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*Asian seabass from Thailand. Picture credit. Hsiang Pin Lan. Page 52*

**Editor/Publisher**
Zuridah Merican, PhD
Tel: +60122053130
Email: zuridah@aquaasiapac.com

**Editorial Coordination**
Corporate Media Services P L
Tel: +65 6327 8825/6327 8824
Fax: +65 6223 7314
Email: irene@corpmediapl.com
Web: www.corpmediapl.com

**Design and Layout**
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Management Pte Ltd
Email: sales@wordsworth.com.sg
Web: www.wordsworth.com.sg

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Fax: +65 6223 7314

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Zuridah Merican

# Seafood Demand vs Supply Outlook. Jump-on the aquaculture band wagon!

Shrimp imports to the USA reached a record 890,000 tonnes in 2021 while Ecuador is the first country to reach the one million tonnes production benchmark. Norway exported USD13.7 billion worth of seafood products in 2021 – a record and an increase of 14.3% over 2020. This included 1.4 million tonnes of fish from aquaculture operations valued at USD9.7 billion. Meanwhile, US seafood retail sales reached new records in 2021, boosted by robust demand as well as inflation. Fresh seafood sales at USD7.1billion rose 30.8% vs pre-pandemic levels in 2019. Frozen seafood sales at USD7.2 billion rose 40.8% vs 2019. All these data seem to ignore (or be due to) the pandemic and lockdowns of 2020. The data quoted here (SeafoodSource.com) are for the US as they are readily available, but it sets a good example of expectations in the EU as well.

During the lockdowns, retail sales of seafood surged as food service suffered but when restaurants reopened, there was an overall net increase. There is no doubt that retail seafood benefitted from the pandemic with ready to cook, ready to heat and ready to eat meals and analysts see this as an advantage in the supply chain. China's Guolian share price surged 19% in mid-January when it announced a strategic partnership with Hema (an upmarket retail hypermarket, majority owned by Alibaba).

Rabobank reported that the aquaculture industry is primed to have another strong year in 2022, especially with the leading farmed species of shrimp and salmon. Asia, as a major producer, must take advantage of this growth in shrimp. With a current global production at 4.58 million tonnes of shrimp, the forecast for 2030 is to exceed 6 million tonnes, even with a conservative CAGR of 3%. The old school of thought would be a case of supply exceeding demand leading to low prices, but the past two years has shown that this may not be the case. However, Asian shrimp has three issues working against it. Firstly, is the uncertainty of production i.e., due to the short cycle, farmers can pull out and skip cycles when prices are poor. Secondly, Asia does not have a sustainability story to tell and sell; and finally, investors still see Asian shrimp aquaculture as a 'casino' with little control over winning and losing big.

Rabobank also reports that higher seafood retail consumption is here to stay which is driven by increased familiarity of cooking at home, demand for healthy food and availability of convenient seafood products. Asia also needs to build a single species marine fish to complement shrimp. While this growth has benefitted salmon, consumers are looking for alternatives in whitefish from aquaculture. One can only consume that much salmon in a week and tilapia and pangasius do not reach that higher value product. This is where the Asian seabass comes in and fits the sweet spot. But we can also add the groupers and snappers if we have volumes.

Unfortunately, today farmers may experience low ex farm prices while prices in the consuming country are high. We know that in the short term, global prices are not determined by supply and demand but by disruptions in the supply chain and high inventory in warehouses lead to poor buying capability in the producing country. Farmers skipping cycles will only lead to uncertainty and higher volatility in demand vs supply outlook. To enter these markets, the cycle will be 18 months for the seabass (>2kg fish). Our advantage is no over wintering when compared to Mediterranean seabass and seabream and producers should take advantage of this strength, but it requires the supply chain working together.

Inflation is no longer transient but here to stay and higher energy and feed ingredient prices will increase cost of production. These prices cannot be borne by the supply side alone and will have to be passed on to the consumer. In conclusion, even with increased supply, there is a matching increase in demand and prices will not fall. This is a good time to jump on the aquaculture band wagon.

*If you have any comments, please email: zuridah@aquaasiapac.com*

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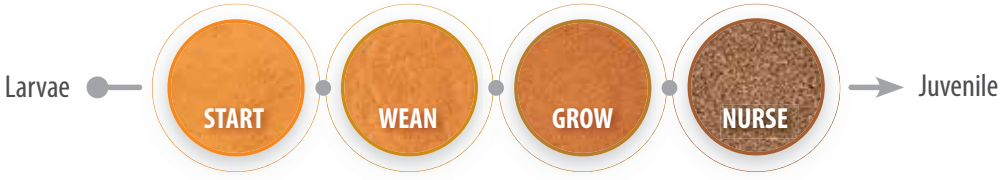


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# How Russia-Ukraine conflict is affecting feed ingredient prices

In the 12 months leading to August 2021, the industry saw increases of 60% and 74% of soybean and corn prices impacting aquafeed production. Feed companies were forced to increase feed prices from an average of 6% in shrimp feeds up to 25% for lower priced pangasius feeds.

In 2022, the industry has to deal with more increases with wheat products included in this portfolio. The Russian Ukraine conflict has had the greatest influence on wheat prices. As of the first week of March, the price per tonne of wheat has surged 80%, compared to that of the past 12 months.


*Chart of wheat prices over past 12 months (Source: Market Insider)*

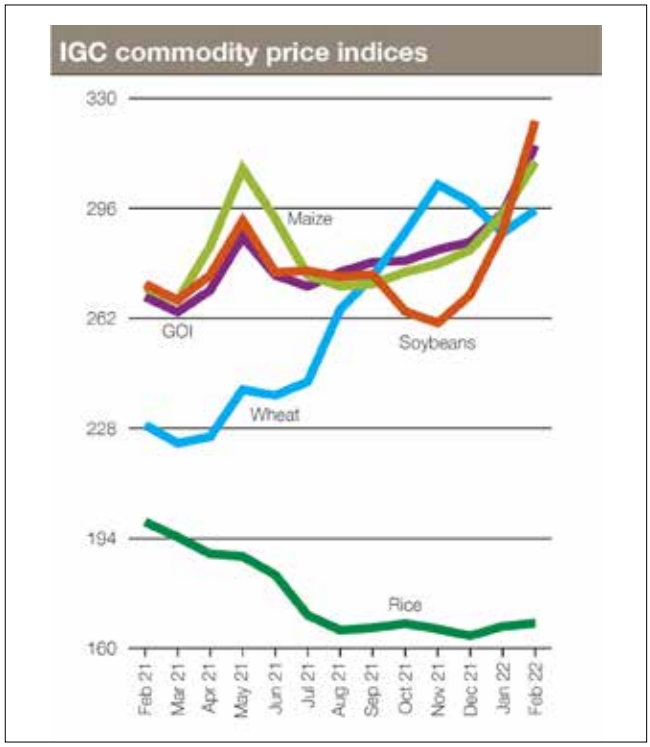
Russia and Ukraine's wheat exports account for over 25% of the global market in 2019 (Observatory of Economic Complexity). Data shows a recent high for Russian wheat exports of 900,000 tonnes in the week to February 17, falling slightly to 800,000 tonnes in the week to February 24 - the day of the invasion. For the week to March 3, however, the volume halved to 400,000 tonnes, reports AgriCensus.

"Most Indonesian buyers are covered until May. They are trying to cover June and July. I believe Indian wheat is available and many have little choice but to buy it. Australian wheat is at a premium now," said a buyer in Asia.

Wheat flour comprises 20% of a pelleted shrimp feed formulation. In addition to acting as a cost- effective filler providing nutrition, it also has a functional purpose of binding with starch gelatinisation contributing to overall water stability and reduced fines. "It is going to be difficult to find a cost comparable alternative and we may have no choice but to increase price again in order to maintain feed quality and performance", said an aquaculture nutritionist.

Corn prices have surged to meet its previous high achieved in May 2021. Ukraine has significantly climbed the ranks to be No. 4 in corn production.

Soybean meal prices have also crossed its previous 12-month high closing at USD483/tonne on March 11. The Russia-Ukraine situation has had minor impact on the supply-demand. The USDA's Wasde report was almost neutral to soybeans, as it showed lower estimates for ending stocks and productions but came within market expectations, according to AgriCensus. The 2021/22 world




ending stocks are estimated at 89.96 million tonnes, while global soybean production was seen down 10.05 million tonnes from the previous estimates to 353.8 million tonnes.

In an opinion article, FAO's Director-General Qu Dongyu said, "Cereal crops will be ready for harvest in June. Whether farmers in Ukraine would be able to harvest them and deliver to the market is unclear. Massive population displacement has reduced the number of agricultural labourers and workers. Accessing agricultural fields would be difficult. Rearing livestock and poultry and producing fruits and vegetables would be constrained as well."

The crisis also risks having negative repercussions for next season's harvest as it could affect supplies and prices of natural gas and fertilisers, for which the Russian Federation is a key exporter. As farmers prepare for the new planting season, soaring input prices could result in lower yields, lower quality production as well as a lower acreage being planted.

"It is still too early to fully comprehend the implications of the crisis on agricultural markets. These will critically depend on the degree of disruption, the length of the conflict as well as the type and severity of counter measures being put in place," highlights the Agricultural Market Information System (AMIS).

Experts warn that the conflict may disrupt Ukrainian farming and create a more long-term disruption to world wheat production in an already tight global market. "Spring grain planting is right around the corner for both (Russia and Ukraine), most importantly corn for Ukraine and spring wheat for Russia and it is unclear whether the ongoing conflict will impact production either physically or economically," said Reuters columnist Karen Braun.

# Strengthening Singapore's food security through sustainable and productive aquaculture

*The latest generation of a floating closed containment system in Singapore was developed by EcoArk, with co-funding support from SFA. It is purpose-built and incorporates high-tech features including the RAS and green energy solutions to power the farm. Source: SFA.*

In its media release in March, the Singapore Food Agency (SFA) says that it is committed to building the capability and capacity of its agri-food industry. It will continue to support farmers to increase productivity, while ensuring that local production remains climate-resilient and resource-efficient. SFA will do so through various means such as facilitating long-term investments to increase production, encouraging demand for local produce, and providing funding support.

Fish is a commonly consumed source of protein that can be grown locally in a productive and sustainable manner. Singapore's farms play an important role in strengthening its food security as local production mitigates the reliance on imports and serves as a buffer during supply disruptions. SFA will support sea-based farms to invest in their future.

SFA plans to uplift the local aquaculture industry through the Singapore Aquaculture Plan. Strategies include:

- Unlocking new spaces through new sea space tenders and longer leases.
- Supporting the aquaculture sector to transform into one that is highly productive, climate- resilient and resource-efficient using technology and adopting appropriate farm management methods, including conducting environmental surveys and water and seabed quality surveys.
- Supporting research and innovation for sustainable tropical marine aquaculture by leveraging on SFA's Marine Aquaculture Centre.

## Tendering new sites with leases

New sea space tenders in the southern waters and east Johor Straits will be progressively launched from end-2022 on a 20+10 years duration to provide certainty on the tenure and facilitate long-term planning and investments. (New sea spaces will have a 20-year lease, with an option to extend another 10 years).

Existing farmers will also have better assurance to make longer-term investments and ensure that the use of sea space is accounted for with the introduction of temporary occupation licences (TOL) from 1 January 2023. The valuation of sea-based farms considers factors such as locational attributes. Farms are to pay 20% in the first year, but this will be waived in line with the Government's commitment to not increase Government fees and charges for 2023, and to mitigate the cost impact on the farmers. SFA also announce the review of farm license fees.

## Strengthening Singapore's food security

Since early 2021, SFA has been engaging sea-based farms on farming management methods and measures to facilitate the adoption of more sustainable practices in support of higher production. These include monitoring the impact of aquaculture activities, measures to prevent and control the spread of fish diseases, and the use of better feed. This will also help sea-based fish farms enhance their business resilience by improving the yield and survival rate of fish and ensuring that the surrounding waters are not degraded over time.

SFA will continue to work with farmers to develop the potential of Singapore's aquaculture industry by transforming it to become more productive and sustainable.

Demand from consumers is also key to sustaining a healthy and vibrant agri-food ecosystem. Supporting local produce will support local farmers and spur them to improve productivity to meet the increased demand and adopt sustainable farming practices. This will, in turn, contribute to strengthening food security.

*Asian seabass broodstock tanks at SFA's Marine Aquaculture Centre. The centre has also collaborated with Temasek Life Sciences Laboratory to successfully develop superior lines of Asian seabass with desirable traits such as fast growth, disease resistance, and high nutritional value.*

## Vietnam's Seafood export turnover reaches USD8 billion in 2021

The Vietnam Association of Seafood Exporters and Producers (VASEP) said that in the first 11 months of 2021, the country's seafood exports reached about USD8 billion, up 4% over the same period in 2020. Shrimp exports reached USD3.56 billion, up 3.4% and pangasius exports reached USD1.4 billion.

In November, seafood exports to the EU market recovered the most, up 65%. Except for pangasius (which did not increase compared to the same period last year), exports of other products to the EU increased sharply. Shrimp exports increased by 86%. The US market still maintained a high and stable growth with an increase of 37% in November where pangasius exports increased sharply by 58% and shrimp increased by 24%. By the end of November 2021, seafood exports to the US reached nearly USD1.9 billion, up 26% over the same period last year and accounting for 23% of Vietnam's total seafood exports. Seafood exports to China recovered slightly in November, up nearly 3% over the same period. The export of pangasius increased by 17.4%, the rest of other products still fell deeply by 15 - 89%. By the end of November, seafood exports to China was down nearly 21% over the same period last year.

It is expected that export results for the whole year of 2021 will be up to over USD 8.8 billion, up 5% compared to 2020.

