA either singly or in combination has no effect (or even negative). However, the addition of LC-PUFA (irrespective of whether EPA, DHA, ARA or EPA+DHA) stimulates growth. There is also some evidence for fortifying body lipid levels, though the effect is not strong. There are several studies that have reported zero-fish oil inclusion with varying degrees of success, most relying on algal oil supplementation.

In general, the vannamei shrimp trials have some limitations, with inconsistencies between the quantitative work and the fish oil replacement studies. Much of the work has null hypothesis outcomes (i.e., no result) indicating some flaws in the designs. More needs to be explored, especially around the inclusion of "conditioning" diets, which seems counterproductive and the use of ethyl esters. Data is also lacking on independent requirements for EPA and/or DHA in vannamei shrimp, the role of EPA and/or DHA on immune function and finally on environment x requirement interactions.



With regards to omega 3s in penaeids, IFFO's Brett Glencross said more needs to be explored, especially around the inclusion of "conditioning" diets and the use of ethyl esters.

What do we know on requirements for marine fish?

Glencross also explored omega-3 requirements for marine fish. Responses vary across species, notably greatly differing from Atlantic salmon and again requirements also change across the life cycle. In general, without EPA and DHA, there is growth retardation and essential fatty acid retention also drops. Smaller fish need more omega-3s and increasing the level of ARA results in poorer growth in some species, and DHA alone produces only nominal improvement.

Data is still lacking on the influence of 18:2n-6 on LC-PUFA requirements, and the role EPA and/or DHA in immune function needs further clarification. Finally, there are few quantitative models on maximising the uptake and retention efficiency.

Conclusion

The role of EPA and DHA varies across species, but in general they remain essential in most aquaculture species and for human health. It is evident that we are not underestimating their importance in aquaculture and the continued strategic inclusion of these nutrients in aquaculture diets demonstrates this.

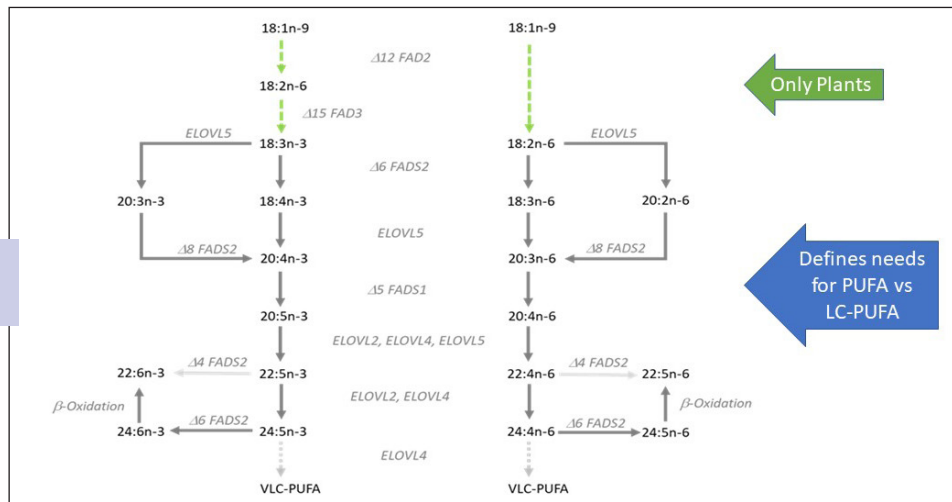
Emerging shortages can potentially be addressed with increasing production from by-products and ensuring their strategic use between feed and direct human consumption. Alternative ingredients appear unlikely to fill the current gap in omega-3 demands. However, algal products do show potential; due to fish oil price increases and they are beginning to make a notable contribution, but GM ingredients still appear some way off. Lessons can be learned from both the human and aquaculture sectors to fill the science gaps, especially on biological markers.

This article was contributed by the IFFO team

The essential fatty acids in marine shrimp.

- Essential fatty acid requirements by shrimp are reasonably well known.
- Requirements for EFA have been demonstrated in several species.
- Shrimp are relatively responsive to changes in EFA supply.

What biologically defines essentiality?



The effects of black soldier fly meal on growth performance, lipid and fatty acid composition of juvenile red swamp crayfish

By Shanmugam Neviliappan, Mun Ka Ki and Lim Jie Min



Red swamp crayfish culture at the Centre for Aquatic Science and Technology (CAST).

In promoting a circular economy in aquaculture, the use of black soldier fly meal (BSFM) for red swamp crayfish *Procambarus clarkii* can be supported. Annually, the red swamp crayfish accounts for most crayfish consumption, and the continued growing production of crustaceans is expected (Wisconsin Department of Natural Resources, 2009). Overcoming factors limiting the aquaculture of the red swamp crayfish is paramount to developing and maintaining an economically sustainable farming industry (Ponce-Marbán et al., 2006; Bostock, 2011).

A potential feed ingredient for farming the crayfish is the meal from the larvae of the black soldier fly *Hermetia illucens*. However, questions remain on the effects of BSFM on the growth performance and lipid and fatty acid composition of juvenile red swamp crayfish. In this article, we report on those effects with a feeding trial on juvenile crayfish conducted at the Centre for Aquatic Science and Technology (CAST), School of Life Sciences and Chemical Technology (LSCT), Ngee Ann Polytechnic, Singapore.

Importance of alternative proteins

Formulated feed is a major cost for farmers in aquaculture (Baki and Yucel, 2017). So, it is important to develop cost-effective and nutritionally balanced feeds for this crayfish (Hasan, 2001). Fishmeal (FM) is an essential ingredient in formulated feed, but its reliance is detrimental to the environment and aquatic wildlife sustainability (FAO, 2018; Bostock, 2011). This has led to the adaptation of alternative protein sources in feed formulation, with insect protein being a recent development in aquaculture.

With the ease of proliferation and minimal risks as a carrier of harmful diseases, the larvae meal of the black soldier fly is an ecologically and economically sustainable protein alternative (Wang and Shelomi, 2017).

Given that the larvae meal has a similar essential amino acids profile as FM (Smets et al., 2020) and high levels

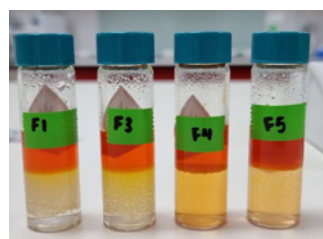
of protein content ranging from $40.8 \pm 3.8\%$ (Wang and Shelomi, 2017), the partial replacement of FM with BSFM has been deemed feasible for most fish and crustacean species with minimal compromise on growth performance (Foyosal et al., 2019; Katya et al., 2017).

Benefits of essential fatty acids

When the black soldier fly larvae is fed on an optimal substrate diet, their lipid content can reach 30% (Wang and Shelomi, 2017) which is higher than most insects. Zhou et al. (2017) reported a significant increase in saturated fatty acids, such as lauric acid and a decrease in unsaturated fatty acids, such as omega-3 fatty acids, in Jian carp when fed an increasing amount of BSFM.

Polyunsaturated fatty acids (PUFA), comprising omega-3 and omega-6 fatty acids, are known as essential fatty acids (Kaur et al., 2014) and dietary consumption has been demonstrated to show numerous health benefits to humans – helping to reduce the risk of chronic diseases as well as reducing inflammation (Wall et al., 2010).

Medium-chain unsaturated fatty acids (MUFA), comprising of omega-9 fatty acids, such as oleic acid, have been shown to produce numerous health benefits for humans, such as reducing the risk of cardiovascular disease as well as maintaining body weight (Mashek and Wu, 2015).



Separation of fatty acid methyl esters (FAMES) in the hexane layer (top layer) and aqueous layer (bottom layer).

| | Control | Feed 2 | Feed 3 | Feed 4 | Feed 5 |
|-------------------------------|---------|--------|--------|--------|--------|
| Fishmeal (FM) | 20% | 15% | 10% | 5% | 0% |
| Black soldier fly meal (BSFM) | 0% | 5% | 10% | 15% | 20% |
| Soybean meal (SBM) | 10% | 10% | 10% | 10% | 10% |

Table 1. Total crude protein used was 30% in all experimental and control feeds.

| Ingredients | Dietary treatment (g/100g) | | | | |
|--------------------------------|----------------------------|--------|--------|--------|--------|
| | Control | Feed 2 | Feed 3 | Feed 4 | Feed 5 |
| Black soldier fly meal | 0.00 | 10.89 | 21.79 | 32.68 | 43.57 |
| Fish meal | 36.36 | 27.27 | 18.18 | 9.09 | 0.00 |
| Soybean meal | 27.40 | 27.40 | 27.40 | 27.40 | 27.40 |
| Cod liver oil | 9.44 | 7.10 | 4.75 | 2.41 | 0.06 |
| Dextrin | 6.27 | 6.27 | 6.27 | 6.27 | 6.27 |
| Vitamin premix | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Mineral premix | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Squid meal | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Sodium carboxymethyl-cellulose | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Alpha cellulose | 6.52 | 7.06 | 7.61 | 8.15 | 8.70 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

Table 2. The formulation of experimental and control feeds. Fish meal was purchased from Mainland Tropical Fish Farm, Singapore. Soybean and black soldier fly meal were sponsored by Biofuel Research Pte Ltd. Other ingredients were purchased from the local suppliers.

Feeding trial

The feeding trial (Table 1) lasted for 35 days and the growth performance of the crayfish was measured and calculated. The control and experimental groups consisted of a sample size of 18–20 at the start of the experiment.

The survival rate of the control and experimental feeds 3 to 5 ranged from 61.1% to 75.0%. However, for Feed 2, the survival rate was 5.6%, with only one crayfish remaining at the end of the trial. This result could be due to poor health and disease from observations showing the experimental group's inactivity and lack of appetite. As a result, Feed 2 was subsequently removed from the measurement of growth parameters and further analysis.

Amongst the feeds (Table 2), Feed 5, containing the highest level of BSFM (43.57g/100g diet), produced the lowest feed conversion ratio (FCR) of 3.18 and Feed 4 (32.68g BSFM/100g diet) produced the highest at 3.59.

Growth performance

There was no significant difference in the final body length of crayfish across all experimental feeds, with the percentage increase in body length ranging from 19.7% to 20.6%. The same applies to the final body weight, where

the percentage increase ranged from 45.9% in the control to 47.2% in Feed 3. Overall, through statistical analysis using one-way ANOVA, it was concluded that the replacement of FM with BSFM does not affect the growth parameters of red swamp crayfish when reared over a period of 35 days (Figure 1).



Ventral view of red swamp crayfish used in the feeding trial.

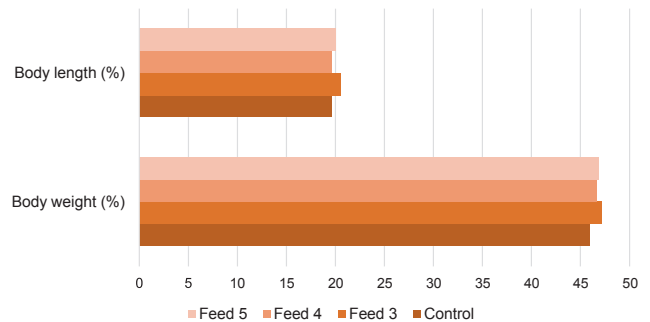


Figure 1. Percentage increase of growth parameters of red swamp crayfish in the feeding trial.

Results from lipid and fatty acid analyses

The increasing replacement of FM with BSFM led to a general upward trend, as observed in Figure 2, contrary to other studies on crustaceans, such as in Chen et al., 2022. This may be due to the use of different crustacean species and the extraction of muscle lipids in fillets compared to the entire body of the red swamp crayfish. The crude lipid composition of red swamp crayfish fed with Feed 4 (8.90%) and Feed 5 (8.25%) exceeded 8% (per 5g of sample), while control feed (7.26%) and Feed 3 (7.05%) was below 8% (per 5g of sample, Figure 2).

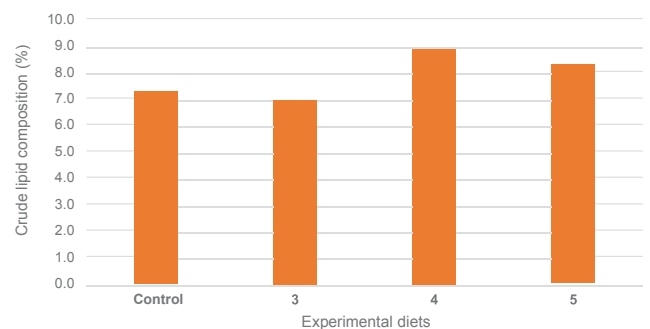


Figure 2. The crude lipid composition of red swamp crayfish fed with control and experimental feeds for 35 days.

In Table 3, the presence of saturated fatty acids such as palmitic acid and melissic acid, oleic acid (MUFA) and linoleic acid (PUFA) was observed in all feeds. This result suggests that these fatty acids were naturally present in red swamp crayfish (Wen et al., 2007; Thompson et al., 2010; Gao et al., 2020).

At the same time, the number of fatty acids increases with higher amounts of BSFM (Table 3). For example, comparing Feed 4 and Feed 5 to Control and Feed 3, we see an increase in the number of fatty acids such as lauric acid, palmitic acid, eicosatrienoic acid, and arachidonic acid.

Considering that this is a preliminary study, other fatty acids reported in other studies (Wen et al., 2007; Xu et al., 2012) were not reflected in the fatty acid profiles of the present study. Hence, further investigation with longer feeding trial is warranted to depict the actual full effects of BSFM on the fatty acid composition of red swamp crayfish.

| Classification of fatty acids | Fatty acids | Control | Feed 3 | Feed 4 | Feed 5 |
|-------------------------------|---------------------|---------|--------|--------|--------|
| Saturated fatty acid | Lauric acid | | | ✓ | ✓ |
| | Palmitic acid | ✓ | ✓ | ✓ | ✓ |
| | Stearic acid | ✓ | | | |
| | Heneicosylic acid | | | | ✓ |
| | Melissic acid | ✓ | ✓ | ✓ | ✓ |
| MUFA | Oleic acid | ✓ | ✓ | ✓ | ✓ |
| PUFA | Linoleic acid | ✓ | ✓ | ✓ | ✓ |
| | Eicosatrienoic acid | | | ✓ | ✓ |
| | Arachidonic acid | | | ✓ | |

Table 3. Fatty acid profile of red swamp crayfish lipid extracts. Ticks indicate presence of fatty acids in red swamp cray fish fed with different types of feeds.

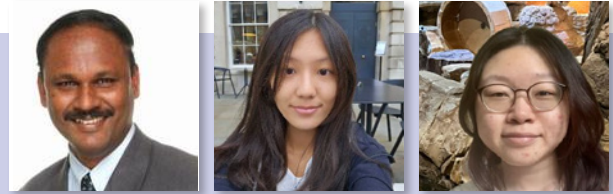
Conclusion

The use of insect protein has consistently shown to be a sustainable alternative to FM. Although there were no visible effects seen, that are significant from the replacement of FM with BSFM, the impacts on the fatty acid composition suggest that the excessive use of BSFM in farming red swamp crayfish will need to be further monitored for long-term adverse health effects in consumers.

Acknowledgement

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References are available on request.



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ASC's Improver Programme and what producers need to know

ASC's Roy van Daatselaar and Thai Union's Blake Stok rationalise on efforts to be inclusive in certification and best practices among small scale shrimp farmers

The Aquaculture Stewardship Council (ASC) has a mission to drive the transformation of global aquaculture towards environmental sustainability and social responsibility through its certification programme. However, not all aquaculture producers are able to meet ASC's robust and strict standards requirement.

"The aquaculture industry includes a significant number of small-scale farms, particularly in Asia, and providing guidance to these producers on how to improve practices will play an important role in the ASC's mission to raise the overall performance of aquaculture," says **Roy van Daatselaar**, ASC's Global Lead Improver Programme, in Utrecht, The Netherlands at the Global Shrimp Forum 2023 on September 7.

On September 6, ASC announced the launch of the Aquaculture Improvement Project (AIP) framework for the Improver Programme after successfully undertaking several pilots in different countries. It also announced the participation of Thai Union, as one of the first partners to implement ASC's AIP with farmers in Thailand.

"In July, we launched an extension of our sustainability strategy SeaChange®2030 with solutions across people and planet that better sustain a future for all. First created in 2016, SeaChange® was early in meeting commitments which actively support the delivery of UN's Sustainable Development Goals (SDGs). In SeaChange®2030, we have an expanded set of commitments that take us to 2030 and recognise that the time for change is now. That's why Thai Union is committing the equivalent of its entire 2022 net profit of THB 7.2 billion (USD 200 million) to SeaChange® through 2030 and setting aggressive new goals that will impact the entire seafood value chain on a global scale. Our aquaculture commitments are that 100% of our shrimp will be responsibly sourced or in an improvement program," said **Blake Stok**, Thai Union's Sustainability Director for North America, who also works with the company's sustainability teams in Thailand and Europe.

AAP: Why is there a need for an Improver Programme?

Roy van Daatselaar: Our certification program is ASC's main instrument for the transformation of global aquaculture. We realise that for many producers, it is difficult to meet certification requirements. Some of the smaller producers face a lot of technical hurdles, from understanding the standard itself to its implementation on the farm, and sometimes there are investment hurdles too. In 2019, we came up with this Improver Programme (IP).

As announced, we have developed an AIP framework to facilitate a better and more structured approach for the entire industry to drive transparent and credible improvements. ASC is now supporting producers with training and qualification of implementers, which are local organisations that can support producers on a day-to-day basis with the implementation of the AIP. Independent verification will ensure that producers in an AIP are moving



Roy van Daatselaar (left) is ASC Global Lead Improver Programme with Blake Stok. As Thai Union's Sustainability Director for North America, Stok is supporting two operating companies; Chicken of the Sea International and Chicken of the Sea Frozen Foods. The latter is the largest importer of shrimp into the US, but shrimp verified through this AIP could also flow into the Japanese or European markets.

in the right direction. Our first focus is on shrimp farms and once the ASC Farm Standard has been released and in operation, we will move to other species.

What are the pull factors for Thai Union to participate in this programme?

Blake Stok: In line with SeaChange®2030, there is a new set of 11 commitments towards 2030. In terms of responsible aquaculture, we have committed that 100% of our shrimp is produced minimising ecosystem impact and meets current industry best practices in welfare and working conditions.

We recognise that not all farms are fit for certification today and we need to have options to drive better practices and improvement. This AIP is the first real credible framework that is out there to assist us with transparency and verification under the ASC banner. It helps improve potentially thousands of farms in Thailand and elsewhere that are not yet certified. For farmers, the pull factor is improved practices that, hopefully, lead to efficiency gains for themselves.

This programme gives us another tool to help achieve our commitment. We see this as a rigorous framework, standardised and with a credible assurance system behind it. It allows for time-bound improvements that we can monitor and track.

RVD: Regarding demands in the US market, ASC feels that it has a strong value proposition in terms of assurances we offer in the supply chain. Increasingly, we see ASC being preferred by US retailers over other schemes because of the robustness of the programme.

BS: For Thai Union, this is a strong market connection as some customers in the US market are committed to ASC-certified product or products that are in credible improvement programmes like this one. This gives our customers assurance on the market conditions that

they can expect. As Roy indicates, there are a number of customers that have explicit commitments to ASC.

How do you determine who gets into an AIP?

RVD: If a farm has a buyer that is asking for certification or is working with one that is saying, "If we improve our water quality practices, we might all become better producers with less risk. I want to promote this"; the producer can come to us together with the partners. We do a screening at entry to ensure companies meet basic laws and regulations (such as the permit to operate) and are not involved in any legal cases.

We would not accept a farm that is, for instance, sited in a mangrove or critical wetland area as this prevents it from reaching certification.

Producers can choose one of two tracks for their AIP. The first is with the end goal of going towards ASC certification, where the four phase-plan is designed to improve performance of a farm to a stage where it would be ready to begin the ASC certification process at the end of the AIP. Producers who do not wish to become ASC certified but want to improve responsible practices in specific environmental or social areas, will have the option to go for the second route, an AIP to better practices only.

In the latter, producers can pick from a select number of indicators that link back to the requirements in the ASC standard. It is good because we can still measure progress along the same set of indicators as we do for certification. We are still being transparent on what is being approved.

For the first group, after the three years, they are not automatically certified. They have to undergo the normal auditing process but basically, achieving certification is more feasible, as they have implemented all the requirements with external checks. The independent verifier would have confirmed that they meet the requirements of the ASC standard and are ready to enter the audit. Certification has to be separate as this is an independent third-party check.

BS: Thai Union's supply is predominantly from independent farms and farms in this AIP are going to be third-party owned. We have identified a group of farms to participate and Thai Union's technical team is going to guide those farms along the way. ASC is going to schedule training sessions to equip partners with technical understanding, tools and assets that they need to implement over time.

The concept of an AIP is new, so there may be challenges convincing farmers to participate. Thai Union is committed to supporting farmer adoption of this novel approach and building the necessary capacity to ensure its success.

What is the adoption rate to date towards certification for a group or a farm since you started in 2019?

RVD: The first pilot was in Indonesia, working with three medium-size intensive farms linked to PT BMI, Sekar Bumi and JALA (the technology company) over 1.5 years. We trained and equipped local NGO - Yayasan Sinergi Aquaculture Indonesia (YSAI) to support the farms to implement the full suite of certification requirements. ThinkAqua was involved as a partner to support us to capture learnings of the AIP and provide support and oversight on the implementation.

The adoption rate of the producers to meet requirements and follow on improvement steps is very different. In Indonesia, the first farm was fast in going through the



process. They have now achieved ASC certification and as such they are the first to fully complete the AIP cycle. The second one will probably go for certification towards the end of the year.

The third farm is facing a range of challenges, mainly because it needs to begin from a lower starting point, requiring continuous assistance and more investment for the site. Probably, this farm will be ready for certification at the end of the AIP time frame.

In the second half of 2022, we started another pilot with Lenk Seafoods, a German seafood buyer and Luna Seafoods, a local processor acting as the implementer organisation, working with 125 extensive monodon shrimp farmers in Bangladesh. They are working with five different farm clusters to implement not only ASC's Shrimp Standard, but also the group certification requirements. This requires the farmers to set up internal management systems, which include a set of standard operating procedures to keep track of all the practices of every individual farmer within the farm cluster. The dynamics in this AIP are quite different from the one in Indonesia.

What are the preconditions?

RVD: The program is time-bound for a maximum of three years. The standard is divided into different sets of indicators, which are gradually brought into the AIP over a maximum of four phases. There are certain minimum requirements that producers need to meet in the first phase. After every phase, there will be a progress report from the implementer (the local organisation helping the producer). Following that progress report, an independent verifier will go on site to confirm the progress. The verification reports will go back to ASC and all the AIP partners and a summary of the report will be published on our website. There can be slight deviations to the AIP implementation but in essence, AIP farmers should adhere to the timelines in order for us to make sure that improvements are timely and meaningful.

Because of the phased approach in the AIP, producers do not need to start with the full 120 indicators of the standard, but start with the basics and over time, build it up to encompass the full suite of indicators. Then there is the independent verification, which will be followed by the publication on our website of the summary progress reports. This allows stakeholders in the marketplace to engage with producers as they can start to endorse them and build a relationship as well as take a role and responsibility in that process.