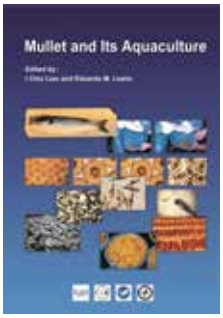
## Five locations identified for expansion in shrimp production

Indonesia's Ministry of Marine Affairs and Fisheries have identified 5 locations for its integrated shrimp estate project in line with the target to produce 2 million tonnes of farmed shrimp by 2024. These are in Sumbawa in West Nusa Tenggara, Muna in Sulawesi, East Aceh, Kota Baru, South Kalimantan and South Konawe, Sultra. It plans to have integrated shrimp estates in each one of them.

Officials said that the strategy to reach this target is through two models; revitalisation to increase productivity of traditional farms and the other model is integrated shrimp aquaculture. The second model will involve collaboration at the district, community and to central levels. Currently there are 300,501ha of shrimp ponds; 9,055ha of intensive ponds, 43,643ha of semi-intensive ponds and 247,803ha of traditional ponds.

In his presentation at the DSM conference Asia Pacific, Dr Romi Novriadi (see p35) described the shrimp estate concept for intensive shrimp farming production where all supporting elements - energy, hatchery, feed mill, cold storage, processing waste water treatment, laboratory and other required facilities are integrated in one area. The other innovation is the millennial farming system with digitalisation and IoT to speed up decision making and minimise losses as well a circular design to ensure water circulation and facilitate waste removal.

## Mullet and Its Aquaculture




During the 2nd Marine Fish Aquaculture Forum held on December 2, 2021, Dr Yew-Hu Chien introduce this latest book on the aquaculture of the mullet to forum participants.

Dr I Chiu Liao is with the Department of Aquaculture, National Taiwan Ocean University. Dr Eduardo M. Leaño is currently Senior Programme Officer of Aquatic Animal Health Programme, Network of Aquaculture Centers in Asia-Pacific (NACA) based in Bangkok, Thailand. Together they have authored/edited several books on aquaculture, from Cobia Aquaculture (2007), Aquaculture of Groupers (2008), Milkfish Aquaculture in Asia (2010) to Progress of Shrimp and Prawn Aquaculture in the World (2016).

This book covers all aspects for the sustainable development of mullet aquaculture: Technologies on cryopreservation, induced breeding, innovative development on grow out, processing and management. The basics on species, distribution, ecology, fishery and marketing are also illustrated. The book ends with mullet cuisines to amplify the reading enjoyment.

The chapters are as follows:

- The *Mugil cephalus* species complex, from Taiwan to the world.
- Review on induced breeding research and cultivation of grey mullet (*Mugil cephalus*) in Taiwan.
- Cryopreservation of grey mullet sperm.
- The pursuit of culturing mullet gold: A personal memoir.
- Mullet in Hawaii.
- Mullet culture in India: Present status and future prospects.
- Seasonal migration and fishing technology of Lobed River Mullet "Ludong" (*Cestraeus* spp.) in Cagayan River, Philippines.
- Advanced development of dated grey mullet fishery in Taiwan.
- Past and present development of mullet aquaculture in Taiwan.
- Taiwan consumers' cognition and purchasing behaviour for Mullet (*Mugil cephalus*) roe.
- Mullet culture with leisure business.

*Editors: I Chiu Liao (right) and Eduardo M. Leaño*

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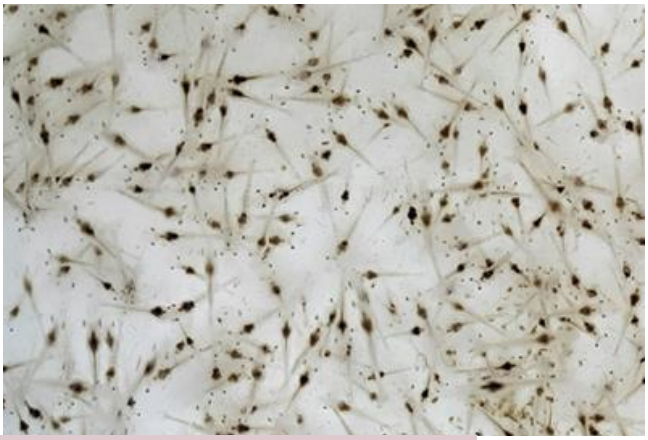
# Beyond the hatchery

## Managing post larvae for successful shrimp pond production

By Dean M. Akiyama



*Post larvae of good quality and of uniform size*

Post larvae quality is important, but good farm management is vital to the success of shrimp pond production. This was shown clearly in an extensive pond performance and post larvae quality data analysis that was done for 9,500 harvested ponds in Indonesia, where post larvae were estimated to have just a 25% influence on pond production.

Only ponds that were from one broodstock family and harvested from one hatchery tank were analysed. All ponds were HDPE-lined rectangular ponds of 2,500-5,000m$^2$, stocked at 100PL/m$^2$ with 20-24HP/ha of paddlewheel aeration.

Pond harvest parameters were correlated to those on post larvae quality. The pond parameters included production level (tonnes/ha), average daily gain (g/day), survival rate and feed conversion ratio. The post larvae quality parameters included tank survival rate, eyestalk length, growth rate, coefficient of variation (CV) of length, luminescent bacteria, total *Vibrio* count, necrosis, gut muscle ratio, chromatophores, and stress test at both hatchery and pond sites. Broodstock and all post larvae (PL3 and PL8) within this study were PCR tested for Infectious hypothermal and hematopoietic necrosis virus (IHHNV), Taura syndrome virus (TSV) and white spot syndrome virus (WSSV). All post larvae were virus negative.

Post larvae eyestalk length and growth rates were adjusted to PL10 parameters because PL9-12 were harvested and stocked into production ponds. Growth as average daily growth (ADG) in the hatchery was calculated as eyestalk length divided by total time.

Harvested biomass data were adjusted to 100 days in 1ha ponds because ponds were harvested from 85-115 days as required.

## Survival rate

As essential as survival rate may be to production performance, it could never be reliably statistically analysed or statistically predicted with accuracy. The actual number stocked and the actual number harvested were too variable to be reliably analysed.

Hatchery tank survival rate, PL10 eyestalk length, PL10 ADG, PL10 eyestalk length CV and luminescent bacteria all affected pond performance but not pond survival rate. If these hatchery standards were obtained, then other criteria had no influence. All other parameters such as stress tests, necrosis, gut muscle ratio, chromatophores, etc., had no correlation to pond performance in the integrated farming system surveyed.

The "minimum" post larvae quality standards at harvested hatchery tank were determined as below:

| | |
|---|---|
| **Survival rate** | 30% |
| **PL10 length** | 10mm |
| **PL10 ADG** | 0.4mm |
| **CV length** | 0.10 |
| **Luminescent bacteria** | Negative |

These are minimum requirements for all parameters concurrently. Hatchery tanks with 65% survival rate, PL10 of 12mm, PL10 ADG of 0.6mm and CV of >0.6 were routinely observed and were better for pond production. These standards will be further improved as hatchery management knowledge increases with genetic improvement of broodstocks.

The relatively small 25% influence that post larvae were estimated to have on pond production demonstrated that success depends on farm management. The following paragraphs discuss the steps that farmers can take to optimise the success of their shrimp ponds.

## Post larvae selection

Farmers should always select a reliable hatchery that provides good service and honest information. It does not pay to purchase the cheapest post larvae as they often fall below quality standards and this will most likely result in inconsistent pond production. Farmers should have their own team to select the post larvae from the hatchery at the time of packing and shipping. Most good hatcheries will add 10% more post larvae to cover handling and shipping mortalities.

| Parameter | Value |
|---|---|
| **PL age (day)** | 10 - 12 |
| **PL length (eyestalk, mm)** | > 10.0 |
| **Uniformity (% CV)** | < 10 |
| **Hatchery tank survival (%)** | >30 |
| **Viruses PCR, PL3 and PL8** | negative |
| **Luminescent bacteria** | negative |
| **Total *Vibrio* count (TVC)** | <$10^4$ |

**Table 1.** List of acceptable post larvae quality standards at the hatchery level.

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## Stress test upon arrival

For every shipment of post larvae entering the farm, it is crucial to conduct stress tests. The recommended protocol is given below:

- Fill three 5L containers with 2L of freshwater. Bottled water is preferred because it will always have the same composition and consistency.
  - Directly add 100PL to each container
  - After an hour, count the mortality for each container. The transport survival rate is the average of the three containers
  - Acceptable stress test survival rate is >95%.

*Post larvae shipping bags being acclimated in pond water, Philippines. Bags should be left in pond water for 30 minutes before post larvae are released into acclimation tanks.*



*Counting post larvae. Before counting, place post larvae in a basin (counting tub) and stir to collect dying/dead post larvae in the centre.*

## Post larvae counting on arrival

Post larvae in every shipment entering the farm should be counted. To do this, take random samples from the delivery truck and sample one box for every million post larvae received.

Before counting, place post larvae in a basin (counting tub) and stir to collect dying/dead post larvae in the centre. Remove all dead and weak post larvae and count only those that are healthy and active. Use the average of the boxes counted to estimate the number of post larvae received at the farm; the actual number received must be verified by the farm manager.

## Acclimation of post larvae

Proper acclimation of the post larvae is critical for the initial survival rate. The number of tanks required per pond needs to be determined: each 1,000L acclimation tank can be stocked with 250,000 post larvae. Place the required number of acclimation tanks on the pond dykes and follow these steps:

- Prepare air pump or blower with air stone lines for aeration of the acclimation tanks. Dissolved oxygen (DO) should be maintained at a minimum of 6ppm.
- Prepare water pump or buckets to transfer pond water to acclimation tanks. Add the water slowly and evenly for the total time required, estimated from the acclimation below.
- Stock post larvae in the early morning while it is cooler. If you must stock at a later time, shade the tanks from direct sunlight.
- Fill the acclimation tanks about 10% with pond water. Add air lines with air stones to each tank for proper aeration. Place the unopened bags of post larvae in tanks or pond for about 20-30 minutes to acclimate for temperature.
- Open bags and release post larvae into the acclimation tank. Add 20g of the smallest shrimp crumble feed to each tank.
- Add pond water evenly and slowly until tanks are full at the calculated acclimation time.
- Check temperature, DO, pH and salinity every 15 minutes to verify that all measured parameters are being adjusted evenly to pond water.

After the determined acclimation time, verify that all parameters are the same as pond water. Then, the post larvae are ready to be stocked into the pond. The maximum acclimation time is two hours.

For the transfer of post larvae from the acclimation tanks, large siphon hoses can be used to drain post larvae into survival screens or directly to ponds.

*Set of acclimation tanks alongside a pond being stocked in the Philippines. Tanks of 1,000L should be stocked with 250,000 post larvae.*

*Pond water being pumped into acclimation tanks in the Philippines. The volume of water pumped was estimated to coincide with the total acclimation period.*

| | | |
|---|---|---|
| **pH** | every 0.5 | 15 min |
| **Temperature** | every 1°C | 15 min |
| **Salinity** | every 3ppt | 15 min, from 10-30ppt |

**Table 2.** Sample of an acclimation timetable

If the pond salinity is <10ppt, the salinity should be adjusted at the hatchery. Post larvae are more sensitive to salinity adjustments below 10ppt and very sensitive to lower than 5ppt. The adjustment from below 5ppt to 0ppt will require several days to avoid mortality. The total acclimation time required will be determined by the longest time required for pH, temperature or salinity adjustments.

*A covered post larvae acclimation station in Peru. Large siphon hoses can be used to drain post larvae directly to ponds from the acclimation tanks.*

## Pond stocking screens and PL survival boxes

The problems that occur during packing and transport are often overlooked. When the purchased post larvae from the hatchery may not be the quality as specified, post larvae transport bags could have been improperly packed and/or problems could have arisen from the estimated transport time; all of these factors can degrade the quality of the post larvae being stocked into ponds. The use of stocking screens and survival nets help to identify problematic post larvae at the time of arrival at the farm.

### *Stocking screens*

Place a minimum of two 2 x 2m screens for 250,000 PL/screen per pond. Larger screens can be used to hold more post larvae. Screens should be made from nylon nets with a mesh size of 1.0µm.

Place the screen 50cm above the pond bottom, with the screen edges 10-20cm below the water surface. Attach the corners of the screen to a pole secured to the pond bottom and/or dyke. A stone weight (500g) should be placed in the middle of the screen to stretch it so that the centre of the screen is about 50cm from the pond bottom. The sides of the screen should be below the water surface to allow stronger post larvae to swim out of the survival screen into the pond.

Check survival screens after 8-10 hours. The weak post larvae unable to swim out of the screen and dead shrimp should be removed from the pond and counted (estimated by weight).

The acceptable standard for PL survival in stocking screen is 95%. If survival rates are close but below standard, the pond manager may decide to stock more post larvae as soon as possible. If the survival rate is <70%, the ponds will need to be restocked, as there will be continued mortality for the next 7-10 days.

*Stocking screens in a pond, Philippines. If survival rate is <70%, the ponds will need to be restocked, as there will be continued mortality for the next 7-10 days.*

### *PL survival boxes*

Post larvae survival boxes are used when direct stocking of ponds from acclimation tanks is practised. Survival boxes are made with a 1m x 1m x1m frame with nylon nets of mesh size 1.0µm. Secure the boxes to the lift net bridge by cord. Place weights in every box corner to ensure at least 50cm of the boxes are submerged in the pond water. There should be a minimum of three survival boxes per pond, each containing 100 post larvae and fed 20g of the smallest shrimp crumble feed twice a day.

Survival boxes should be checked and counted 7 days after stocking to estimate survival rate from stocking. The survival rate is the average of three survival boxes.

The acceptable PL survival standard in the survival box is 90%. If survival rates are close but below this standard, the pond manager may decide to stock more post larvae, as soon as possible. If survival rate is <60%, the ponds will need to be restocked as there may be continued mortality for the next 5-7 days.

*An example of a survival box. There should be a minimum of three survival boxes per pond, each containing 100 post larvae and fed 20g of smallest shrimp feed crumble twice a day.*

## Water quality pond stocking

Water quality parameter measurements start after the pond is completely filled with water. Parameters that need to be checked are water level, salinity, DO, pH, temperature, alkalinity, transparency, water colour, plankton, Bicarbonate ($HCO_3$-), total ammonia nitrogen (TAN), ammonia ($NH_3$) and total *Vibrio* count (TVC). DO, water level, temperature, transparency, and water colour must be checked daily, while plankton, $HCO_3$-, TAN, $NH_3$ and TVC can be checked weekly.

| Parameter | Value |
|---|---|
| Water depth (cm) | 120 – 130 |
| Transparency (cm) | 50 - 80 |
| Salinity (ppt) | 15 – 30 |
| Dissolved oxygen (ppm) | 5 - 9 |
| pH | 7.5 – 8.5 |
| Temperature (0C) | 28 - 32 |
| Total alkalinity (ppm) | 80 - 150 |
| TAN maximum (ppm) | 0.5 |
| NH3 maximum (ppm) | 0.05 |
| Water colour | Green/brown |
| Plankton preferred | green algae/diatom |
| TVC (CFU/mL) | < 2200 |

**Table 3.** Water quality standards for post larvae stocking

**"The weak post larvae unable to swim out of the screen and dead shrimp should be removed from the pond and counted (estimated by weight). The acceptable standard for PL survival in stocking screen is 95%."**

**Dean M. Akiyama,** PhD. is an Aquaculture Advisor, based in Jakarta, Indonesia.
Email: akiyamadm@gmail.com


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# Tilapia vaccines – new developments and new market approaches

## Vaccination in the tilapia industry is a challenging and complex process, evolving through multiple strategic approaches

By Roberto Cascione

*Graded and sedated 15-20g black tilapia on the vaccination table, ready to be immunised with TILAVAC S3 (Streptococcus agalactiae, serotype Ia, Ib and III)*

Annually, over 6,000,000 tonnes of tilapia (*Oreochromis niloticus*) are produced globally, compared to 3,000,000 tonnes of Atlantic salmon. The growth coefficient for tilapia over 10 years (2010-2019) was 5.9%, but in 2022, the growth coefficient is expected to be 3.7% due to the interruption from the COVID-19 pandemic (GOAL 2021, Global Seafood Alliance, 2021).

Diseases hamper and affect a large part of the massive global production of tilapia. However, if we look at the vaccination rate of this leading industry, we will discover that 35% of the total tilapia produced in South America and only 1% of the whole production of Africa and Asia are currently vaccinated. This is a great contrast to the farmed salmon industry where 100% of the fish are vaccinated.

Clearly, the two industries are not comparable. Tropical aquaculture is composed of small-to-medium scale production systems, comprising a vast multitude of producers with different and sometimes country-specific farming methods. Farming structures, seasonality, husbandry practices, environmental conditions and many other parameters are extremely diverse and surely do not help to harmonise the production in a sort of "global standard" as is present for the salmonids.

**"Vaccination and tropical aquaculture must be combined for a more sustainable and efficient production system."**

Moreover, the epidemiological situation and disease presence are constantly evolving, creating a growing and continuous need for new prophylactic methods.

Even if the tilapia industry is not as accessible as the salmon industry for vaccination, in the last 15 years different models of vaccination strategies have been set up, providing and demonstrating that vaccination and tropical aquaculture must be combined for a more sustainable and efficient production system. Disease outbreaks and major losses due to an increasing number of pathologies are constant occurrences within the major production systems in Latin America, Asia Pacific and West and East Africa.

Big producers and, nowadays, also medium-scale farmers are more conscious of the benefits of vaccination. They understand that what in the beginning is an extra cost turns into a major benefit in the end.

## Overview on vaccine solutions

The tilapia vaccine panorama is widely dominated by three major pharmaceutical players and a multitude of smaller local producers that supply the industry with autogenous vaccines. The latter vaccines are mostly water-based, with a range of immersion and intraperitoneal (IP) administration routes.

In Thailand, since 2015, local universities and research centres have tried to supply the industry with multivalent autogenous vaccines based on the diseases identified in the field. A similar scenario recently appeared in Indonesia and on a larger scale in South America, especially Brazil, where the tailor-made strategy is becoming a prevalent industry strategy for disease control.

This is undoubtedly a very important approach, but it is necessary to be very careful of the outcomes. Creating a tailor-made product compatible with the farming needs is an excellent strategy to penetrate the market and support the industry. On the other hand, it is risky to oversell the efficacy expectation, which will then lead to a loss of confidence in the overall vaccination practice when vaccines do not give the expected results. For example, this happened in Thailand where multiple vaccination campaigns have not unfortunately gained the confidence of the industry.

On the other hand, if we look at commercial vaccines, most of the globally registered vaccines for the tilapia are focusing on the protection against *Streptococcus agalactiae*, serotype 1a, 1b or III and *Streptococcus iniae*. With a mortality rate of up to 60-85% during very strong outbreaks, Streptococcosis is still one of the major threats of the tilapia industry.

In the early days, vaccines were mostly monovalent or bivalent adjuvanted products. Nowadays, the more varied epidemiological situations in the major production areas are driving the industry to develop more multivalent vaccines that can answer the needs of farms with the growing number of pathogens causing disease in many geographical areas.

Therefore, even the classic *Streptococcus agalactiae* prophylaxis is changing toward a multivalent approach where, indeed, TILAVAC S3 vaccine (Virbac, France) is the only trivalent vaccine available in the market, protecting against all major pathogenic serotypes of *S. agalactiae* (1a, 1b and III).

## Vaccine strategies – Old, current and new frontiers

It is undeniable that the IP administration route is the most secure immunisation procedure. Therefore, it is expected that the tilapia industry will move towards vaccine delivery by IP injection and a multivalent protection approach similar to that applied in the salmon industry.

As the IP vaccination is the most efficient administration route, it is associated with husbandry and size constraints, which sometimes oblige farmers to use a more obsolete technique of vaccination such as immersion. In South America, for example, some local autogenous vaccine producers are providing early-stage immersion multivalent vaccines.

*Intraperitoneal injection of 15-20g tilapia fingerling with TILAVAC S3 Vaccine*

As mentioned previously, vaccines could be a very useful tool for supporting emergency situations, but it is essential to underline that this prophylactic approach has a very short time protection and may require multiple applications (boosts) with consequent increase of costs.

Nevertheless, with the increasing knowledge in nanotechnologies, the immersion vaccine technique is also going through a modernisation process. Nanotechnologies could be the future answer to fix two of the major limitations of immersion vaccine: onset and duration of immunity (DOI), given it can be produced in a cost-efficient way.

The oral vaccine administration route is another method that has monopolised the efforts of many research and development players. Currently, oral vaccination is far from being an efficient vaccination technique but also in this case, new technologies are taking over, giving hope for new product developments in the coming years. Oral vaccines could be integrated with the classical vaccination schemes as potential boosts or alternative administration routes to address emergency situations and/or seasonal problems.

The vaccination approach in the tilapia industry is not always compatible since a disease can appear at different stages of the production. For this reason, it is very complicated for the fish health industry to provide a solution that can cover all the possible needs of the farmers.

## New frontiers of vaccination

*Francisella spp., Edwarsiella* spp. and viruses such as infectious spleen and kidney necrosis virus or ISKNV and tilapia lake virus or TiLV are new threats. They are gaining the attention of all major players. It is expected that the new frontiers of vaccination in fish health management will consider the inclusion of these pathogens in future developments.

In conclusion, vaccination in the tilapia industry is challenging and complex. It has evolved with multiple diverse strategic approaches. The sometimes complex, epidemiological scenarios, together with a multitude of farming practices are definitely the most important factors to consider, and vaccination itself cannot solve all disease problems, if not combined with strong biosecurity measures and solid fish health associated practices.

Virbac is committed to developing new technologies and to play a major role in state-of-the-art fish health approaches. Thanks to a field-oriented, highly experienced team and strong understanding of the farmers' needs, the company promotes and provides continuous monitoring of the major farming areas to understand and react promptly to the industry.

As the largest producer of tilapia globally but with a low vaccination rate, the Asian tilapia industry may need to move forward with vaccination as part of a better health management strategy if it wants to stay ahead.

**Dr Roberto Cascione** is Aquaculture Key Account Manager - Southeast Asia and Middle East, Virbac, based in Bangkok, Thailand.
Email: roberto.cascione@virbac.com

# Synergistic approach for challenging shrimp farming conditions

## Top dressing feeds with a multi-component immunostimulant enhanced growth performance, survival and immune parameters in post larvae and juvenile shrimp

By Niti Chuchird, Chiow-Yen Liew, Daranee Seguin and Rutchanee Chotikachinda

Using a multi-component nutritional approach to optimise stress resistance in shrimp is one of the practical adaptation strategies and de-risking tools that the farmer can adopt to overcome challenging farming periods. In this article, we describe two trials using a multi-component nutritional approach to investigate the efficacy of a high-performance immunostimulant for the early stages in shrimp farming. The trials involved a first stage nursery from post larvae PL15 and subsequently, the second stage for 1.0g juvenile shrimp. This is a sustainable approach that increases the defense mechanism and promotes immunocompetence in shrimp.

## Trial 1: Application in the nursery phase

To demonstrate the efficacy of the multi-component immunostimulant, Rovimax® HB Ultra, containing a mixture of free nucleotides, brewer's yeast and antioxidant vitamins, a nursery growth trial was carried out in a hatchery in Nakhon Si Thammarat Province, Thailand. Six 5-tonne concrete tanks were used, each stocked with 50,000 *Litopenaeus vannamei* post larvae (PL15) in 3 tonnes of water at a salinity of 20ppt. The stocking density was 17 PL/L.

Post larvae in three tanks were fed a commercial control diet containing 42% crude protein, while post larvae in the other three treatment tanks were fed a test diet where the commercial diet was top dressed with the multi-component immunostimulant at a dosage of 10g/kg of feed. The feeding regime for all treatments were eight meals daily, adjusted following bodyweight and estimated survival rate daily. Water quality parameters were maintained at an acceptable range throughout the 20-day feeding period.

Table 1 summarises the growth performance of the control and treatment groups. Post larvae fed test diet supplemented with the multi-component immunostimulant showed better growth performance with more uniform size (lower % coefficient of variation, CV) than the control group. Additionally, a 24% higher survival was observed in shrimp fed the treatment diet with the immunostimulant supplement as compared to the control group.

| Parameters | Control | HB Ultra |
|---|---|---|
| Initial weight (g) | 0.008±0.00 | 0.008±0.00 |
| Weight gain (g) | 0.34±0.02[a] | 0.47±0.03[b] |
| Survival rate (%) | 52.97±11.33 | 76.04±9.12 |
| Different superscript letters within rows denote significant $p<0.05$ difference among treatments | | |

**Table 1.** Summary of nursery production results. Comparison of growth performance of *Litopenaeus vannamei* post larvae fed the control and treatment diet supplemented with Rovimax®HB Ultra in a 20-day feed trial.

## Trial 2: Application in the juvenile phase

Here we investigated the efficacy of this multi-component immunostimulant in enhancing shrimp growth performance, survival and reducing stress for *L. vannamei* juveniles (~1g).

Juvenile shrimp were fed four times daily to satiation for 21 days with a commercial control diet containing 38% crude protein and a test diet where the commercial diet was top-dressed with the multi-component immunostimulant at the same dosage of the nursery trial (10g/kg of diet).

The experimental groups were carried out using five replicates. Water quality parameters such as pH, dissolved oxygen (DO), alkalinity, ammonia, and nitrite were maintained to optimal levels for rearing shrimp and analysed weekly throughout the experiment.

Table 2 shows that the juvenile shrimp fed the test diet demonstrated a significantly better feed conversion ratio (FCR) and survival rate than the control group.

| Parameters | Control | HB Ultra |
|---|---|---|
| Initial weight (g) | 1.01±0.03 | 1.00±0.03 |
| Weight gain (g) | 3.16±0.11 | 3.21±0.62 |
| Average daily growth | 0.15±0.01 | 0.15±0.03 |
| Feed conversion ratio (FCR) | 1.46±0.06[b] | 1.23±0.19[a] |
| Survival rate (%) | 86.80±1.10[b] | 93.20±1.10[a] |
| Different superscript letters within rows denote significant $p<0.05$ difference among treatments. | | |

**Table 2.** Growth performance, feed conversion ratio (FCR) and survival (%) of *Litopenaeus vannamei* juveniles fed the control and treatment diet supplemented with Rovimax®HB Ultra in the 21-day feed trial.

## Maximising growth while enhancing stress resistance

Compared to shrimp fed the control diet, shrimp fed the test diet supplemented with the multi-component immunostimulant showed higher immune responses, which resulted in better survival. Table 3 indicated the efficacy of the multi-component immunostimulant in boosting immune parameters (phenol oxidase activity (PO), total haemocyte count (THC), superoxide-dismutase (SOD) and serum bactericidal activity (inhibition against *V. harveyi*) against the control group.

| Parameters | Control | HB Ultra |
|---|---|---|
| THC ($10^7$ cell/mL) | 1.29±0.01[b] | 2.53±0.09[a] |
| Phagocytosis (%) | 62.89±1.54[b] | 81.33±0.67[a] |
| PO (units/min/mg protein) | 270.73±6.45[b] | 293.56±3.38[a] |
| SOD (% inhibition) | 50.30±0.72[b] | 65.64±0.93[a] |
| Serum bactericidal | 1:8 | 1:32 |
| Different superscript letters within rows denote significant p<0.05 difference among treatments. THC =total haemocyte count; PO =phenol oxidase activity; SOD=superoxide-dismutase. | | |

**Table 3.** Efficacy of Rovimax®HB Ultra with regards to immune parameters for *Litopenaeus vannamei* juveniles.

Following the 21-day feeding period, juvenile shrimp were exposed to hypoxia stress condition in which a low DO level at 1.5mg/L was applied to the juveniles for 7 days. Hypoxia clearly negatively affected shrimp survival. On the other hand, the enhancement of stress resistance according to immune modulation and improvement of survivals were observed in shrimp fed diets supplemented with the multi-component immunostimulant as shown in Figure 1.