ASC's Roy van Daatselaar and Esther Luiten, Commercial Director, with ThinkAqua's CEO, Anton Immink at the launch of the AIP framework in Utrecht, The Netherlands, at the Global Shrimp Forum 2023 on September 6. Photo credit, Pierre-Banoori-Photography.

What are the benefits and challenges for both parties?

BS: We expect that a portion of our farms in this program will move towards ASC certification and a portion of them will move towards best practices. We're at the start of this improvement journey and will grow the number of farms and volume of output covered under the IP over the next three years, from 2024 to 2026. We assume that by 2026, we will have an output of 15,700 tonnes of shrimp from this IP, 4,000 tonnes up to ASC certification and another 11,700 tonnes implementing best practices in line with the social and water quality requirements of the ASC standards.

We see the value proposition for farmers to improve practices, reduce risks and optimise efficiency, which in turn should lead to increased yields or reduced costs.

RVD: Often, processors tend to sponsor farms for certification because, ultimately, they are the ones interfacing and bargaining with the market. They pay for the certification and the audit costs, and they have direct monetary rewards through a premium or through accessing new markets.

With regards to a premium on prices, there is no guarantee as prices are determined by the market. More often, it is access to markets and building longer-term, sustainable relationships with customers. These are the key incentives instead of short-term monetary returns.

Once signed up and on track towards ASC certification, can the producer begin to market itself with a consumer-facing ASC logo?

RVD: We have developed a set of claims for the producer as well as for the other participants signed up to the AIP that have a role and a responsibility in the project. They can make certain claims related to their role in the project. They can claim, "I am in an improvement project with the aim to meet ASC certification" but because the product is not certified, it does not enter a chain of custody. It does not have the full traceability assurances of a product with full ASC certification.

ASC has to be mindful with the claims. There is a specific

clause for farmers that can demonstrate that they meet Key Data Elements (KDE) requirements (ASC's traceability requirements that are aligned with the Global Dialogue on Seafood Traceability). If farmers in the AIP meet those and they are selling into a processing plant that is Chain-of-Custody certified, we will allow a claim to be made on the product.

With regards to charges, we are mindful that already when moving to certification, producers are faced with a lot of costs. We therefore do not want to be charging producers or stakeholders who are already making a strong commitment and investments to improve. We see this as giving back to the industry and trying to create something valuable and meaningful.

How do you measure the key performance indicators (KPIs) for improvement and its traceability?

RVD: In terms of KPIs, when farms enter the programme, they basically start with a gap analysis or a baseline measurement against all the indicators of the standard. These are about 120 indicators. After each improvement phase, there is a detailed analysis on the progress and performance in the AIP through the progress reports of the implementer and the verification of progress by the independent verifier.

On the reporting side, we group the progress indicators under themes to make it more reader-friendly on the website. The idea is to show how a farm is performing on meeting regulations or meeting environmental indicators. We also aggregate into percentages in speedometer graphs.

BS: The KPIs are set at the AIP level. We expect the group to determine and assess where they are today and set targets for themselves to track progress and make improvements towards the goals that are in line with the IP.

The baseline assessment is done by the participating group. Firstly, it chooses the pathway, whether it is proceeding towards certification or to pursue best practices and then sets the ultimate goals and targets to reach their end objective. The ASC framework provides the oversight and the verification of progress towards those goals.

Last words

RVD: Ultimately, we need to generate impacts with this programme. For ASC, it is good if producers move to its certification. But at the end of the day, it is not only about certification but about driving impact at scale. Every producer can improve and as long as those improvements are meaningful and measurable, we should endorse that. We have set up the model, either choose an AIP with the end goal of going to ASC certification or an AIP to better practices. A shrimp farmer may say that their customers are not asking for certification at this point in time, but they would still like to improve their water quality or any item from the standard in a modular approach.

BS: This programme delivers perfectly towards our 2030 commitment of 100% of our farmed shrimp being produced responsibly, meeting industry credible standards, or being in an improvement programme that minimises impact on surrounding ecosystems. From a commercial perspective, we have partners in the US that are committed to ASC certification. In order for us to continue to service those customers and provide them a diverse set of offerings, this is one avenue we pursue.

From boom to uncertainty in largemouth seabass aquaculture in China

Post pandemic, industry is optimistic on the potential growth of this fish

By Zhang Yufan and Henry Wong



A largemouth bass grow-out pond in Foshan, Guangdong.

China, often referred to as the global aquaculture powerhouse, boasts the farming of the most extensive array of aquatic species. Its aquaculture industry is synonymous with the culture of the “four major carp” fish, collectively known as Asian carps, which account for about half of China’s aquaculture production in terms of volume.

A rising star

The largemouth bass, affectionately referred to as the ‘California bass’ in China, has made a remarkable leap, emerging as the next major freshwater cultured fish after the Asian carps. The largemouth bass market thrives primarily in tier one and two cities, harbouring considerable potential for market expansion.

The growth of largemouth seabass in China

The largemouth bass (*Micropterus salmoides*), originally from North America, was introduced to mainland China in 1983. Over the past 30 years, the industry has fine-tuned its operations, creating a complete supply chain from seed production to marketing.

Data from the Chinese Fishery Yearbook showed its production increasing from 457,000 tonnes in 2017 to 802,000 tonnes in 2022. The main aquaculture regions are in Guangdong, Zhejiang, Jiangsu, Hunan and Sichuan provinces. In 2022, the total aquaculture production in these top five provinces was approximately 685,000 tonnes, accounting for 85% of the national total, with Guangdong alone contributing about 382,000 tonnes or 48% of the national total.



A storage room for largemouth bass feed



Largemouth bass feeding on the water surface.

Pond culture in Guangdong

Pond culture is the most prevalent, particularly in Guangdong province. The sizes of ponds typically range from 2,000 to 3,500m² with water depths of 1.5 to 2.0m. Stocking densities in ponds are approximately 4,000 to 10,000 juveniles (8–10cm) per 1,000m². In the past, largemouth bass in China were primarily fed frozen trash fish during their growth phase, yielding a feed conversion ratio (FCR) exceeding 4.0, but its farming was still profitable.

Since 2017, the government has discouraged feeding of frozen trash fish in aquaculture, leading to the development of pelleted feeds. FCR improved to 1.1–1.3. Commonly, largemouth bass extruded feeds have 44–48% crude protein. The use of such feeds in farming requires less labour, improves water quality and reduces risks of diseases.

Price seasonality and profitability

Price fluctuations over the past five years reveal significant seasonality in the market for largemouth bass. Prices remain steady from January to April each year and steadily rising from May to August to reach their annual peak. In October, prices undergo a decline due to an increase of supply at year-end. The decline continues into the beginning of the following year.

The recorded best profit occurred in August 2019, reaching an impressive RMB14.8/500g (USD4.06/kg). In 2022, increases in production costs related to feed ingredients, pond rentals and labour resulted in a production cost increase of RMB1–1.50/500g (USD0.27–0.41/kg) compared to the previous year. In Guangdong, rearing the first crop incurred a cost of RMB 9–11.5/500g (USD2.46–3.14/kg). However, the farmgate price showed a nearly RMB1/500g (USD 0.27/kg) year-on-year decrease, reducing the average profitability of largemouth bass farming in 2022 by RMB1–2/500g (USD0.27–0.54/kg).

In 2023, the largemouth bass industry encountered an unexpected price collapse and caught many farmers off guard. The average price of largemouth bass in major producing areas was approximately RMB12.8/500g (USD3.51/kg), with some areas, such as in Foshan (Guangdong Province), seeing historic lows of RMB11/500g or USD3.0/kg (October, www.fishfirst.cn). High pond rental costs, expensive feed and low fish prices prompted many farmers to reconsider restocking and farming.



Harvest of largemouth bass



A farmer manually broadcasting feed to largemouth bass



Largemouth bass extruded feed.

To gain insight into the situation, the authors visited Mr Chen Gang, a pioneer of largemouth bass farming in China. He attributed the price decline to an oversaturated market, noting that the industry had grown significantly over the years, 2017 to 2019. This expansion, combined with the industry's reliance on credit sales and private lending, placed immense pressure on the entire supply chain, affecting farmers, feed distributors and raw material suppliers. As a result, some farmers hesitated to sell their fish due to poor prices, and the ongoing decline in fish prices since August exacerbated the financial difficulties of farmers across the industry.

Challenges

The industry has long grappled with disease-related challenges, which intensified this year due to increases in stocking density. During the larval stage, splenorenal necrosis virus outbreaks often result in the mortality of over 50% of larvae. Iridoviridae viruses are also prevalent and their uncontrolled presence in the middle and late stages of fish farming can lead to mortality rates of around 15-20%.

Feed, constituting 70% of farming costs, accounted for both cost and nutritional issues. In 2018, a tonne of largemouth bass feed costing RMB11,000/tonne (USD1,503), has a FCR of close to 1.05. Presently, feed prices have surged to RMB13,000/tonne (USD1785.50) while the FCR has exceeded 1.2. Additionally, nutritional problems were intertwined with diseases, leading to the rising occurrences of pale liver and pericardial congestion. These challenges pose diagnostic and treatment complexities. Furthermore, there have been reports on the yellow flesh of largemouth bass, rendering them unmarketable.

New developments in nutrition

Initially, the nutrition of largemouth bass was primarily focused on macro nutrients, particularly protein, amino acids, lipids and carbohydrate digestibility, aiming to replace frozen trash fish in their diet. However, recent scientific advancements have shifted the focus towards micronutrient studies, specifically vitamins and minerals.

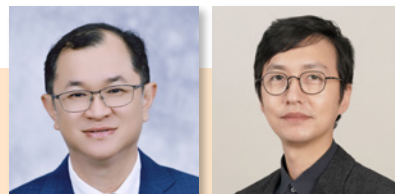
The Guangdong Academy of Agricultural Sciences in China made a significant discovery, revealing that incorporating

selenium yeast (Alltech Sel-Plex) in the feed substantially enhanced the antioxidant capacity of largemouth bass haemocytes and reduced apoptotic cell counts. This form of selenium also proved more efficient in accumulating selenium in fish muscle compared to inorganic selenium (Xu et al., 2023). Another study by Sun Yat-sen University showed that substituting inorganic zinc with zinc proteinate in largemouth bass feed improved their growth performance. The optimal dosage of peptide zinc, at just 60ppm, was significantly lower than the industry's usage of inorganic zinc. This low-dosage, high-efficiency zinc source enhanced largemouth bass' overall antioxidant capacity and muscle quality (He et al., 2023).

Conclusion

Although the farming of largemouth bass still faces many challenges, it is important to remember that this is just a part of its farming development. With the right approach and dedication, the industry is poised to rebound. Market factors, including the lower demand caused by the post-pandemic recovery and increased feed costs, have undoubtedly changed the supply and demand curve.

Optimism is warranted for the potential future growth of this species. With advancements in genetics, precision nutrition and a growing market acceptance for largemouth bass, the culture of this species will take a turn for the better. It is a testament to the resilience and adaptability of aquaculture, and it reinforces the industry's ability to overcome challenges and thrive in the face of adversity.



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Moving freshwater fish farming in India

Converting traditional farming systems to modern techniques will increase fish production address environmental sustainability

By B. Laxmappa and S. Narsaiah



A carp culture pond in Andhra Pradesh

The Indian fish production sector has witnessed a paradigm shift from being marine dominated to freshwater fisheries, with the latter becoming a significant contributor to fish production from 40% in 1990/1991 to 75% in 2021/2022. A transition from capture fisheries has paved the way for a sustainable blue economy in the freshwater sector. Although freshwater fisheries and aquaculture have grown in absolute terms, they have yet to reach their full potential. At the primary level, the sector provides a living for approximately 16 million fishermen, fish farmers and tens of thousands of individuals along the value chain.

Fish production trends

In the Indian fiscal year 1990/1991 (April 1990–March 1991), freshwater fish production was 1.53 million tonnes. By the fiscal year 2021/2022, production volumes skyrocketed to 12.12 million tonnes (Figure 1). This growth is the result of the combined efforts of fisheries scientists, federal and state administrations and the dedication of the nation's fishermen, fish farmers and entrepreneurs.

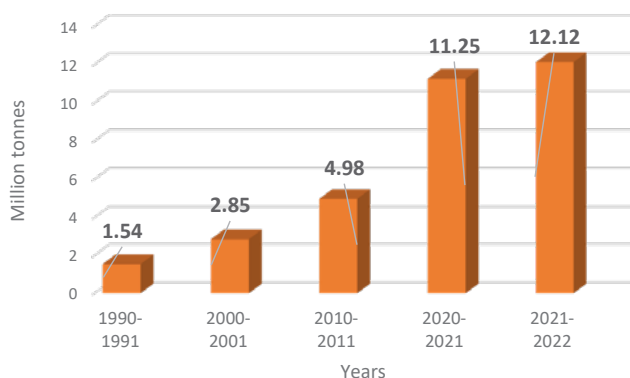


Figure 1. Yearly trend in freshwater fish production in India from the fiscal years 1990/1991.

Major fish producing states

Andhra Pradesh is India's largest producer of freshwater fish, accounting for 34.8% of total freshwater fish production, followed by West Bengal at 13.6% (Table 1). Although every Indian state produces some species of freshwater fish, the top six states account for 75% of the nation's total freshwater fish production. Andhra Pradesh, West Bengal and Uttar Pradesh accounted for 50% of production.

| State | Production in million tonnes | Share of total freshwater fish production (%) |
|----------------|------------------------------|---|
| Andhra Pradesh | 4.22 | 34.81 |
| West Bengal | 1.65 | 13.63 |
| Uttar Pradesh | 0.81 | 6.67 |
| Odisha | 0.79 | 6.51 |
| Bihar | 0.76 | 6.29 |
| Chhattisgarh | 0.58 | 4.76 |
| Karnataka | 0.49 | 4.00 |
| Assam | 0.42 | 3.44 |
| Telangana | 0.39 | 3.22 |
| Madhya Pradesh | 0.29 | 2.42 |

Table 1. The top 10 freshwater fish-producing states in India.

Fish farming practices

Although an old tradition in India, fish aquaculture is primarily limited to freshwater species such as catla *Labeo catla*, rohu *Labeo rohita*, and mrigala *Cirrhinus mrigala* in private and community tanks/ponds. Feeding depends on natural fish food organisms, created by



Harvesting carps and cooling in ice before packing



adding organic and inorganic fertiliser to the water. The pond's trophic system dictates that multiple species use this food. There is also the farming of high value fish species such as tilapia *Oreochromis niloticus*, pangasius *Pangasius hypophthalmus*, pacu *Piaractus brachypomus* and trout (rainbow trout *Oncorhynchus mykiss* and brown trout *Salmo trutta*) to meet the increasing demand for these species.

Freshwater fish farming is India's most prevalent type of fish farming, with significant producers including Andhra Pradesh, West Bengal, and Punjab. The Indian Major Carps (IMCs), catla, rohu, and mrigal account for approximately 58% of India's aquaculture production. Currently, India is the world's largest producer of the IMCs.

Alongside the catla, rohu and mrigala are a few Chinese carps, such as silver carp *Hypophthalmichthys molitrix*, grass carp *Ctenopharyngodon idella* and common carp *Cyprinus carpio*. The technology developed for the induced reproduction of the carp and the abundance of agriculture by products used as supplemental feed led to the rapid development in their farming.

Supplemental local feed

Usually, fish are fed nutritionally deficient feed ingredients in a loose form using feed bags or by directly broadcasting feed into tanks/ponds. In these types of feeding systems, the feed conversion ratio (FCR) ranges from 3-4. After 8-10 months, fish are typically harvested at 1 to 1.2kg body weight. They are transported in refrigerated trucks to domestic markets that can be 24-48 hours away by road.



Feeds used in pangasius, tilapia and murrel fish culture and (right), agricultural by products used as supplemental feeds.

Culture diversification with species and systems

Formulated extruded floating fish feeds have paved the way for species and system diversification in this sector. In addition to intensive pond culture, many Indian states

have adopted cage aquaculture and the recirculation aquaculture system (RAS) of freshwater fish.

The country relies heavily on carp, which can be fed a variety of non-formulated combinations of feed ingredients. When the farm gate price of carp is profitable for the farmer, the fish are fed high quality and higher cost pelleted or extruded feeds. However, when farm gate prices fluctuate and decrease, the fish are given the cheaper supplemental feed ingredients. The Indian major carps, by nature, are slow feeders.

Aquafeeds

Most of India's aquafeed production is used for the farming of pangasius, pacu, tilapia and snakehead. In India, tilapia farming is yet to develop as an established activity.

Increasing species diversity appears essential for India to advance not only regarding feed utilisation but also to boost fish production and address farm gate price stability. This intervention will aid in producing fish with fewer intermuscular bones, which has been identified as a significant consumer preference.

The fed fish system has led to some recent but small developments in efforts to diversify culture species. Modern feed mills with high-quality imported equipment can now produce high-protein, high-energy feeds for species such as the Asian sea bass or barramundi *Lates calcarifer*, snakeheads or murrel *Channa striatus*, pompano *Trachinotus blochii* and cobia *Rachycentron canadum*.

It is estimated that only 10-15% of farmed freshwater fish production is based on feeding formulated feeds. Therefore, a vast majority of farmed freshwater has the potential to convert to this system, which, if properly addressed, will contribute more to resource savings and increase the country's fish production.



Feeding snakeheads or murels with pelleted feeds in a culture pond



Harvesting pangasius and pacu fish from a culture pond in Telangana state

With approximately 30 high-tech feed mills operating for fish feed production, the sector has generated substantial employment opportunities for both skilled and unskilled employees. Allied businesses like feed equipment manufacturers (domestic and international firms), feed additive and raw material suppliers and other infrastructure support for this new sector are helping, which is a significant change and development for the industry.

Market scenario

Most freshwater fish are distributed to markets in fresh or chilled forms. Some are transported live to obtain higher selling prices if farms are located near markets. There are markets, such as those in the state of West Bengal, where live and fresh carps are in daily demand. Culturally, consumers in West Bengal prefer freshwater fish and farmers and merchants prioritise their harvests/products for these markets.

In India, fish merchants typically collect fish at the time of harvest and sell at higher prices to various markets. In many markets, fish is only sold in the mornings or evenings for a limited time, thus restricting the availability of fish to consumers.

Government initiatives

The Indian government launched the 'Blue Revolution' Mission in December 2014 to focus on an integrated approach to developing and managing marine and inland fisheries. This is to ensure a sustained annual growth rate of 6-8% in fish production. This is the role of the National Fisheries Development Board (NFDB).

It also intends to increase fish production and productivity by prudently utilising fisheries resources and double the income of fishermen and fish farmers. The scheme has adopted the strategy of encouraging private investment, entrepreneurship development and improved leveraging of institutional finance. These objectives require skill development and capacity building in fisheries and allied activities, as well as the creation of post harvest and cold chain infrastructure facilities. The program was implemented between 2015/2016 and 2019/2020.

In recent years, the government has implemented numerous initiatives to promote fish aquaculture. These initiatives include equipment and feed subsidies, farmer training

programmes and the establishment of fish seed banks. In May 2020, the Indian government, in recognising the substantial potential of this industry, recently unveiled the Pradhan Mantri Matsya Sampada Yojana (PMMSY), a new flagship program with a substantial investment. This concentrates on enhancing infrastructure and fish seed quality and promoting aquaculture in freshwater and marine water resources.

To resolve the industry's challenges, the government has been developing cost-effective feeds and providing training and technical support to farmers. Through concerted and collaborative efforts by the government and private sectors, India's fisheries and aquaculture sectors have made remarkable advancements towards modernisation and sustainable economic growth over the past few years.

The Indian fisheries and aquaculture industries are now the fastest-growing agriculture-related industries in the nation. The contribution of freshwater fisheries and aquaculture to global fish production has increased incrementally over the past few decades. Aquaculture is expanding into new areas, such as saline and brackish waterways, reservoirs and flood plains. Wastelands are being converted into prosperous lands.

The way forward

There is enormous potential for developing India's freshwater fish sector when improved systems and species are employed. Converting traditional farming systems to modern agricultural techniques will undoubtedly increase fish production, provide more opportunities for fish farmers, and address environmental sustainability.

The high cost of fish feed, which can account for as much as 60% of total production costs, is one of the most pressing issues in freshwater fish culture today. Moreover, administration of water quality, disease control and the lack of technical knowledge are also major concerns. The government and private companies have launched initiatives to educate farmers on better management practices (BMP) and provide them with affordable, quality feeds to reduce losses and increase production significantly.

In many regions of the country, inadequate cold chain and distribution systems hinder fish marketing. Another challenge is the low farmgate prices for some fish species, a deterrent to using factory made formulated feed. India should implement farming of fish species and marketing methods that are certain to generate high farmgate prices for the nation's fish producers.



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Pangasius in 2023: Cyclical supply issues in Vietnam

High costs of production and declining exfarm prices reduce interest in farming



Vietnam's pangasius producers and exporters at the Seafood Expo Global in Barcelona, Spain in April 2023.

In March 2023, Globefish noted that exfarm prices for pangasius rose to VND33,000/kg. There was a raw material shortage leading to higher farm gate prices. During Viefish 2023, held in Ho Chi Minh City in August, the price was down to VND26,000/kg. A supplier at the event said that this was below the cost of production (COP). The higher prices during early January were attributed to high demand from China, post lockdown. In this situation, the only winners are the integrators.

High costs of production

In Vinh Long, farm gate prices of pangasius have fluctuated between VND27,500 – 31,000/kg, according to its Provincial Department of Agriculture and Rural Development. Pangasius size 1.3 – 1.5 kg were priced at VND27,000/kg while fish from 850g – 1kg range between VND26,000 – 26,500/kg in October (viefishmagazine.com). The province has 231ha of ponds and tanks used for intensive pangasius farming, down 8.6% from 2022.

With the average production cost of VND27,800–30,700/kg, fish farmers are either experiencing losses or earning minimal profits. The price of pangasius feed has increased significantly, from VND10,000/kg before the pandemic to VND 13,000/kg, contributing to 75% from the previous 55% of the COP. Feed costs coupled with

energy and labour costs have led some farmers to downsize (vietnamagriculture.nongnghiep.vn). Good quality fingerlings are also in short supply.

Markets and prices

Globefish says that the pangasius is enjoying increasing popularity across all market segments as consumers, retailers and processors seek out more affordable fish products. China is the major market for Vietnam's pangasius and exports to China and Hong Kong for the first nine months of 2023 showed a 15% y-o-y increase, said the Vietnam

Association of Seafood Exporters and Producers (VASEP). The European Union (EU) also increased its imports of Vietnamese pangasius in September, with 11% y-o-y increase.

Previously, the average price of exports to the EU was only USD2.7/kg; in the first 6 months in 2023, the average export price to this region reached USD3.45/kg. Price of pangasius exported to the US reached USD4.5/kg, the highest ever. In the past, pangasius exported to the US usually only reached USD2.9–3.1/kg. Export prices to China were the lowest at USD2.2/kg.