## Efficacy against pathogens

Juvenile shrimp fed control and treatment diets were immersed in the cultured water with *Vibrio parahaemolyticus* (Vp), at a concentration of $10^5$CFU/mL. This strain was isolated from shrimp which had exhibited signs of white faeces. Vp infection strongly impacted the survival rate of shrimp compared to non-infected group (negative control). Figure 2 demonstrated that HB Ultra prevented losses from mortality and against pathogenic diseases compared to the control group. In addition, shrimp fed the test diet has 30% less mortality than the control group after a 14-day challenge with Vp.

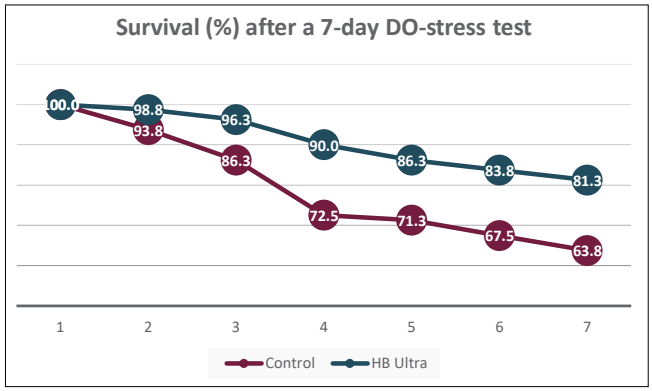


**Figure 1.** Comparison of survival rates of *Litopenaeus vannamei* juveniles fed control and diets supplemented with Rovimax®HB Ultra exposed to a hypoxia condition with dissolved oxygen at 1.5mg/L for 7 days.

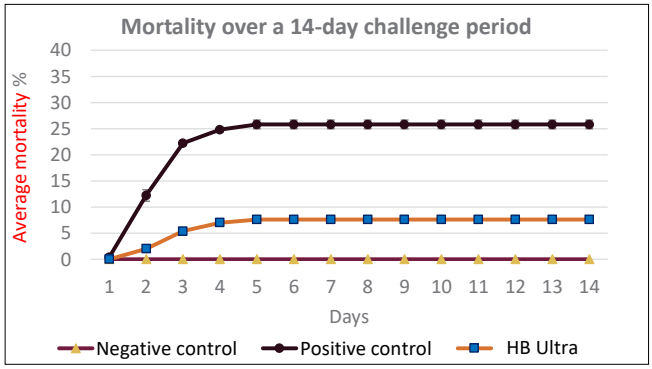


**Figure 2.** Mortality of *Litopenaeus vannamei* juveniles fed Rovimax®HB Ultra in a 14-day challenge test with *Vibrio parahaemolyticus* (Vp) strain.

Additionally, shrimp fed the multi-component immunostimulant showed a lower degree of sloughing of hepatopancreatic cells and lower *Vibrio* count than the control group after a 14-day post-challenge period as shown in Figure 3 and Table 4.

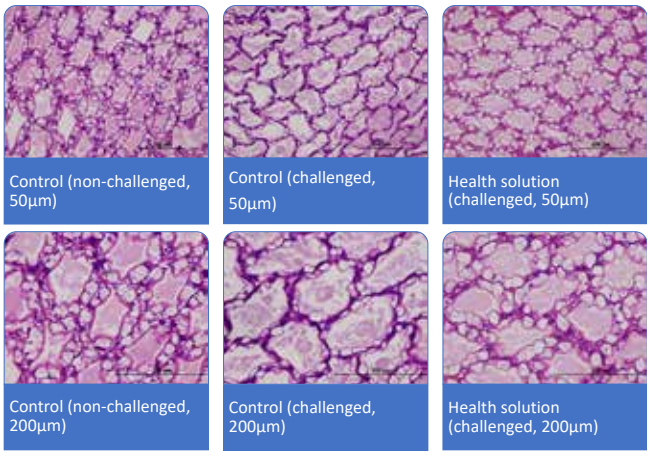


**Figure 3.** Histology of hepatopancreas of *Litopenaeus vannamei* juveniles after the 14-day challenge test with *Vibrio parahaemolyticus* (Vp) strain showed a lower degree of sloughing of hepatopancreatic cells in the group fed diets with the health solution, Rovimax®HB Ultra.

# Rovimax® HB Ultra
## An Adaptation Strategy

### A high performance immunostimulant for challenging aquaculture conditions

Using Rovimax® HB Ultra as part of the farm stress management strategy supports the animals in their defense functions to overcome challenging farming periods. Rovimax® HB Ultra is a practical health and stress management tool that strengthens the aquaculture animal immunity and supports disease resistance.

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| Treatment | Total *Vibrio* spp. ($10^5$ CFU/g) |
|---|---|
| Neg. Control (non-challenged) | 0.55±0.04[a] |
| Pos. Control (challenged) | 8.48±0.11[c] |
| HB Ultra (challenged) | 3.33±0.20[b] |
| Different superscript letters within columns denote significant $p<0.05$ difference among treatments. | |

**Table 4.** Total *Vibrio* count in intestines of Litopenaeus vannamei juveniles after the 14-day challenge test with *Vibrio parahaemolyticus* (Vp) strain.

In addition, there was less sloughing of the hepatopancreatic cells but with a high number of lipid accumulation in R cells in the treatment group compared to the control group. Better gut integrity indicates healthier shrimp, better digestion, and absorption of nutrients for growth.

## Adaptation is the key

Stress is inevitable and in aquaculture, it is often not visible. It is common to see the absence of clinical or subclinical signs until it becomes chronic and irreversible. Strategies to increase survival require adaptation and integrated stress management that combines immune modulation to reduce the negative effects of pathogenic agents. It is important for shrimp farmers and producers to ensure that a robust immune stimulation and modulation are achieved when selecting the right tool to increase the animal's ability to adapt.

At DSM, our approach is to build health and immunity to achieve robust immune stimulation and modulation in shrimp through cell proliferation, cell activation, antioxidant enhancement, and gut homeostasis, as shown in Figure 5.


**Niti Chuchird,** PhD is Niti Chuchird is Assistant Professor at Kasetsart University, Bangkok, Thailand.
Email: ffisntc@ku.ac.th

**Chiow-Yen Liew** is Regional Marketing Aquaculture, DSM Nutritional Products Asia Pacific, Singapore.
Email: Chiow-Yen.Liew@dsm.com

**Daranee Seguin,** PhD is Manager of Nutrition and Health Solutions, Aqua at DSM Nutritional Products (Thailand) Ltd.
Email: Daranee.Seguin@dsm.com

**Rutchanee Chotikachinda,** PhD is Manager, Nutrition & Health Solution Aqua (Asia Pacific) at DSM Nutritional Products (Thailand) Ltd..
Email: Rutchanee.Chotikachinda@dsm.com

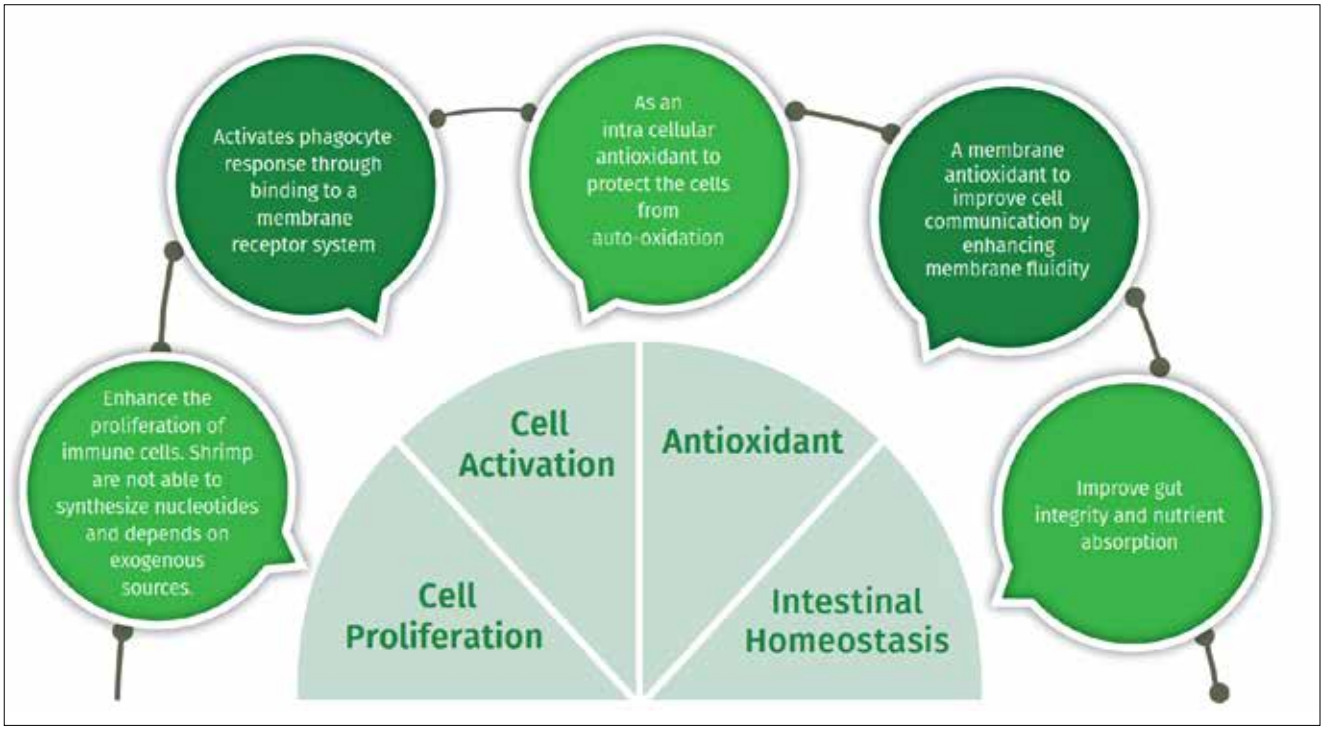




**Figure 5.** Synergistic immune activation for robust immune stimulation and modulation.

# White faeces syndrome: Latest understanding and preventive measures

## Factors triggering WFS remain unclear but some actions relating to shrimp and environment can be taken to reduce severe impacts and losses from this syndrome

By Sophie Reys and Pierre Fortin

First described around 2010, white faeces syndrome or WFS is an important disease in shrimp farming in Asian countries that can cause severe mortalities and economic losses. This disease is a complex syndrome. Factors triggering WFS are yet unknown and the triggers might not be the result of one single agent. In this article, we describe its etiology and preventive measures.

## A syndrome that causes mortality and reduces performances

The WFS refers to the presence of floating white faecal strings in ponds. It can be observed in both farm-reared black tiger shrimp (*Penaeus monodon*) and Pacific white shrimp (*Litopenaeus vannamei*). The syndrome causes several issues, including high mortality, growth retardation, size heterogeneity and elevated feed conversion ratio. Survival is generally reduced by 20-30% (Tamilarasu et al., 2020) and the cumulative mortalities can be as high as 50% in the summer periods (Hou et al., 2018). Early disease indications (floating faecal strings) appear in feed trays and at the water surface (Figures 1a-1b), with a sudden reduction in feed consumption. It usually happens in grow-out ponds around the second month after stocking.

The shrimp faeces turn from normal (a brownish colour) to pale white, leading to the name of this disease. White faeces appear to be more buoyant than normal faeces and float on the water surface. The shrimp hepatopancreas also becomes whitish, soft and looks empty due to the lack of feed. The midgut is distended and filled with substances that are white to yellow in colour (Figure 1c). Also, a loose exoskeleton and dark-coloured gills can be observed.

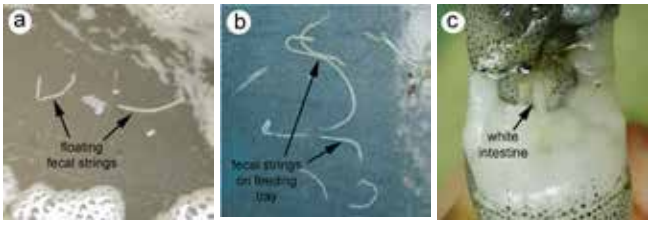



**Figure 1.** Some gross signs of white faeces syndrome WFS showing (a) Floating, white faecal strings. (b) White faecal strings on a feeding tray. (c) White intestine of affected shrimp. Source: Sriurairatana et al. (2014)

But these faeces are not "true" faeces. While normal ones are mostly composed of undigested feed, the white faeces are composed of leftovers of tissues from hepatopancreas and gut mucus, and frequently contain a mixed bacterial component and massive number of spores from the microsporidian parasite *Enterocytozoon hepatopenaei* or EHP (Pachumwat et al., 2021). *Vibrio* species have also been found in the faeces of infected shrimp (Suguna, 2020). When the contents of the gut or faecal strings were examined with a light microscope, they consisted of masses of vermiform bodies that looked like protozoan gregarines (Sriurairatana et al., 2014). This explains why at some point, it was postulated that gregarines were the causative agents of WFS.

Sriurairatana et al. (2014) described the WFS as a disorder in the microvilli from epithelial cells of the hepatopancreas. Transformed microvilli, sloughed away are collected in the tubule lumen and aggregated together as vermiform bodies. Stripped of microvilli, cells undergo lysis. The vermiform bodies are almost transparent with no cellular structure. They accumulate with tissue debris, mucus, EHP spores and eventually *Vibrio* bacteria at the hepatopancreas-midgut junction and in the midgut. These aggregated and transformed microvilli lead to the formation of white faecal strings, which are finally excreted (Figure 2).