There is hope for industry players. The US Department of Agriculture Food Safety and Inspection Service (FSIS) has just completed an inspection of several pangasius export processing enterprises. VASEP regards this positive inspection as the driving force to promote pangasius exports to the US in the coming months. Dong Thap's provincial government wants to improve the quality of exports and plans for at least 50% of producers to comply with the Vietnamese Good Agricultural Practices. It also wants the 76 fish breeding centres to fit into the new requirement that 75% of the pangasius fingerlings must be classified as "high quality". The Dong Thap region accounts for close to a third of the country's pangasius harvests.

References available on request

Global pangasius production

The annual global finfish aquaculture production survey and forecast report from the Global Seafood Alliance, jointly prepared with Gorjan Nikolik of Rabobank and Ragnar Nystøyl of Kontali and presented at the recent Responsible Seafood Summit 2023 held in Saint John, New Brunswick, Canada gave the following data. Global pangasius supply is still to recover to the level reached in 2019. Global supply is driven by Vietnam – now in gradual recovery mode, but still well below the supply of

2019. Global production is estimated at 3.13 million tonnes in 2023 (up 0.5% from 2022 production of 3.11 million tonnes). Vietnam led with 1.62 million tonnes followed by India, Indonesia, Bangladesh and China (Jory, 2023). In this survey, Vietnam's production for 2023 and 2024 are forecasted to remain close to 2022 levels.

Source: Darryl Jory, 2023. Annual farmed finfish production survey: A modest supply decline for 2023 and a predicted return to growth in 2024, Global Seafood Alliance.

TIOFIS 2023: Ways to balance profit and sustainability

Addressing a cleaner marine environment, carbon reduction to sequestration while maintaining profitability

The eighth edition of the annual Taiwan International Ocean and Fisheries Show (TIOFIS) 2023 was held Taipei, from August 31 to September 2, with the theme: *Ways to Balance Profit and Sustainability*. Ball K.C. Chang, President of My Exhibition Co. Ltd, organiser of the event, and Du Wen Jane, Deputy Minister, Ministry of Agriculture, Taiwan welcomed around 13,000 visitors from 20 countries, including those from Indonesia, Malaysia, Singapore, New Zealand, Thailand, Vietnam, Myanmar, Japan, India, South Korea and US.

Apart from the traditional seafood product displays, this year, the focus was on biotechnology usage, the Internet of Things (IoT) and artificial intelligence (AI) for solving sustainability problems in fisheries and aquaculture. Apart from Taiwan, there were 27 exhibitors from China, Guadeloupe, India, Indonesia, Myanmar, and Vietnam. Several exhibitors displayed technologies used to address issues from carbon sequestration, carbon reduction to net zero emission. Conservation of fisheries and the aquatic environment was given some prominence since overfishing and pollution of the oceans have become serious problems worldwide. The Ocean Conservation Administration, Ocean Affairs Council, Taiwan, had a booth displaying their work on marine debris governance and enlightened visitors on their roles in cleaning up marine wastes from the oceans. Taiwan has a Marine Debris Recycling Coalition where efforts were made to recycle plastic wastes and convert them to everyday materials like bags, spectacle frames, scarves and towels.

Taiwan, well known for its expertise in fish breeding, had several booths displaying their success in closing the cycle of several species of fish, including several grouper species. The Taiwan Fisheries Agency also described their unenviable role in conserving the Japanese eel (*Anguilla japonica*) amidst pressing issues like global warming and ocean pollution. Also on display were cutting-edge technologies to overcome the shrimp disease *Enterocytozoon hepatopenaei* (EHP) and a shrimp disease detection kit, combining direct polymerase chain reaction (PCR) and capillary gel electrophoresis for an easy-to-operate and highly sensitive system for shrimp.



Seafood products on display by an exhibitor from Penghu, Taiwan.



Recycled items made from marine debris by the Marine Debris Recycling Coalition.

Recycling coalition

The **Marine Debris Recycling Coalition** was established on October 21, 2021, by the Ocean Conservation Administration of the Ocean Affairs Council to promote ocean sustainability, protect the marine environment, and address the increasingly severe issues of marine waste pollution. Public-private partnerships connect recycling operators, marine waste material suppliers, entrepreneurs, financial investors and other industry stakeholders, to build a circular economy for marine waste resources. "The coalition actively develops new technological applications and business models, transforming marine wastes into commonly-use items and promoting the sustainable coexistence of the environment and the economy," said Jane Kwan, Researcher at Plastics Industry Development Centre.

The coalition actively promotes interaction and cooperation among members to collectively address marine waste issues, invigorate business opportunities, demonstrate policy initiatives and concrete achievements of marine waste reduction and recycling waste and reuse in Taiwan and engage with international entities involved in marine waste management. The aim is to actively participate in international efforts to promote marine reduction and recycling, fulfilling its responsibilities as a global citizen.

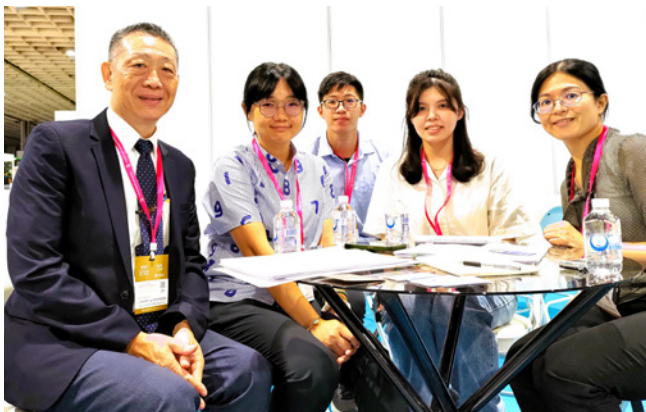
Japanese eel conservation by Taiwan Fisheries Agency

Japanese eel culture was a thriving industry in Taiwan in the 1980s and 1990s, and Taiwan was once the regional leader in eel production, overtaking China, Korea and Japan. During that period, it exported eels to Japan worth TWD600 million (USD18.6 million) compared to the 2022 export of only TWD 58 million (USD1.8 million). The natural eel population has been dropping over the years due to overfishing, the loss of riverside habitats to development, pollution of rivers and seas and, recently, global warming.

"This alarming decrease in numbers has led to the Japanese eel being placed in the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List of endangered species on June 12, 2014," said Dr Tzyh-Chung Miaw, Chief Secretary Fisheries Agency, Ministry of Agriculture. "Since the eel is a transboundary migratory fish, East Asian countries

(China, Japan, Korea and Taiwan) came together to promote the conservation and management of the Japanese eel stock and other relevant eel species and reached a consensus in 2014 for its conservation," he added.

The **Taiwan Fisheries Agency** imposed regulations on elver collection season; county governments to declare rivers in their jurisdictions off-limits for catching adult eel to allow elvers to migrate upstream and when they reach marketable size, rebuild the eel stock. Elvers are not allowed to be caught in waters three nautical miles from the shore, intertidal zones and estuaries from March 1 to October 31, with certain conditions. Fry catching is forbidden during March, April and October. This period may be adjusted in the future if there is a change in the fry season due to global warming. City and county governments must also declare the midstream and downstream of at least one river in their jurisdictions as off-limits for eel catching. In recent years, the elver catch has been declining, and there is reason to urge more action from the regulators and the enforcement officers to prevent a further slide to this important resource.



The team from the Fisheries Agency, Taiwan, interviewed by Aqua Culture Asia Pacific. From left: Tzyh-Chung Miaw, Chief Secretary; You-Hua Cheng, Section Chief; Yu-Kai Huang, Associate Specialist; Wen-Hsin Liu, Assistant Specialist and Yen-Ju Lin, Section Chief.

Fish breeding in Taiwan

Overfishing is one of the problems that results in the depletion of fisheries resources. Therefore, breeding efforts are important to replace the loss and possible extinction of selected fish resources. Taiwan has long been recognised as a leader in aquaculture innovation and production. It is one of the top three global producers of grouper, ranking second after China, followed by Indonesia in third position. According to FAO, the total grouper demand for 2020 was an estimated 500,000 tonnes, shared equally by capture fisheries and aquaculture. By 2030, aquaculture production of groupers will exceed the production from capture fisheries.



Pei-Chi Wu, Project Manager, Taiwan Fish Breeding Association (left) and Sean Lan (USSEC Asia Marine Aquaculture Specialist) discussing developments in fish breeding.

Presently, the most popular farmed grouper species in Taiwan is the hybrid grouper, a cross between the female tiger grouper (*Epinephelus fuscoguttatus*) and the male giant grouper (*Epinephelus lanceolatus*). The hybrids are produced through *in vitro* fertilisation (IVF) and they inherit the fast growth characteristic of the giant grouper and the robustness associated with the tiger grouper. Wu Pei-Chi, Project Manager of the **Fish Breeding Association**, said, "The hybrid grouper is the most favoured grouper fish in Taiwan; they take only a year to reach the marketable size of 1kg and are often marketed live. In 2022, an estimated 25 million hybrid grouper fry were produced with a production of an estimated 11,200 tonnes of market size fish."

Long Diann Bio Technology Co. Ltd., a member of the Fish Breeding Association, ranks as a leader in fish breeding and production in Taiwan. Founded in 1985, it began its business by raising lobsters but later moved on to artificially propagating and mass-producing fish, especially those highly favoured by consumers. The tiger grouper was successfully artificially reproduced starting from the egg stage from brood stock in 1991, followed by the giant grouper in 1995, *Lutianus sebae* in 1997, *Trachinotus blochii* in 1998, *Epinephelus tukula* in 2001, *Seriola dumerili* in 2001, *Plectropomus leopardus* and *P. maculatus* in 2004, *Epinephelus cyanopodus* in 2006, *Epinephelus flavocaeruleus* in 2007, *Epinephelus bruneus* in 2009, *Cheilinus undulatus* in 2012, *Cephalopholis sonnerati* in 2019 and *Epinephelus fasciatus* in 2022. With their superior technology in closing the cycle of endangered fish species, Long Diann Bio Technology has contributed significantly to the conservation of these endangered species.



According to William Chan (above), Long Diann Marine Bio Technology's superior technology has contributed significantly to closing the cycle of many endangered fish species.

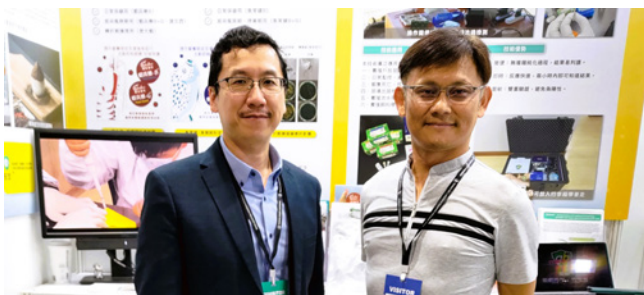
Qexp-Aqu shrimp disease detection kit

Giant Bio Technology is a startup company founded by the National Taiwan Ocean University. Professor Han-Jia Lin, Founder of Giant Bio Technology Inc., explained that the company has developed a shrimp detection field kit combining the use of direct polymerase chain reaction (PCR) and capillary gel electrophoresis. "There is no need for nuclei acid extraction with direct PCR; this method is simple and quick to operate, and highly sensitive," said Lin.

Three simple steps are required to identify the pathogens. The first step is sample collection (e.g., mud, tissue, larvae). The second step is adding lysis buffer to the

sample in a tube before grinding the sample with a glass rod. The ground sample is then amplified with direct PCR. The third step involves using the capillary gel electrophoresis to detect the presence of pathogens, and the Q-analyser automatically generates the results.

The diagnostic kit can detect up to 4-5 diseases in one test sample, and it can diagnose the following diseases: decapod iridescent virus 1 (DIV1); EHP; hepatopancreatic parvovirus (HPV); infectious hypodermal and hematopoietic necrosis (IHHNV); *Penaeus monodon* baculovirus (MBV); necrotising hepatopancreas (NHP); white spot syndrome virus (WSSV); infectious myonecrosis virus (IMNV); Taura syndrome virus (TSV); yellow head disease (YHD); gill associated virus (GAV) and the highly lethal *Vibrio* disease (HLVD).



Professor Han-Jia Lin, Founder of Giant Bio Technology (left) and Dr Eric Tsai, President/CEO of Bioptic.

EHPurge to mitigate EHP

EHPurge is a basemix effective in preventing the microsporidian parasite EHP infection in shrimp hepatopancreas. EHPurge was developed by **BiomiXin Co. Ltd.**, Taiwan. Cristian Chen, Manager of the Aquaculture Department, explained, "The active ingredient is extracted from a plant, and other ingredients - piperine, flavonoids, polyphenol and mannans are added to the product to build up the immunity of the shrimp." Symptoms of EHP infection include damage to the hepatopancreas, growth retardation and uneven body size and muscle turning white and turbid.

"EHPurge works by preventing infection in three steps: it rapidly forms a protective layer on the surface of the tubule epithelial cells of hepatopancreas; the active ingredient in EHPurge will next dissolve the spore wall of EHP and destroy the spore; it can further eliminate the polar tube of EHP to reduce the spread of the contagion. Besides Taiwan, this product is also used by shrimp farmers in India, Indonesia, Malaysia, Thailand and Vietnam," said Chen.



Cristian Chen, Manager, Aquaculture Department, BiomiXin Co. Ltd., explained how EHPurge reduces the spread of EHP.



From left: Peter Chiang, Founder, Hanaqua Tech Inc. and partner Meo Sheng Liu

GreeNaqua concept of farming

Established in 1984, **Hanaqua Tech Inc.** started as an aquaculture feed company but has now expanded its core business to include other aquaculture activities. "The fatal flaw in the current aquaculture industry structure is the lack of a clearly defined mutually beneficial platform for business operations," said Peter Chiang, Founder of Hanaqua. "At the moment, the grow-out activity is the core of the aquaculture industry. Hanaqua, through the GreeNaqua concept, which was conceived five years ago in 2018, has the vision to establish a mutually beneficial platform to provide a strong protective shield for the whole production supply chain."

Mao Sheng Liu, Chiang's partner, said, "The success of this platform depends greatly on the establishment of a rational and sustainable contractual model that must meet several conditions, among which the most basic is to provide reasonable profitability to the producers and for the producers to meet the expectations of the consumers in terms of biological characteristics, cultural connotations and environmental demands." Both strongly believed that GreeNaqua would be the model to meet all these expectations.

The GreeNaqua farm will utilise solar energy and recirculating aquaculture systems aided by digitisation and IoT to provide a transparent system complying with certification standards. It will be fully ESG compliant, work towards net zero emission and provide food security. The company intends to set up a demonstration integrated system in Taiwan, actively promote this concept and seek partners, starting with India and US and then moving to other countries.

TIOFIS 2024 will be held from September 12-14

MAC celebrates 20 years in marine aquaculture research and innovation in Singapore

Views at the anniversary symposium on moving marine fish aquaculture towards the 30 by 30 vision



Group photo of SFA staff and guests outside of MAC's building. Photo credit:SFA.

Singapore Food Agency or SFA's Marine Aquaculture Centre (MAC), was set up on St John's Island back in 2003. The key role is to advance marine aquaculture in Singapore. This year marked its 20th anniversary and the celebrations included a visit to MAC and a symposium on August 14. The event fostered collaboration between professionals and experts from both industry and academia, providing a platform to explore research opportunities and discuss the future of aquaculture in Singapore and the region.

"Over the past two decades, MAC has done a tremendous job in transforming our aquaculture landscape," said Senior Minister of State for Sustainability and the Environment, Dr Koh Poh Koon in his address during the celebration. "The local aquaculture sector is critical for us to work towards the 30 by 30 vision – to build our agri-food industry's capability and capacity to sustainably produce 30% of our nutritional needs by 2030. Seafood is a priority area for our agri-food sector, as it is a good source of protein which we can efficiently and sustainably produce."

In 2022, Singapore consumed 129,100 tonnes of seafood, mainly imported from Malaysia, Indonesia and Vietnam. Local supply of chilled and live seafood was 4,400 tonnes in 2022. With regards to local marine aquaculture, there are 109 licensed sea-based seafood farms, located in the Straits of Johor and in the southern waters producing Asian seabass, milk fish, mullet, pompano, groupers, red snapper, marine tilapia and threadfin for the live fish market and supermarkets. Licensed land based seafood farms number 27 in 2022 (Singapore Food Statistics, 2022)

Some achievements at MAC to date include:

- The long-term sustainable supply of marine fish fry via intensive indoor closed-containment system for large-scale fry production.
- In 2021, it worked with Singapore Aquaculture Technologies to set up a new floating indoor hatchery.
- With Temasek Life Sciences Laboratory (TLL), it successfully developed a genetically superior Asian seabass line where growth is at least 30% faster.
- In collaboration with GovTech, MAC used AI and image recognition technology to automate the counting of rotifers, reducing the time needed for counting rotifer density from 40 minutes to only a minute.

In late 2022, SFA initiated the Singapore Aquaculture Plan (SAP) to transform its aquaculture into a more productive and sustainable sector by increasing and optimising spaces for aquaculture farming; investing in research and innovation; and helping the industry to adopt technology and better farming practices. At the heart of the SAP is AquaPolis to support Singapore's ambition of becoming a leading research and innovation hub for sustainable tropical aquaculture. AquaPolis brings the industry players and scientists together, and MAC will serve as the research nucleus of AquaPolis.

At the end of 2022, an MOU was signed for the setup of the SFA-INVE Hatchery Technology Centre for developing advanced hatchery technologies. As part of longer-term planning to support the aquaculture sector, SFA is commissioning a study to review how MAC's research facilities could be developed and integrated with other aquaculture infrastructures such as hatcheries in the future.

At the symposium, there were presentations from four invited experts. Dr Albert Tacon, Founder, AquaHana LLC, Hawaii and Piet Verstraete, Managing Director at 4SEA Consulting Ltd, Thailand, presented on trends in global aquaculture and aquafeeds designed for warm water marine fish, respectively. Emeritus Professor Patrick Sorgeloos, Ghent University, Belgium and Dr Richard Le Boucher, Research Director in Precision Aquaculture, TLL, discussed aspects of live feed and early life nutrition and on the possibilities of genetics, respectively.

MAC is working closely with the industry to better understand the impacts of aquaculture on the environment and how it can steadily grow its commercial aquaculture sector. Dr Rui Alexandre Gonçalves, Deputy Director in SFA's, Aquaculture Department, said that it is critical for industry players to prioritise resources, including R&D and solving issues to meet Singapore's 30 by 30 vision.

Focus on a few species

With a need to prioritise resources, there should be a clear decision on the species to focus on, based on market demand. Tacon said in Norway research institutions are very focussed on one or two species. The options on production strategy are either open cage systems or controlled environments to minimise stress.

Sorgeloos added that interdisciplinary cooperation as well as optimising expertise and technology from the public and private sectors, is critical. Most farmers share the same problems and any interactions and learning together will be a win-win for all.

While livestock nutrition is far ahead with nutrient requirements to the last decimal, in aquaculture nutrition, information on requirements of amino acids is missing. "Therefore, it will be a huge effort to simultaneously work on these requirements on many species. We need to select the species, and work thoroughly on digestibility of ingredients, together with non-feed aspects, genetics and larvae quality," said Verstraete.

There is a concern on aquaculture production sustainability as feedmillers are struggling to get suitable feed raw materials while ingredient costs are going up. Maximising nutrient utilisation requires focus on processing technology, formulation and digestibility data.

Singapore's end vision is not only production of affordable marine fish but also to meet the global demands for healthy seafood for human consumption. During the discussion on feeding healthy diets to fish to secure maximum nutrient content for the consumer, Sorgeloos highlighted on the public relations fiasco when farmers in Norway shifted to feeding salmon with soybean oil. Consumer organisations found that the lipid composition did not reflect that of a 'sea salmon'.

Economic innovation

Le Boucher suggested this as the alternative focus since family-based cage farmers contribute to local supply of marine fish and are finding it difficult to access markets amidst competition from other countries. In some European projects, social science is incorporated into aquaculture planning to safeguard family and small-scale farmers so that they will not be phased out. "I think the innovation we need right now is how to protect the farmers with a compatible economic model."

IMTA for Singapore

According to Emeritus Professor Lam Toong Jin, a critical issue in Singapore is finding a sustainable aquaculture system. He alluded to the failures with some land-based recirculation aquaculture systems (RAS) where the accumulation of sludge and its removal is a major challenge. Lam suggested an alternative system where the recycling of waste is incorporated in integrated multi-tropic aquaculture (IMTA) where sludge is used to produce biofloc to feed shrimp and fish in a polyculture. This led to a discussion on the role of bacteria in aquaculture and nutrition.

Focus on bacteria communities

Sorgeloos recalled that in the past, the aquaculture sector's practice was to disinfect the water to remove pathogenic bacteria. With new tools and information on the role of bacteria in aquaculture, a different approach is to first sterilise the water but quickly followed by the addition of mature water i.e. water where time is given for r and k strategists to develop with good balance between the good versus the few bad bacteria.

With new knowledge on bacteria in aquaculture, the shift in focus in RAS is more into the functionality of the bacteria. Sorgeloos noted that ornamental fish farmers in



Dr Rui Alexandre Gonçalves (left) with speakers, from second left, Dr Richard Le Boucher, Emeritus Professor Patrick Sorgeloos, Piet Verstraete and Dr Albert Tacon.
Photo credit: SFA.



MAC staff Teo Man Yin (far left, in dark blue) sharing how the feed mill at the feed trial facility works. Photo credit: SFA.

Singapore and Malaysia using RAS, used different biofilter compartments with different substrates for different bacteria. Conversely in Europe, the need has been for systems to be as compact as possible. This implies a need to involve microbiologists in filtration technology.

Cost of breeding programs

MAC has a successful breeding program for the Asian seabass but Gonçalves brought up the concern of this being a cost centre as opposed to that of a profit centre. Although cost of its breeding programs for the salmon is unknown, Le Boucher said that the Norwegian government deems this as a long-term support for its industry. Similarly in France, the government has been funding a full time team to support the breeding program strategy of private companies for all species. "In integrated companies, it is difficult to judge whether the breeding program *per se* is a profit centre as it is masked by other activities, such as sales of post larvae."

Genetics and nutrition

Singapore's coastal waters has an active and diverse pathobiome and farmers face a challenge to keep diseases away. Often breeding programs focus on growth and Gonçalves sought opinions on what can be done to select for disease resistance. Genetics has been accepted as a solution for almost all the problems in farming and how much can nutrition support genetics.

For Le Boucher, genetics, nutrition and health must come together. An interesting way is to select for disease resistance with fish in cages, exposed to the pathogen. Knowledge on the basic nutritional requirements is mandatory but even for the seabass, not all is known on its requirements. Verstraete commented that it is very important to use nutrition together with genetic selection as has been clearly shown in shrimp culture. Selection

for growth is tied not only to genetics but also to the diet provided to the cultured species since the potential for faster growth comes with the right nutrients.

Cost sharing along production chain

As farmers are the most vulnerable group in the production chain, can costs be shared through the production chain? The insight given by Sorgeloos is to have predictability in farming. "Farmers need to realise this but this will take time and the government needs to assist and collect data. It is critical that farmers realise that when they buy higher quality fry, compounded by high quality early starter feeds, there will be 9 out of 10 successful crops."