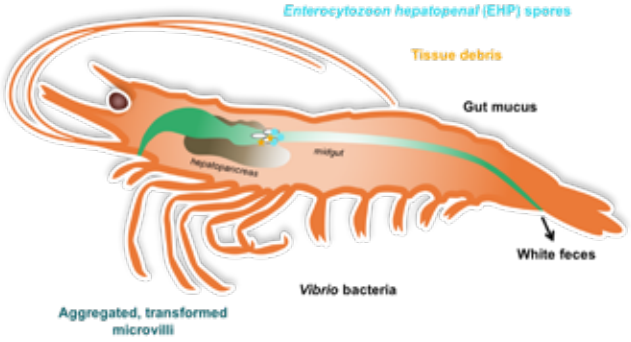



**Figure 2.** The formation of white faecal strings in shrimp. Source: TECHNA

Histology performed by Sriurairatana et al. (2014) on a cross section of hepatopancreas tubule (Figure 3a) showed a modified, sloughed B-cell in the lumen with microvilli spread over its surface. Epithelial cells with normal microvilli and others with abnormally thin layers, or denuded of microvilli, with lysis process ongoing were also seen.

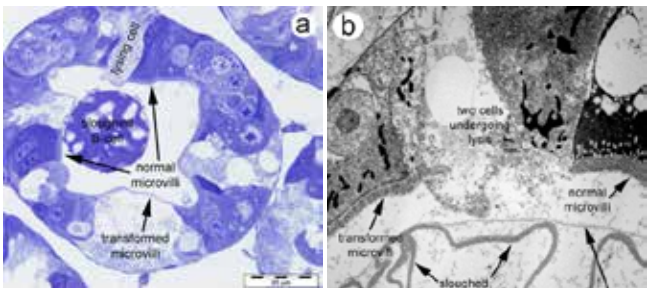



**Figure 3.** a) Cross section of hepatopancreas tubule stained with toluidine blue showed a modified, sloughed B-cell in the lumen with microvilli spread over its surface.

**Figure 3.** b) TEM microscopy showed normal and transformed microvilli and two denuded cells undergoing lysis. Source: Sriurairatana et al (2014)

By transmission electron microscopy (Figure 3b), hepatopancreas epithelial cells showed normal and transformed microvilli and an early stage in the aggregation of transformed and sloughed microvilli surrounded by an enclosing membrane. After, aggregated transformed microvilli formed gregarine-like entities.

## Environment, microbiota and stressful conditions: Key factors

WFS is a syndromic condition of complex etiology, similar to diarrhea in humans (Pachumwat et al., 2021), and its origin is still unclear. Recent study showed that a full intestinal ecosystem alteration, rather than a single pathogen, was associated with WFS (Huang et al., 2020). Many studies demonstrated that adverse environmental and stressful conditions have been associated with the development of this syndrome. These adverse conditions can also facilitate the development of opportunistic pathogens and create an unbalanced digestive bacterial community. Furthermore, anti-nutritional factors, toxins such as mycotoxins contained in feeds might create damage to the hepatopancreas, thus promoting degraded hepatopancreas conditions that favour the occurrence of WFS.

Similar to humans, the shrimp digestive system hosts a large number of microorganisms dominated by bacteria, which constitute a complex microbial ecosystem called the microbiota. It has multiple functions and plays an important role in maintaining host health, nutritional absorption or immune response. The balance in the intestinal microbiota population is crucial and the loss of microbial diversity in the intestine can bring about diseases to shrimp.

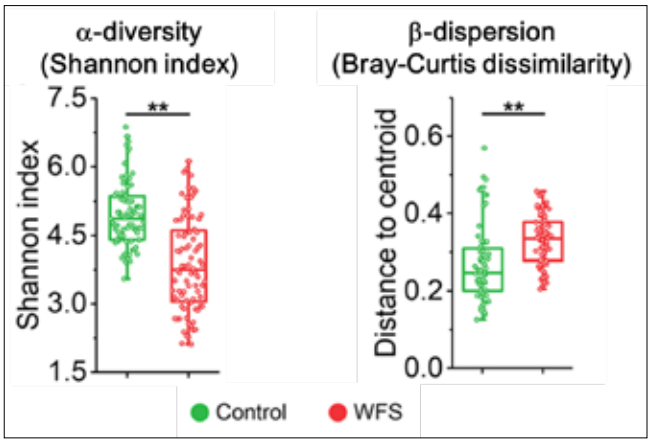



**Figure 4.** Shannon index and Bray-Curtis dissimilarity of intestinal bacterial communities of white faeces affected shrimp. Source: Huang et al. (2020)

Recent studies (Hou et al., 2018; Huang et al., 2020) reported a close relationship between dysbiosis of the intestinal microbiota and WFS. According to these authors, the intestinal bacterial communities of white faeces affected shrimp were significantly less diverse and more heterogeneous than normal shrimp as was represented respectively by Shannon index and Bray-Curtis dissimilarity in Figure 4.

The profile of the intestinal bacterial community is significantly different between healthy and white faeces affected shrimp. According to Huang et al. (2020), the increased abundances of opportunistic pathogens (*Vibrio, Candidatus* Bacilloplasma, *Aeromonas* and *Photobacterium* species) and decreased abundance of the beneficial bacteria (*Chitinibacter* spp.) were the common features associated with white faeces affected shrimp. Furthermore, this study demonstrated that the transplantation of intestinal microbiota from white faeces infected donors to healthy shrimp leads to similar symptoms in about one third of cases. Hou et al. (2018) reported that the overgrowth of intestinal *Candidatus* Bacilloplasma and *Phascolarctobacterium* species and depression of *Paracoccus* and *Lactococcus*, known to be beneficial to the host, might result in the occurrence of WFS.

WFS is often associated with the microsporidian EHP whose spores were found in and around the transformed microvilli. As described by Huang et al (2020), the microsporidian was firstly proposed as the causative agent of WFS, but this hypothesis was not supported by subsequent studies. Recently, Pachumwat et al. (2021) showed that EHP might be a component but was not the only causative agent. According to Sathish Kumar et al. (2022), WFS is a shrimp diarrhea associated with severe EHP infection that may be caused by a combination with an unknown agent.

The severe loss of microvilli may predispose shrimp to other enteric pathogens. The study of Somboon et al. (2012) indicated that most of the shrimp that had white faeces had significantly higher amounts of *Vibrio* bacteria, including *V. vulnificus*, *V. fluvialis*, *V. parahaemolyticus* and *V.alginolyticus*, in their haemolymph and intestine, than in control shrimp.

## Preventive measures

Even though the exact causative agent or factor triggering WFS is unknown, some actions could be taken to avoid outbreaks or, at least, reduce severe impacts and losses because of this syndrome. We can divide possible actions into two different categories, the shrimp and its environment.

### *Shrimp*

It has been proven that WFS initially targets the hepatopancreas cells of shrimp. Therefore, promoting a better condition of this organ could help to counter the WFS effects. This could be done by using a high quality, highly digestible feed. Quality ingredients and proper formulation will lead to improved digestion and less demand on the hepatopancreas which could be more resilient.

Choosing raw materials that contain low levels of toxins or anti-nutritional factors is also important, as these compounds will directly affect the hepatopancreas. Indeed, this organ handles a lot of toxins in the shrimp. Furthermore, the feeding ratio should be adjusted. High feeding rates are stressful for the animal and its digestive system. Lowering the amount of feed during risky periods is as important as the feed quality.

We have seen that the impact of WFS on shrimp mortality is mostly due to the opportunistic pathogens such as EHP or *Vibrio* bacteria. Specific feed additives could be used to limit the proliferation of these pathogens in the digestive tract of shrimp. Immunity of the animals could also be increased by using specific ingredients,

called immune stimulants. Thanks to its long-time experience and knowledge in the field of additives, Aquaneo has designed a product called WF Detox. This helps the shrimp's immune system and has actions on the pathogens and overall microbial population of the digestive tract (Figure 5). WF Detox also incorporates plant extracts that prevent membrane degradation and help toxin excretion. These actions aim to improve the health status of the hepatopancreas. WF Detox should be used as a preventive additive when conditions are in favour of a WFS outbreak. It can also be used at higher doses when WFS is present in the ponds.

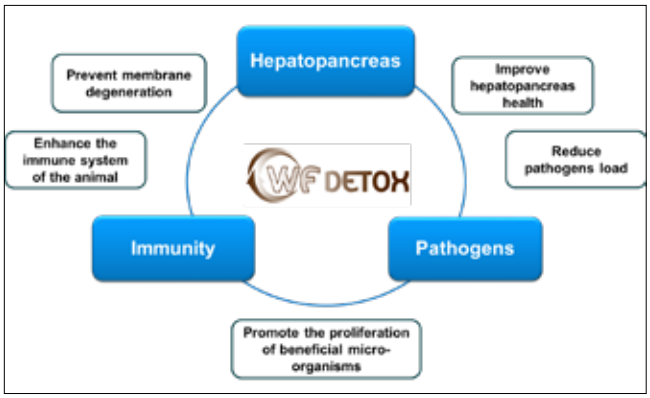



**Figure 5.** The mode of action of WF Detox. Source: TECHNA

## *Environment*

Besides the shrimp, the environment has to be considered. Indeed, the pond is a complex ecosystem that not only has a direct impact on the animal, but also on the surrounding pathogens. It is important to monitor parameters and adapt farming practices accordingly.

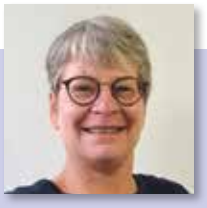
First, high temperatures (Tamilarasu et al., 2020), and especially strong temperature fluctuations induce stress to the animals that could enhance the WFS outbreak or increase its severity. Other important parameters to monitor include: pH, alkalinity, ammonia, nitrite and dissolved oxygen levels. Similarly, maximum and/or minimum levels as well as strong fluctuation could favour a WFS outbreak or increase its severity. High densities, poor pond-bottom quality and high planktonic blooms also negatively affect environmental quality and animals.

Feeding and feed quality also have an impact on the environment as the undigested feed will remain in the ecosystem, polluting it and ensuring conditions for the growth of opportunistic pathogens. As mentioned above, feeding ratio should be adjusted and reduced when risk increases (values close to the limits and strong fluctuations).

Strict enforcement of biosecurity measures is also of importance to keep pathogens as low as possible in the environment. Opportunistic pathogens could have a very strong impact in the case of WFS outbreaks.

Finally, it is important to adapt and anticipate. Indeed, prevention is more effective and less expensive than cure. Farm management should be adapted according to the conditions. For example, ammonia toxicity varies according to pH and temperature. Therefore, the limit for ammonia concentration is dependent on these parameters. Furthermore, if the ammonia level is increasing, do not wait until it reaches the limit to take action. It is important to anticipate.

Feeding should also be adjusted to the overall pond conditions and not only shrimp size and temperatures. Feed choice or the use of additives such as WF Detox should be linked with the risk of WFS outbreaks.



**Sophie Reys** is R&D Project Manager.
Email: sophie_reys@techna.fr

**Pierre Fortin** is Aquaculture Nutritionist.
Email: pierre_fortin@techna.fr

Both authors are with AQUANEO, the aquaculture brand of TECHNA, France.

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# Early-stage nutrition impacts all lifelong performances

## Maximising fish growth and profit starts with the quality of early nutrition

By Delphine Weissman


**Figure 1.** Three key stages in the life cycle of farmed fish.

For many animal species, early nutrition is recognised as very important for a good start in life, optimising development, maximising the chance of a healthy life and reducing metabolic diseases. In aquaculture, the main source of nutrients is provided through complete feed; it is critical to ensure feed quality and adequate amount, especially at the early stages, not only in terms of nutrition and digestibility, but also on particle size and behaviour of feed and its stability in water. Feed quality not only impacts performances in early stages of animals but also during their whole lifespan until harvest (Figure 1). Consequently, the strategy for maximising aquaculture success and profit at each stage starts as early as first feeding.

### Key organ developments occur at early stages

Not all organs develop and grow simultaneously in young animals. As a result, organ size proportions vary across life stages. This phenomenon is called allometry. For example, in humans, exponential brain growth occurs during the first 1,000 days of life. This explains why babies' heads are proportionally bigger than that of adults. Therefore, from a nutritional point of view, it is a critical time when nutrients that can maximise neural health and development must be prioritised (Valentine, 2020).

In newly hatched fish, not all organs grow simultaneously (Osse et al., 1997) and consequently, growth intensity is not distributed evenly across the body (Fuiman, 1983). Even in species not subject to metamorphosis but only to development after hatching, postembryonic changes exist in structure at varying degrees depending on species (Fujimura and Okada, 2007). These changes allow the progressive transformation from recently hatched fish to juvenile, then to adult stages. They have been described for the tilapia (Fujimura and Okada, 2007) and mullet fish (Khemis et al., 2013).

In the case of mullet, Khemis et al. (2013) described three distinct growth episodes distinguished by allometric inflexions in newly hatched mullet from day post hatch (dph1) to dph71. It starts with cephalic region development events. At first, a fast allometry head growth is observed, together with the development of eyes and vision, increase in mouth size and the shift from cutaneous to gill respiration. The second allometry episode consists of the development of locomotion organs, such as the tail and fins. In the third episode, axial musculature develops: the fillets start to grow. These developments give the fish the ability to better detect feed particles (eyes and vision), ingest them (bigger mouth), swim fast and precisely (locomotion organs and muscle development) and ensure a more efficient oxygen supply (gills) to support swimming behaviour toward feed particles. Fujimura and Okada (2007) divided tilapia early development into many precise stages - from fertilisation to early juvenile - to describe the process of organ growth. Figure 2 presents the evolution of tilapia from yolk absorption and first exogeneous feeding to the early juvenile stage.

Because crucial development events happen during the early life of fish, it is extremely important to provide the nutrients they need at the right time. The nutritional profile of the feed must be adapted for each life stage. Additionally, in the first weeks of life, the intestines are still maturing. That is why feed digestibility and quality of the raw materials must be finely adjusted. A good attractability of the feed also helps to provide nutrients in sufficient quantity. In addition, offering appropriate particle feed size is essential to ensure proper suction feeding and to optimise fish development.

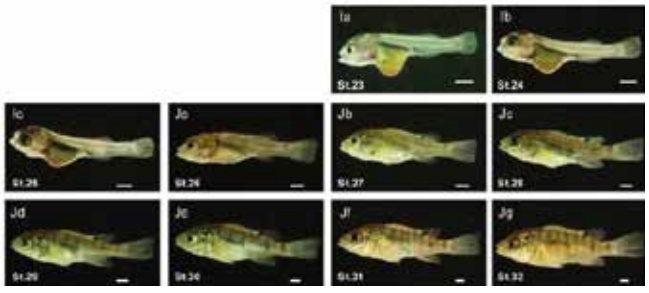

**Figure 2.** Overview of the developmental of Nile tilapia *Oreochromis niloticus* in late larval period stages (St.23-St.25) and in early juvenile period stages (ST.26-St.32). St: stage. Scale bar: 1mm. Source: Fujimura and Okada, 2007.

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## Quality of early nutrition affects animals' phenotypes up to harvest

Early nutrition impacts phenotype to a greater or lesser extent according to animal species. One of the most extreme example is in bees, as larval nutrition will determine if the larvae become either a worker or a queen. Specific nutritional challenges in young stages can modify gene expression and lead to metabolism modifications. The way external factors such as nutrition can impact gene expression is called epigenetics. Furthermore, simple changes in nutrient profile during the juvenile stage impacts animals, not only during the young stage itself but in later stages as well, leading to different phenotypes at slaughter and variations in carcass quality. In swine production, age and weight at weaning influence fat content and carcass quality at slaughter (Dunshea at al., 2003, Figure 3).

> "That is why the strategy for a better profit at slaughter must include precise nutrition at early stages."

The impact of early nutrition on fillet quality at harvest also applies to aquaculture. For example, a decrease in dietary protein: energy ratio with the addition of lipids in trout juvenile feed during the first 75 days of life affects muscle and fillet quality later and leads to a fattier phenotype. For similar body weight at slaughtering, excess fat at early stages decreases muscle fillet deposition (Alami-Durante, 2014, Figure 3).

This example illustrates how early nutrition not only affects performances of fish during the juvenile period but also overall fish performances and quality, up to harvest. The impact of feed on juvenile growth might seem minor, but it will be exacerbated throughout their life. That is why the strategy for a better profit at slaughter must include precise nutrition at early stages.

## Investment in early growth as a strategy to take advantage of growth mechanism changes

Most fish will continue to grow throughout their lives. Since a major part of body mass is muscle, favouring muscle growth will boost fish size. Muscle growth is based on two phenomena: hyperplasia (increase in muscle fibre quantity) and hypertrophy (increase in muscle fibre diameter) according to Kiessling et al., (2006), as illustrated in Figure 4. It has been demonstrated that hyperplasia is the dominant growth process in recently hatched fish and that it gradually decreases as fish increase in size (Zimmerman, 1999), whereas hypertrophy persists beyond this stage. Kiessling et al. (2006) reported that hyperplastic muscle growth, which occurs principally during juvenile life, is of great interest in commercial aquaculture because it contributes to the final market size of the farmed fish. In addition, a higher number of muscle fibres would also lead to a better fillet quality (less gaping, better texture) due to the larger amount of connective tissue in muscles (Kiessling et al., 2006). To take advantage of these muscle growth mechanisms, it can be hypothesised that favouring a good growth in early stage - as long as hyperplasia process is dominant - would favour the later growth of fish and final body weight.

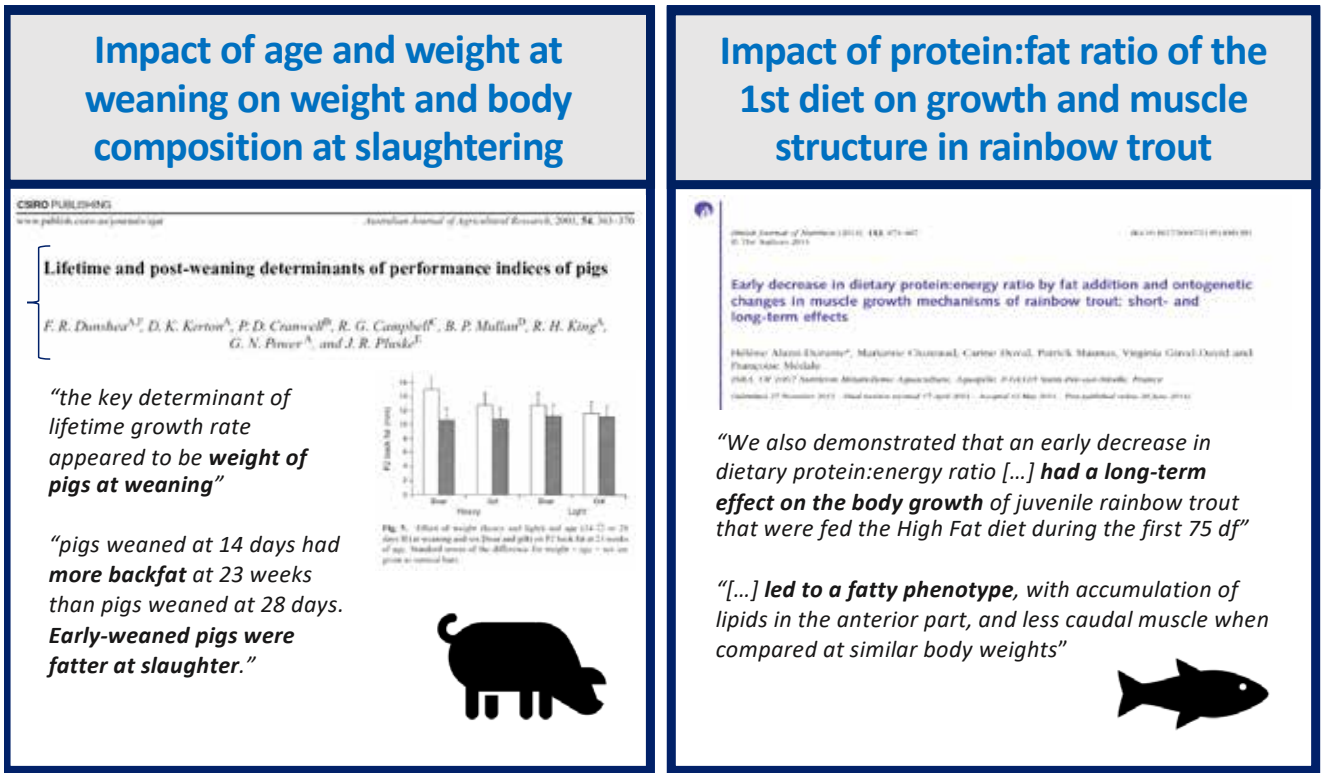


**Figure 3.** Impact of early life nutrition on phenotype and carcass quality at slaughter. Source: Dunshea at al., 2003; Alami-Durante et al. 2014.

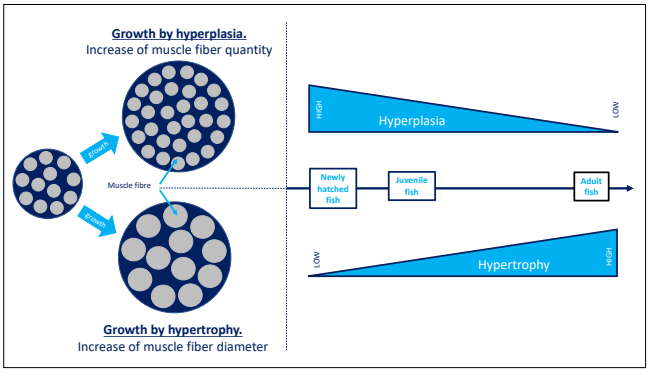


**Figure 4.** Growth muscle mechanism and its evolution through life.

This is an additional demonstration showing that promoting high quality early nutrition would impact technical and economical performances in aquaculture.

To conclude, early nutrition must prioritise the right nutrients at the right time in sufficient quantity to ensure the proper development of fish in the early stage and onwards. The development of the young fish has to be carefully managed, especially with regards to nutrition as it will impact fish performances and quality until harvest.

Apart from all the allometry events and growth of organs, young fish are often exposed to external stresses (such as transfers, handling, variations in water quality and pressures from diverse infections) during a critical period where the digestive system is still immature, as is the immune system and when the fish is not able to efficiently fight off pathogens. Additionally, it is a period of exponential growth. Thus, young fish are exposed to numerous challenges that they need to overcome. A high-quality feed including functional ingredients is certainly key to promoting successful fish farm results.

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**Delphine Weissman** is Manager Research & Application Aquaculture at ADM.

# The gut health revolution with fish meal substitution

## Functional diets are the new trend to achieve sustainable aquafeeds

By Marta Arredondo and José A. Oroz

Aquaculture production has been growing exponentially for years and the World Bank estimated that by 2030, 62% of fish produced worldwide will be from aquaculture. Fishmeal is generally considered the gold standard dietary protein source for many aquatic species. Most farmed fish and shrimp are extremely dependent on fishmeal and fish oil supplies, which, today are considered as environmentally and ecologically unsustainable.

The scarcity of global fishery stocks has affected drastically the capture fishery industry world-wide, provoking a constant fluctuation of fishmeal cost, in addition to continuous environmental concerns (Mousavi et al., 2020). Fisheries trimmings and by-products supply a big proportion of the fishmeal and fish oil, and it has been estimated that by 2050, this resource will not be able to meet feed industry demands which will then influence the nutritional quality of farmed fish.

When we talk about fishmeal and fish oil demands, we should not think about global aquaculture. Global aquaculture production has tripled in live-weight volume from 34 million tonnes in 1997 to 112 million tonnes in 2017. However, 75% of this aquaculture production in 2017 comprised seaweed, carps, bivalves, tilapia and catfish. Today, fishmeal is rarely used in feed for omnivorous fish species, but it is still widely used for carnivorous fish and crustaceans. Its substitution, however, is much more complicated in feeds for carnivorous fish and crustaceans.

## Some realities on substitution of fishmeal with soybean meal

Fishmeal and soybean meal (SBM) are the most common feed ingredients in aquafeeds, representing 40-60% of total variable costs. Plant proteins such as soybean meal are common replacements for fishmeal in aquafeeds and this contributes to the reduction in the feed costs. At the same time, replacing fishmeal with soybean meal in aquafeeds improves the negative perception of consumers on the use of animal by-products for animal nutrition.

Currently 50% of the fishmeal used in carnivorous fish diets can be replaced by plant proteins without affecting their general performance and welfare. However low (<15%) fishmeal inclusion diets remain associated with poor growth and survival, particularly for several carnivorous fish species. In the same way, low fish oil inclusions are generally related to a compromised nutritional value of farmed fish, due to inadequate levels of ω-3 long-chain polyunsaturated fatty acids.

In response to these challenges, novel aquafeed ingredients are gaining attention. These include macroalgae, single-cell protein from microalgae, bacteria or yeasts, insect meal and genetically modified crops. There are also aquafeed additives to prevent or repair the adverse effect of extreme formulations, which might result in impaired growth, enteritis or immune suppression.

Soybean meal is high in protein and currently is a common protein source in aquafeed. However high inclusions of soybean meal have been shown to have detrimental effects on gut health causing enteritis, high vulnerability against pathogenic challenges (bacteria, parasites, or toxins), changes in the absorptive cells provoking inflammation and villi shortening.

An option has been to process the plant-based ingredients to make them more compatible with industry needs for use in aquafeeds such as removing anti-nutritional factors like phytic acid, but all these significantly raise the cost of the raw material making it unviable.

## Gut health, the requisite to sustainable nutrition

The key to fishmeal substitution is gut health. The gut is an important component of the immune system for fish and shrimp. Diet alteration has been demonstrated to have an impact on microbiota affecting negatively or positively to the potential resistance of fish and shrimp to diseases.

The first candidate for this novel protein sources would be single cell protein (SCP). SCPs have a potential to deliver multiple solutions in our efforts to replace fishmeal in diets. However, the challenge in the use of SCP would be to maximise cellular growth and to economically scale-up production. Microalgae, yeasts, bacteria and protists are the most used SCPs. Feeds containing bacteria can offer optimal protein content and can be produced in relatively low-cost substrates. In comparison to fishmeal, yeasts not only can provide optimal amino acid composition but can also be easily produced.

The novel trend to include insect meal in aquafeed is currently being evaluated, and it shows promising results with regards to nutrient quality and palatability. However, it is not yet cost-effective. Initial trials conducted with Butirex C4 (chemically protected sodium butyrate developed by the Spanish company NOVATION 2002 and insect meal showed an improvement in feed cost as well as overall performance compared to only insect meal inclusions in aquafeeds.

## The potential of organic acids in aquaculture

Organic acids are becoming more relevant in aquafeeds not only because of improvements in feed quality, but also for the positive impact on intestinal health. There are more than 20 different organic acids frequently used in animal nutrition. The small structure allows better penetration into the pathogens. Formic, lactic or propionic acids and their salts are the more common organic acids. Probably sodium formate or potassium diformate are the most used in aquafeeds.

The effectiveness of these acids is related to their pKa values, the length of the molecule and their presentation as either the pure acid or as the salt. Its effectiveness is also related to the protection or coating technology.

Organic acids should be included in feeds because of their bactericide or fungicide effects and of their ability to support intestinal pH which will help the good bacteria balance in

the intestine. Formic acid is considered the strongest in terms of bactericidal capacity compared to other organic acids while propionic acid would be the best choice for the control of fungi.

Butyric acid is a novel additive in aquafeeds. It is extensively used in terrestrial animals and is responsible for the maximum development of enterocytes, which improve absorption capacity. Additionally, some immune and permeability benefits have been demonstrated in recent years with the use of butyric acid in aquafeeds.

In the market, there are suppliers of pure organic acids, either in liquid or salt forms. These presentations are not ideal as unprotected or uncoated organic acids are highly volatile and at the same time, they have a limited intestinal effect.

Coated organic acids with palm oil or any other vegetable fat are also available in the market. This protection would be useful if we do not consider extrusion processes and mash technology which are commonly used to manufacture aquafeeds. Fat coated products cannot correctly support this aggressive manufacturing processes.