Le Boucher raised the idea of a national hatchery where local fry production helps farmers to plan and fry is adapted to local conditions. It could be a profitable business although it may be difficult to be cost competitive with fry from Vietnam, Thailand or Indonesia. However, it could be building around the capabilities in Singapore. Supporting this, Sorgeloos added that there could be fry production centres in the region but ultimately it is emanating from R&D in Singapore.

Integration to solve profitability

"In seabream and seabass farming in Turkey and Greece, almost all companies are semi or fully integrated, with genetic programs, feed production to marketing segments," said Verstraete. Whether it is the best model is debatable, especially when fish prices are low. He added that profitability is a matter of scale and not all companies are at the scale of Charoen Pokphand.

Reference

Singapore Food Statistics 2022. Singapore-food-statistics-2022.pdf (sfa.gov.sg)

New fully encapsulated broodstock and larvae feeds for shrimp

The tagline for Huddle Corp is 'design the feed of tomorrow' and it has done that for shrimp and marine fish aquaculture. It has modulated its patented encapsulation technology for individual encapsulation of nutrients then reassembled in multi-layers to maximise feed quality. This allows for the preservation of nutrient quality and for the capture of a high inclusion of lipid in feeds for the shrimp broodstock at 35%.

The product, as described by Huddle Corp's César Cretel, Cofounder and Managing Director is BroodSup for shrimp broodstock. This feed not only has this high lipid content, but is also rich in PUFAs, important for the maturation phase - from gametogenesis until spawning, thus improving on the number of eggs per spawn and hatching percentage. These are 2.5-3mm feeds recommended at 15-20% of daily feed ration.

Cretel said, "Why do we say that these products are different from those in the market? We start with a liquid state process at low temperature and marry this with layers of encapsulation. It is double encapsulation, each for lipids and protein. This is the technology which stands apart. The dry feed rehydrates to recover performance of a semi-moist feed because of our Squishy Protein technology. The high lipid content rich in PUFAs is our LipoCaps Tech which optimises assimilation by the shrimp."

The other product is VivoHatch for shrimp larvae, recommended to be used at least at 50% of live feed replacement to increase the biosecurity and the survival of the larvae to post larvae (PL12).

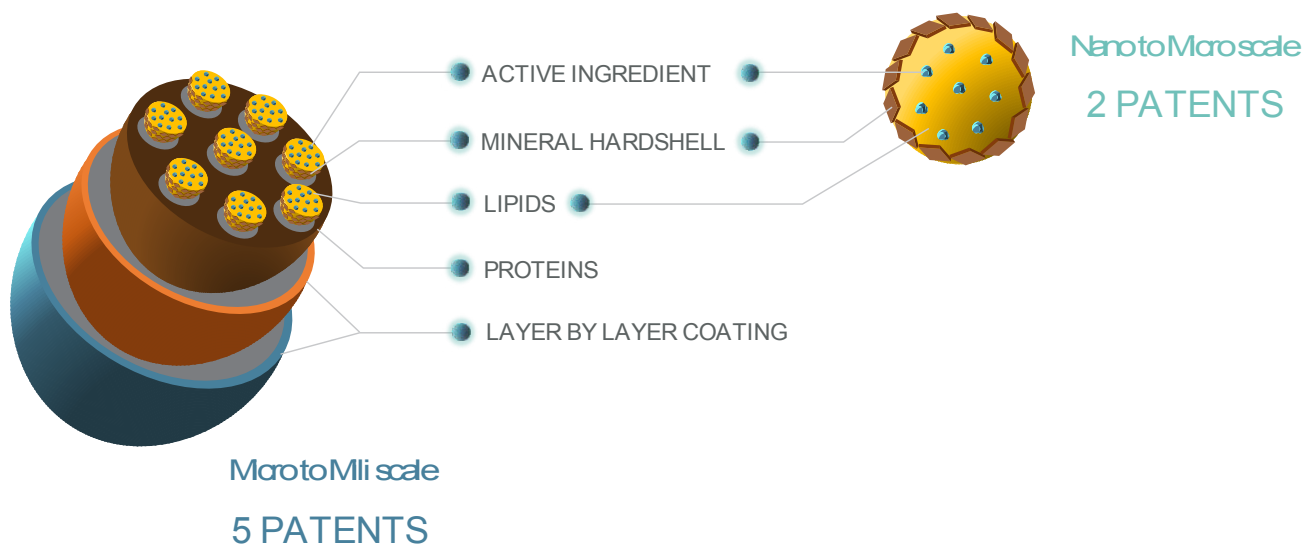
There are three size ranges for the larvae feeds, starting with 50-150 µm and ending with 300-500 µm. "The idea is coming from a biomimetic approach by simulating a live feed targeting the best compromise between artemia, copepod and rotifer composition and in terms of moisture content. We simulate live feeds in terms of amino acids and PUFAs composition too by combining our Squishy Protein technology and our LipoCaps Tech to ensure nutrient delivery to the larvae."



César Cretel holding a sample of VivoHatch feeds for larvae to PL12 during the Global Shrimp Forum, Utrecht, The Netherlands in September.

In the case of BroodSup, feed water stability is 2 hours since the encapsulated proteins allow the feed to rehydrate while keeping physical properties. Huddle is also using the same technology to produce marine fish feeds which contain 45% lipids. To date, these have been developed for the European seabass.

"We have taken the best for a complementary approach based on existing protocols. We have run trials for the European seabass and have trials that are in progress for the turbot. For the shrimp, it is for the monodon and vannamei shrimp. We have interesting results with industrial partners for monodon shrimp and will soon have some others for vannamei with partners in Asia and Ecuador. It is important to highlight that based on targeted specifications, we can modulate our encapsulation structures to tackle several issues. We are looking for partners to join us on this journey." www.huddlecorp.com





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Inauguration of CEAC, a new shrimp-feed dedicated research facility



Guillaume Le Reste, CEO of Halieutica inaugurating the CEAC.

On March 16, **Halieutica** organised an opening ceremony for the new Centre for Experimentation on Aquafeeds in Crustaceans (CEAC) in Angers, France. The CEAC recently moved to this new premises in 2021, post Covid-19.

Halieutica is a French-based aquafeed service company created in 2018 to offer a wide range of services to additives, ingredients and feed producers interested in developing their aquaculture markets. The focus is on ingredients, formulation and manufacturing of aquafeeds.

During the recent Global Shrimp Forum in September, Guillaume Le Reste, CEO of Halieutica, explained the chronological process. "When Covid-19 was almost over, we worked through the registration process as a CRO (contract research organisation) for CEAC, according to French regulations on veterinary services. This then enabled us to promote our services. Basically, we work on three axes: digestibility, growth and behaviour. The latter is mainly videos of shrimp and using artificial intelligence to analyse stress and palatability. As shrimp do not have the chemicals to demonstrate the effects of stress, through videos, we have identified some behavioural characteristics that are clearly related to stress. This will help us develop reliable tools to predict stress and diseases."

Le Reste commented that 80 aquafeed professionals braved train strikes and motorway blockades to gather in Terra Botanica to inaugurate a new research platform dedicated to shrimp nutrition and feeding.

The occasion also included a half-day conference during which eight speakers from 6 companies discussed recent findings obtained in collaboration with Halieutica. This in-person event provided the opportunity to share new information on fish and shrimp nutrition.

The conference was divided into two parts. The first half discussed consulting activities focusing on feed formulation and feed manufacturing. Consulting is the DNA of Halieutica and still constitutes its main activity.

Formulating feeds

Pascal Trintignac, Aquaculture Advisor, SMIDAP for the Loire Region described a recent experiment on carp juveniles fed on locally produced raw materials, including insect meals. He underlined the interesting results obtained, especially from the perspective of setting up a regional pond fish production chain.

Bruno Duranthon, General manager, and Benoit Chesnais, Sales Executive

at A-Systems, presented ways the feed formulation software Allix can help nutritionists improve their feed sustainability through a multiple-step optimisation process. A specific focus was on the new online tools enabling formula sharing between Halieutica's consultants and the feed manufacturer they are working with. This tool facilitates data and knowledge sharing. It is also efficient when collaborators are not in the same time zone, as formulas are always accessible for modifications.

Post formulation is the feed processing step. Frédéric Mauny, Senior Technologist at SoLead Consulting, who specialises in feed mills, explained how to do it. He spoke on some activities with Halieutica to improve feed quality in different plants in Asia and Africa. The crucial link between nutrition and the technologist to manufacture a satisfying pellet was underlined.

Shrimp trials

The second half of the conference was dedicated to output from CEAC. The team from Nor-Feed, the French feed additive company, Pierre Chicoteau, CEO and Paul Engler shared the trust it had put into Halieutica when it launched the CEAC platform during the pandemic. Engler shared data gathered during a trial run at the centre. He focused on the impact of a product on water quality when fed to the shrimp. Apart from data related to animal growth, this new research facility also gave them access to a large number of water samples. Samples were analysed through different processes and gave Nor-Feed useful information to understand how some plant extracts can influence ammonia dynamics.

Charline Pichon, a PhD student from BCF Lifesciences, shared some fascinating findings on the influence of ambient conditions on shrimp feeding behaviour. She detailed three different experiments conducted in the CEAC facility. Her conclusions explained how environmental conditions influence animal behaviour and can alter shrimp growth and feed intake.



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The third presentation was on the influence of different oils on the quality of shrimp flesh. In a recent collaboration with Agrocampus, the team from Halieutica studied the kinetics of fatty acids accumulation in shrimp tissue. Margaux Le Gourrierec, Project Manager, detailed how fatty acids from different oils are stored in the muscle, where they can significantly modify the nutritional quality of the final product. This trial also provided interesting data on shrimp growth according to ingested oils.

The CEAC platform

This was established in 2020 during the pandemic-related confinement and the company needed a new activity to replace the business lost. "It is quite moving when we remember that Halieutica's first R&D station was located in our garage. With the progress we made, we knew that we definitely had to move to a new place. Helped by local investors, today, we have this CEAC," said Le Reste. "A temporary location was found in nearby Angers, France. It took a few months before the current location was identified and developed according to our needs."

A new tool

This new tool enables Halieutica to run different trials related to its core business - aquafeeds. The main room has 80 tanks and it is dedicated to run growth trials. It allows for many replicates and options for experimental plans. A major investment was made in behavioural studies. In the second room, data on feed intake, palatability and general shrimp behaviour are collected to understand their needs and requirements better. The last room is devoted to digestibility. "I am really a happy nutritionist with this tool. I can now test ingredients and feeds from every angle. It also helps our team to work on many different and innovative topics with diverse partners. It is very rewarding."

The CEAC is a research tool available to any company involved in the aquafeed business. Its main activity is to run trials for companies developing new products for the aquaculture market. "Everyone agrees that you can only



Margaux Le Gourrierec, Charline Pichon and Pascal Trintignac during the Q&A session

improve what you measure. Data collection is particularly complex in our business. This station is made to help companies in their R&D process by providing them with reliable and precise data," said Le Reste.

"This platform also allows Halieutica to perform trials to better understand the ingredients used in aquafeeds. This is not only the new ones such as insect meal, microbial biomasses or those derived from algae but also ingredients already in use and available in the market but with very poor documentation in technical and scientific literature. The goal of CEAC here is to produce and share knowledge with the aqua nutritionist community through articles and at conferences."