The latest technology development for organic acid protection is the buffer or chemical protection. Mineral buffer salts can be used to protect volatile compounds such as organic acids. This is a technical and unique advantage for pelleting or extrusion processes. The advantage for the animal is the release of organic acid at the proximal part of the intestinal tract which avoids dependency on enzymatic digestion. It allows maximum acid activity available for all digestive areas and specially at proximal absorptive intestinal areas. Due to an improvement of intestinal conditions and production parameters, we observe that butyric acid has become a necessary ingredient on the feed matrix for aquafeeds. Trials conducted with rainbow trout, Nile tilapia, and vannamei shrimp with Butirex C4 supplemented feed, have shown improved overall performance (Figure 1).

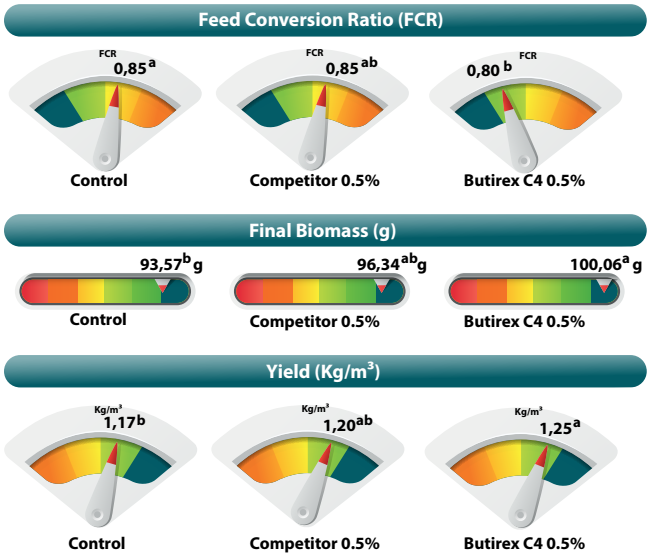


**Figure 1.** Improvements in feed conversion ratio, final biomass and yield with Butirex C4 supplemented feeds for the Nile tilapia.

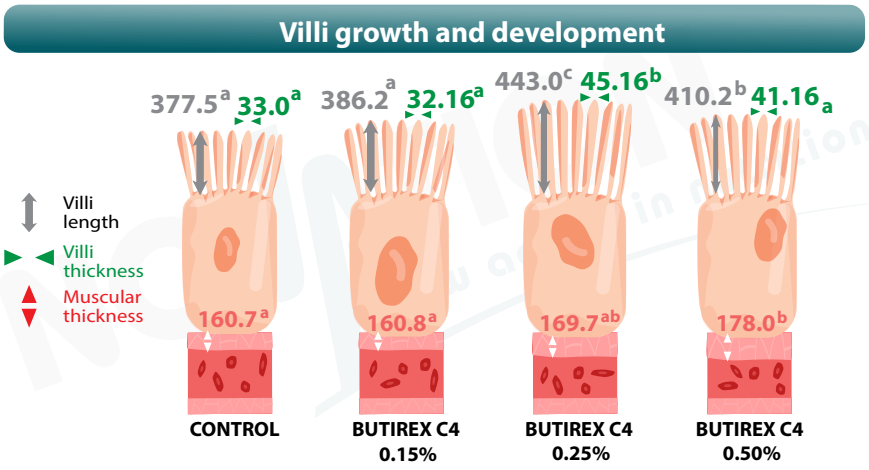


**Figure 2.** The addition of Butirex C4 promotes villi growth and development which translates into a larger surface area and an improved nutrient absorption capacity as shown in trials with rainbow trout.

Over the last years, the scientific community has started to investigate the role of butyric acid on the immune system, its antioxidant effects and intestinal permeability or microbiota modulation.

The main absorption action and metabolic process of butyric acid take place inside the intestinal cells. Butyric acid is absorbed by the enterocyte; it enters the Krebs cycle and provides energy to the enterocyte. This promotes villi growth and development which translates into a larger surface area and an improved nutrient absorption capacity. This has been demonstrated with the use of Butirex C4 in aquafeeds.

The impact of butyric acid on other parts of the body shows a positive effect on animal health status, such as immune health, pancreatic activity and liver functionality.

The enzymatic production in animals supplemented with butyric acid has been analysed. We have observed the increase in digestive enzymes (protease, lipase, amylase) and antioxidant intestinal enzymes (SOD, GPx, CAT). Improving survival and performance during pathogenic challenges have been demonstrated with the use of Butirex C4 in shrimp production (Figure 3).

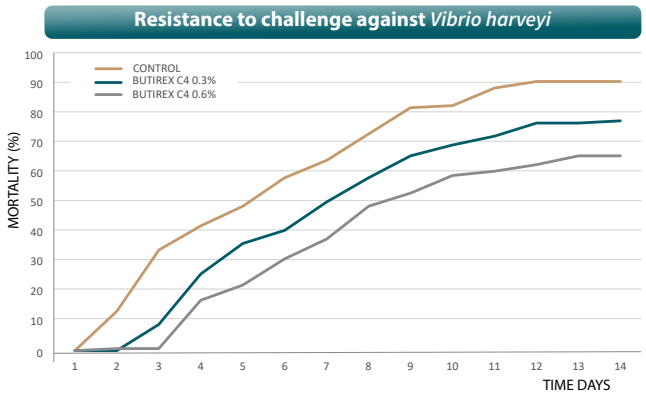


**Figure 3.** Reduction in mortality rate with the addition of Butirex C4 in vannamei shrimp diets in a *Vibrio harveyi* challenge.

This is directly related to its stronger barrier function that blocks the entry of bacteria, parasites and other pathogenic agents from crossing the intestinal barrier and provoking the so-called "leaky gut". Studies conducted with Butirex C4 in rainbow trout have also shown a higher gene expression of tight junctions (TJ). TJ proteins act as a lock or chain that joins the enterocytes making the gut barrier impenetrable and strong (Figure 4). We can reduce the bacterial translocation or bacteria penetration with butyric acid, increasing these TJ proteins.

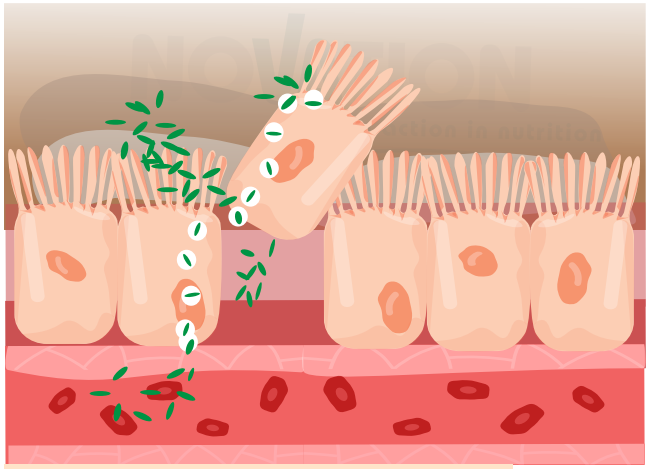

*Illustration of bacterial translocation in gut barrier*

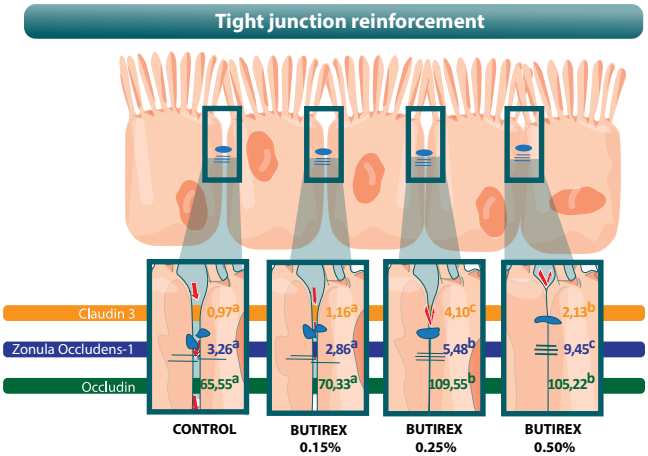


**Figure 4.** Butirex-C4 in rainbow trout showed a higher gene expression of tight junctions (TJ).

Diet changes like fishmeal substitution, stressful challenges and low-quality raw materials normally cause a cytokine storm-like reaction. This triggers a strong intestinal inflammatory response inducing oxidative damage, which can reduce nutrient absorption. In the farm, intestinal inflammatory response translates to higher feed conversion ratio and impaired growth. Results obtained with the supplementation of Butirex C4 in rainbow trout have shown a boost in the anti-inflammatory effect and the control of proinflammatory cytokines.

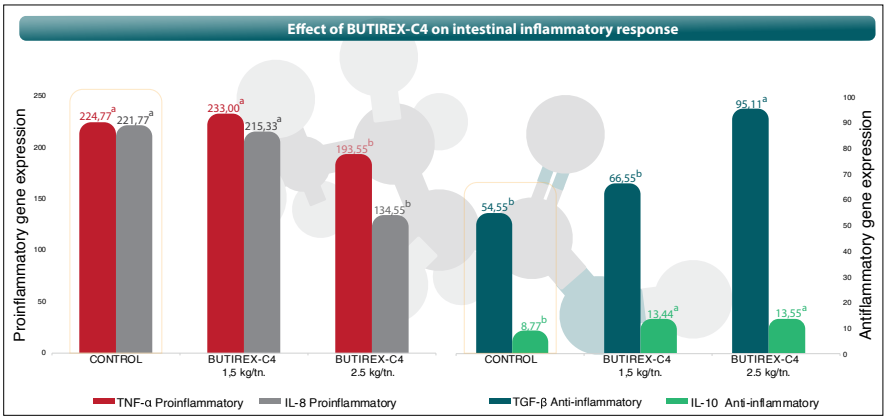


**Figure 5.** Intestinal inflammatory response in rainbow trout showing effects of Butirex C4 supplementation with anti-inflammatory and the control of proinflammatory cytokines.

The supplementation with butyric acid in feed has also resulted in a modification of the microbial bacteria present in the intestine. An increase of lactic bacteria and an improvement of the ratio between lactic and enterobacteria in terrestrial animals have been observed in previous studies. The reason for this is a reduction of undigested feed inside the lumen and a cross-feeding reaction between all bacteria, butyric and other volatile acids. The use of butyric acid as a microbiota stabiliser in aquaculture is starting to draw attention from the scientific community, but the challenge arises with the high variability between aquatic species.

Today, we are sure that fishmeal substitution is critical for a sustainable and productive global aquaculture industry. Functional additives like organic acids and specifically Butirex have a promising future in this novel trend.

**Marta Arredondo** is Aquaculture Global Manager.
Email: marredondo@novation2002.com

**José A. Oroz** is Asia Regional Manager.
Email: jaoroz@novation2002.com

Both authors are with Novation 2002 SL, headquarters in Madrid, Spain.

# The beneficial effects of including L-selenomethionine in fish and shrimp diets on health and performance

Organic selenium has a wide range of effectiveness, including increased coping with stress during the production cycle and enhancing the immunity for fish. Additionally, its use can decrease both environmental selenium load and increase sustainability.

By Matthijs de Jong

In intensive aquaculture production, high growth rates and high feed efficiencies are essential. However, the required high growth performance is more often associated with increased levels of stress. Stress can be from various sources such as high stocking densities, pathogenic pressure, osmotic imbalance, other environmental factors and animal handling. When fish and shrimp experience stress, enhanced levels of reactive oxygen species (ROS) and a suboptimal antioxidant status and immunity are observed. Selenium (Se), an essential trace element, will support the animal during these stressful conditions. For example, it functions as a vital component of selenoenzymes, which play an important role in reducing ROS and maintaining a healthy antioxidant status.

## Selenium contents in aquafeeds under pressure and in need for supplementation

Beneficial effects of Se in aquaculture diets are well-recognised. Nevertheless, due to increased usage of plant-based meals, to replace fishmeal and fish oil, the amount of Se in aquafeeds has been decreasing over the past decades. One of the consequences of these decreased Se levels in the feed is the decreased content of Se in fish, throughout the body and in the fillet (Betancor et al., 2016).

Decreased Se contents in the body are known to be unfavourable for animal health and performance. To counteract this trend, aquafeed producers and fish farmers have the possibility to include organic and inorganic Se sources in their diets. These chemical forms affect the Se bioavailability differently. In general, animals are unable to incorporate dietary inorganic Se sources in body protein, but this is possible for organic Se, in the form of L-selenomethionine (Figure 1). Next to that, it is commonly accepted that organic Se shows greater bioavailability compared to inorganic Se. This combination of high storage capacity and bioavailability is the reason that organic Se sources, in the form of L-selenomethionine (Excential Selenium 4000, Orffa Additives BV) are more functional compared to inorganic Se sources, for example sodium selenite.

Organic Se is involved in numerous biological processes which benefit the antioxidant and immune systems. These systems are negatively affected when Se levels are inadequate, showing the importance of maintaining sufficient Se levels in the diet. Additionally, Se is beneficial for health but decreasing Se concentrations in the fish body is problematic for humans, as fish fillet is one of the major sources of Se in the human diet. Supplementation of Se in the diet is thus a necessity - in order to maintain fish health and to maintain the health benefits of consuming fish and shrimp.