With this new centre, we are looking at European clients seeking to expand in the shrimp market in Asia or elsewhere but need data for marketing and registration. As a small-scale research facility, we can provide them with first-tier data, enabling them to position the product in Asia or Latin American markets. www.halieutica.net

NEXT ISSUES

January/February 2024

Issue focus: Nursery & Hatchery

Industry Review: Marine Shrimp

Feed/Production Technology: Functional Feeds/Additives/Controlled Systems

Deadlines: Articles/Adverts – November 15, 2023

March/April 2024

Issue focus: Health & Disease Management

Industry Review: Marine Fish

Feed/Production Technology: Fishmeal/ Oil Replacements/Industrialisation

Deadlines: Articles/Adverts – January 15/January 24

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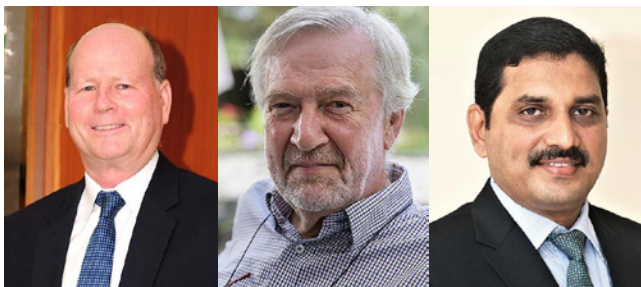


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The GP2023 edition will be in Thailand from November 26-29. It is poised to be another significant event highlighting the global farming and conservation of freshwater prawns of the genus *Macrobrachium*. Once again it presents a global who-is-who of the research and industry supporting freshwater prawns with its panel of distinguished international speakers.



Robins MacIntosh

Patrick Sorgeloos

Krishna R. Salin

There will be two plenary presentations.

- Robins MacIntosh, Executive Vice President, Charoen Pokphand Foods (CPF), Thailand will discuss the potential of the freshwater prawn industry as a global competitor to marine shrimp.
- Patrick Sorgeloos, Emeritus Professor, Ghent University, Belgium will present on the crucial role of beneficial bacteria in crustacean farming; need for new microbial management systems.

Country reports on production will start with a global overview on freshwater prawn farming by Krishna R. Salin, Chair, Aquaculture Program, AIT, Thailand. It will be followed by developments in China and, farming the *Macrobrachium nipponense* and *Macrobrachium rosenbergii* in China. Other presentations will cover trends and developments in Thailand, Bangladesh, India, Vietnam, Cambodia and Myanmar. A 1.5 hour panel will discuss “How resilient is the *Macrobrachium* industry to global challenges?”

The technical presentations on day two will include presentations in the following categories:

- Genetics and novel biotechnology including intensive all-male prawn seed production in a closed system and biotechnology application in gender manipulation on *Macrobrachium rosenbergii* through oral administration;
- Prawn health management including developing health management strategies using molecular and genomics resources;
- Sustainable prawn farming methods with a case study in Kalasin Province, Thailand and organic broodstock production in a biofloc system.
- A panel discussion will be on “What next for the global freshwater prawn industry?”

More details at www.giantprawn.org

| AQUA CULTURE Asia Pacific | | EDITORIAL CALENDAR 2024 | | | | | |
|--|--------|---|---|---------------------------------------|-----------------------------|---|-----------------------------|
| Look out for AAP's annual report on trends in Asia's production of marine shrimp and aquafeeds | | 1 | 2 | 3 | 4 | 5 | 6 |
| Volume 20 | Number | 1 | 2 | 3 | 4 | 5 | 6 |
| | | January/February | March/April | May/June | July/August | September/October | November/December |
| Deadlines - Technical articles | | November 15, 2023 | January 17 | March 13 | May 15 | July 17 | September 18 |
| Deadlines - Advert Bookings | | November 22, 2023 | January 24 | March 20 | May 22 | July 24 | September 25 |
| Innovations/ Startups | | Experiences and opinions covering role models; clear and present needs of industry; innovations and digitalisation in aquaculture | | | | | |
| Interviews with industry leaders | | Focus in 2023 will be leaders pushing for sustainable aquaculture | | | | | |
| Issue focus Emerging trends and challenges | | Nursery & Hatchery | Health & Disease Management | Sustainable & Responsible Aquaculture | Demand & Supply Equilibrium | Aquaculture Innovations | Health & Disease Management |
| Industry Review | | Marine Shrimp | Marine Fish | Aquafeed Production | Tilapia | Marine Shrimp | Catfish & Freshwater Fish |
| Feeds & Processing Technology | | Functional Feeds/ Additives/ Controlled Systems | Fish meal/oil Replacements/ Industrialisation | Hatchery Technology | Novel Ingredients | Larval & Nursery Feeds/ Feed management | Feed Enzymes |
| Marketing | | Market and product developments, post harvest processing, generic marketing, certifications, branding, food safety etc | | | | | |
| Company/Product News | | News on activities at international, regional and local conferences and trade shows | | | | | |
| For advertising/article contributions and guidelines contact: zuridah@aquasiapac.com | | | | | | | |

– New Show Dates –

Asian-Pacific Aquaculture 2024

Aquaculture - Driving the Blue Economy

2-5 July, 2024

Grand City
Surabaya, Indonesia

The Annual International Conference &
Exposition of World Aquaculture Society
and Asian Pacific Aquaculture 2024
Annual meeting of Asian Pacific Chapter, WAS



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The Biennial Marquee event of Indian Aquaculture Organised by
the Society of Aquaculture Professionals
15, 16 & 17 February, 2024
Radisson Blu GRT, Airport, Chennai

AquaIndia is the Biennial Marquee Event of Indian Aquaculture organised by the Society of Aquaculture Professionals (SAP). This year SAP reached its 20th year. SAP is a non-profit, non-government organisation established for and by a group of aquaculture professionals, in India in 2003. Currently, SAP has more than 500+ aquaculture professionals as life members.

Aqua India 2024 will be the 12th edition of this conference series. The last event was held in Chennai in 2022 and was attended by more than 500 aquaculture professionals from India and abroad.

SAP has announced that AquaIndia will be held in Chennai from the February 15-17. The theme is *Improving Efficiencies, Enhancing Opportunities*.

India's shrimp is farming challenges from three fronts: diseases on one side, a glut of shrimp on the other side with no sign of market expansion and consequently low prices; the third is putting pressures on the stakeholders. In this edition, stakeholders in India's shrimp industry intends to discuss all these issues and make changes as it progresses.

Registration is now open at www.aquaprofessional.org/aquaindia.php

2023

November 13-16
AFRAQ 2023
Lusaka, Zambia
was.org

November 27-29
Giant Prawn 2023
Bangkok, Thailand
giantprawn.org

November 29 - December 2
7th International Symposium on
Cage Aquaculture in Asia (CAA7)
Haikou, Hainan
asianfisheriessociety.org

December 7-9
Seafood Expo Eurasia
Istanbul, Turkey
seafoodexpo Eurasia.com

2024

February 15-17
AquaIndia 2024
Chennai
aquaprofessional.org

February 18-21
Aquaculture America 2024
San Antonio, Texas
was.org

March 12-14
Health & Nutrition Asia/Victam Asia
2024
Bangkok, Thailand
vivhealthandnutrition.nl/

March 20-22
VietShrimp
Camau City
vietshrimp.net

April 23-25
Seafood Expo Global
Barcelona, Spain
seafoodexpo.com/global

May 27-31
XXI International Symposium on
Fish Nutrition and Feeding (ISFNF)
Puerto Vallarta, Mexico
isfnf2024.com

June 5-6
Shrimp Aquaculture Conference
Bali, Indonesia

JULY 2-5
Asian Pacific Aquaculture 2024
(APA24)
Surabaya, Indonesia
was.org

August 14-15
TARS 2024: Finfish Aquaculture
Phuket, Thailand
tarsaquaculture.com

August 26-30
AQUA24
Copenhagen, Denmark
was.org

September 3-5
Global Shrimp Forum 2024
shrimp-forum.com

Announcement

Effective date: from 30/06/2023

NEW AQUA FEED PACKAGING



- ✓ Only ADM logo is being used
- ✓ Color-coded for each product group
- ✓ More vivid visuals with key product attributes

* After 30th June 2023, new and old packaging will simultaneously be on the market until out of stock for old packaging.

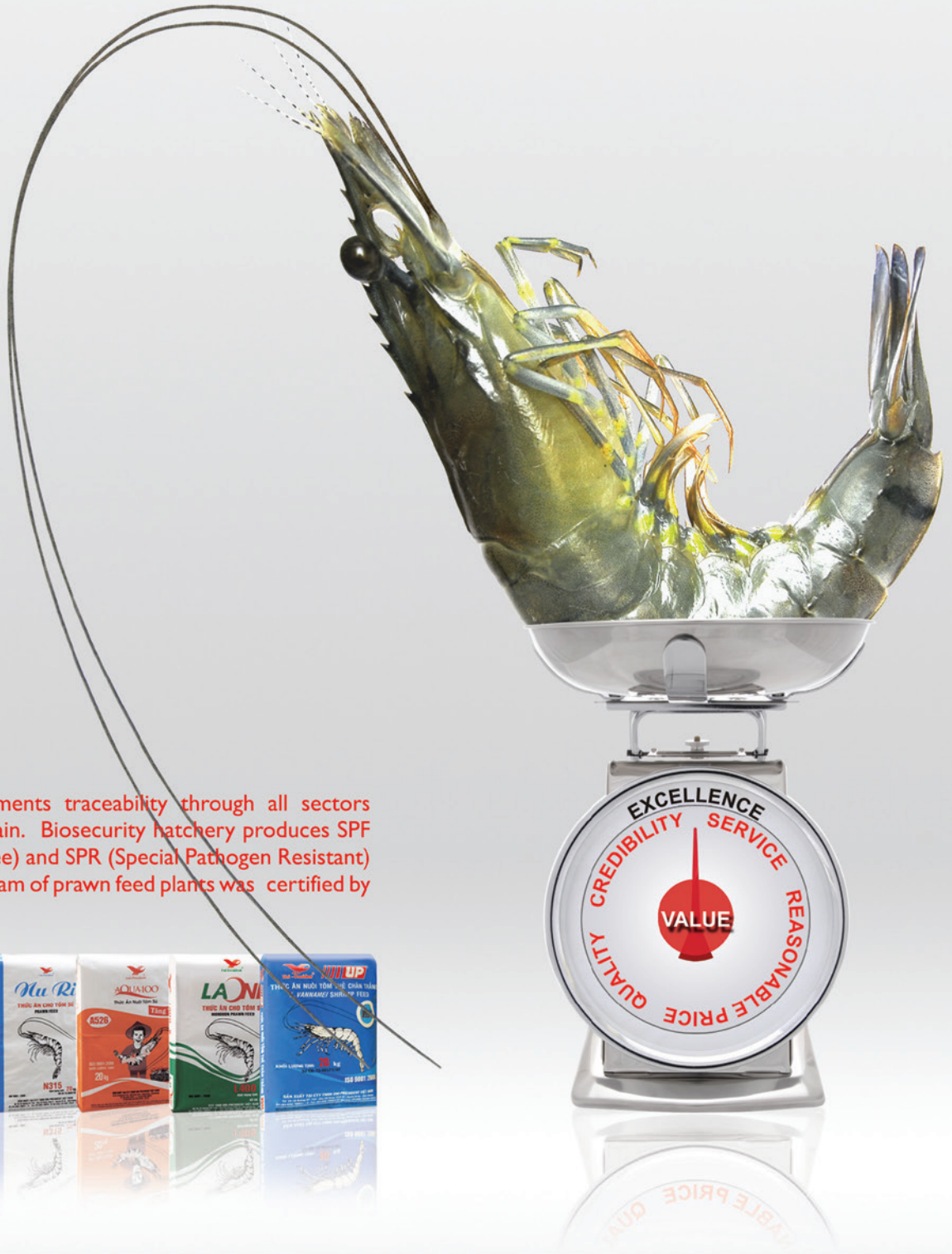
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