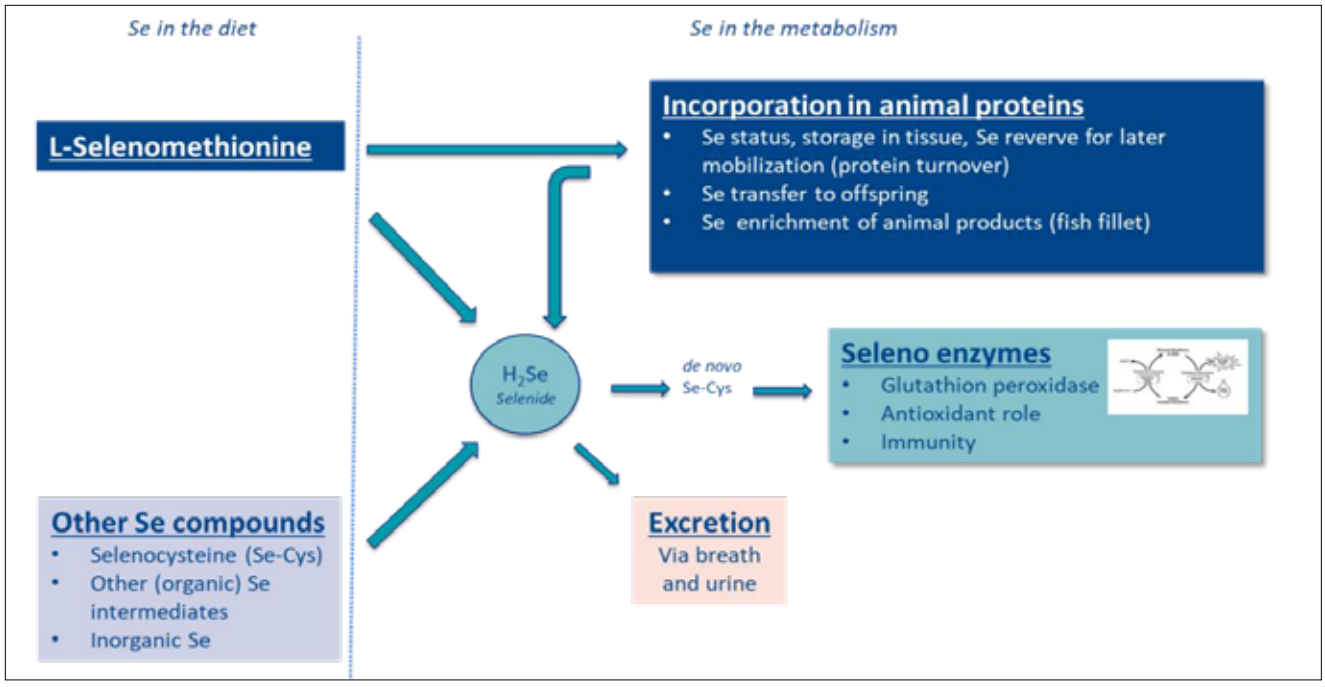


**Figure 1.** Metabolic pathway of L-selenomethionine and all other Se compounds (including inorganic selenium). adapted from Rayman (2004) and Combs (2001).

## Selenium in salmon: Organic vs inorganic

The effect of feeding Se was examined in a trial by Prabhu et al. (2020) with post-smolt Atlantic salmon. During this experiment, different sources of Se (organic; L-selenomethionine Excential Selenium 4000- and inorganic; sodium selenite) and different levels of Se (0.15 to 1.1 mg Se/kg diet) were supplemented and evaluated on growth performance, fish antioxidant status, Se deposition and environmental impact.

It was hypothesised that L-selenomethionine, due to its high storage capacity in body protein, would be able to counteract decreasing Se contents in the fish diet. It was shown that the addition of any Se source increased fish growth performance slightly, but that the largest, numerical, weight gain and lowest, numerical, feed conversion (FCR) were observed in fish fed the diet with 0.4 mg Se addition from L-selenomethionine per kg of diet (Figure 2).

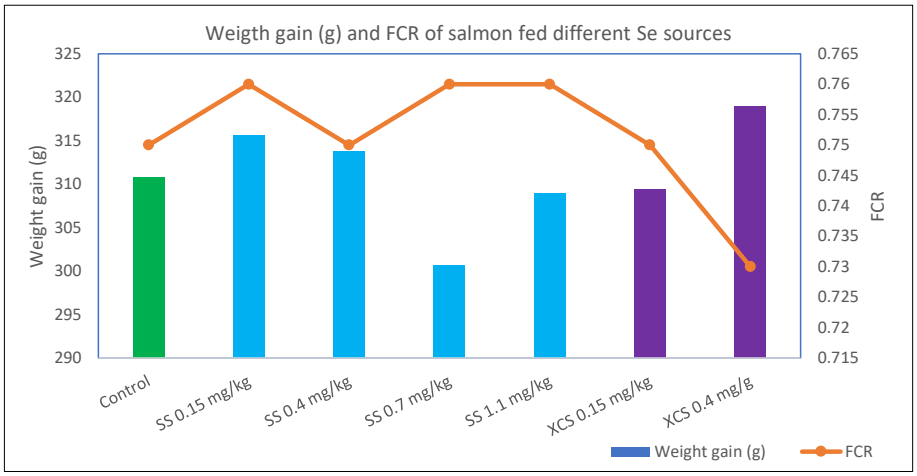


**Figure 2.** Weight gain (g) and feed conversion ratio (FCR) of post-smolt salmon fed different Se sources (SS=sodium selenite; XCS = Excential Selenium 4000), adapted from Prabhu et al. (2020).

Even more promising effects were seen on body Se deposition and immunity. Se concentration in whole body, liver, muscle, plasma, kidney and liver/kidney Se ratio significantly increased with increasing dietary Se compared to the control diet without added Se. Increased Se levels in several parts of the body act as a reserve (Figure 3) and indicate that Se is more available for salmon to cope with the stress periods during the production cycle and when dietary Se in raw materials is low. Another indicator that showed the increased antioxidant status is the level of oxidised glutathione (GSSG). Increased levels of GSSG indicate an increase in cellular oxidative stress in the fish. Similar to the previous observations, Se supplementation, regardless of source, was shown to significantly decrease the GSSG and thus decrease cellular oxidative stress.

However, when comparing different Se sources, it is shown that L-selenomethionine outperforms sodium selenite. The slope ratio shows that L-selenomethionine is more efficient in improving apparent availability, whole body or tissue Se status and Se retention (Figure 3).

These differences in slope ratio result in a lower requirement of L-selenomethionine compared to sodium selenite. In this study, the requirement of Se supplementation was 0.41mg/kg Se from sodium selenite, whilst for Se from L-selenomethionine, the requirement was only 0.17mg/kg. The existing EU limit of Se in salmon diets is 0.5mg Se/kg diet, with a maximum of 0.2mg organic Se/kg supplementation. Therefore, adding organic Se, in the form of L-selenomethionine, instead of inorganic Se sources like sodium selenite is favourable to meet minimal requirements for salmon and at the same time following the existing regulations.

Next to that, Prahbu et al. (2020) showed that inorganic Se is excreted to a higher extent when compared with organic Se. Replacing inorganic with organic Se supplementation therefore results in a decreased environmental Se load and increased sustainability.

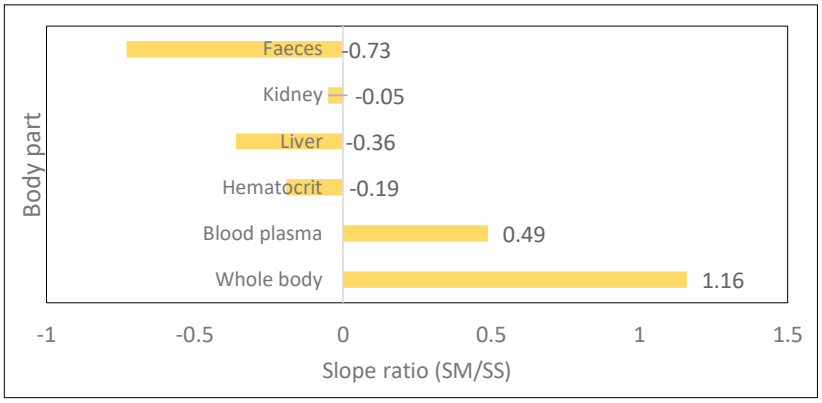


**Figure 3.** Relative differences of selenium concentrations in different parts of the body when L-selenomethionine is fed instead of sodium selenite (Adapted from Prabhu et al., 2020).

## Selenium supplementation in tilapia: More of the same?

Salmon, a highly carnivorous species, is known to have a high Se requirement. However, when looking at species in lower trophic levels similar results regarding Se supplementation were observed as in salmon. A trial was conducted in Thailand with Nile tilapia to see the effect of various Se sources and levels on overall performance, antioxidative status and immunity. The trial, performed by Wangkahart (2022), showed that growth performance was significantly improved when L-selenomethionine (Excential Selenium 4000) was added at 1, 3 and 5mg Se/kg diet, whilst the growth did not improve and even slightly decreased when an inorganic Se source (sodium selenite) was added (Figure 4). An interesting note is that all supplementations are above the 0.5mg Se/kg diet that is allowed in EU regulations. Nevertheless, Prabhu (2020) mentioned that the actual requirement of Se in salmon is closer to 1mg/kg instead of 0.5mg/kg and this trial by Wangkahart underlined this statement: best growth was observed when an organic Se source was added at 1mg/kg inclusion rate. Important to note is that there was only a significant increase in growth observed when this organic Se, L-selenomethionine was added but with inorganic Se, both at higher and lower levels of inclusion no improvement of growth was observed. This again indicates that L-selenomethionine outperforms inorganic Se as a feed additive in aquaculture.

Based on these trials in salmon and Nile tilapia, we can conclude that this organic Se has a wide range of effectiveness. In other words, improvement of fish performance and health can already be achieved at lower inclusion levels but inclusion above the EU limit shows even more improvements.

Increased growth performance upon increasing dietary Se inclusion is linked to improved health of the animal. The tilapia trial showed that fish immunity improved when L-selenomethionine was added. Lysozyme activity, catalase activity, myeloperoxidase, superoxide dismutase and glutathione peroxidase, all indicators of antioxidant status, were improved when L-selenomethionine was added, while these were unaffected when sodium selenite was added. Again, this indicates that organic Se is a better source to feed fish compared to inorganic Se.

## L-selenomethionine, an optimal selenium source in aquafeed

Increased stress accompanied by decreasing Se contents in feed is a serious challenge in the currently expanding aquaculture business. Demand for improved sustainability and increase of fishmeal prices have led to the need for alternative diets, which require supplementation of essential ingredients. Organic Se sources like Excential Selenium 4000 are proven to have higher bioavailability and less polluting effects compared to inorganic Se sources like sodium selenite, which makes it an optimal feed solution.

**Matthijs de Jong** is Central Technical Manager at Orffa, Netherlands.
Email: Jong@orffa.com

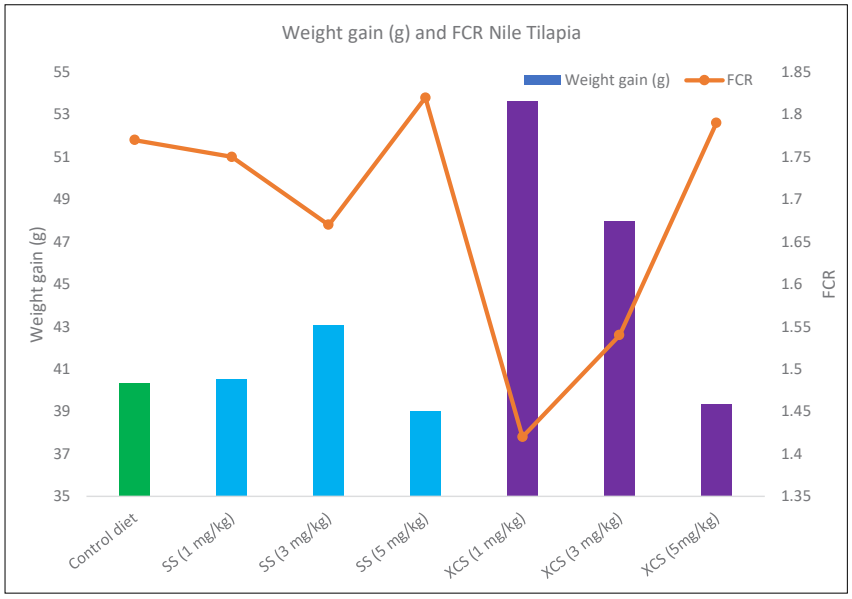


**Figure 4.** Weight gain and feed conversion ratio (FCR) of Nile tilapia fed different sources of selenium (XCS = L-selenomethionine; Excential Selenium 4000 and SS – sodium selenite) for 8 weeks. Adapted from Wangkahart et al. 2022.

# Balancing aquaculture production and consumption

## Part 2: Innovations and applications to manage external factors and support growth

The 26th DSM aquaculture conference Asia Pacific was held on November 23-24, 2021. Part 1 of this report on the conference which covered presentations focusing on ecosystem management and the drive towards sustainability, was published in issue January/February 2022. This second part covers the second day program with presentations on gut health, functional feeds and culture management, precisely to optimise productivity in intensive shrimp farming systems.

In her introduction to this second day program, Dr Daranee Seguin, Manager of Nutrition and Health Solutions, Aquaculture, said, "To progress, we need to be able to innovate, handle the external factors and be able to support growth. These presentations exploring developments in feeds, feeding and farming strategies allow us to dive deeper into what we can do for a profitable business."

### Optimising productivity of intensive shrimp systems

According to **Dr Romi Novriadi**, Lecturer at the Jakarta Technical University of Fisheries, Ministry of Marine Affairs and Fisheries, Indonesia, optimisation of productivity of intensive shrimp systems requires a relook in several areas, including feeds, which comprise 40-60% of production costs, water and pond management, carrying capacity, overall management system as well as biosecurity. Romi is currently the Vice Chairman, Indonesia Aquaculture Society.

### From extensive to super-intensive

"When we look at the evolution of shrimp production systems, we have moved from the relatively low-density extensive culture yielding 500kg to 3 tonnes/ha to the intensive production system, stocking up to 250 PL/$m^2$ and producing 15 to 40 tonnes/ha in smaller 0.2-0.5ha ponds. Now we have super intensive systems with more advanced aeration technology. We stock more than 500 PL/$m^2$ and the productivity can yield more than 50 tonnes/ha while pond sizes are almost similar to an intensive production system."

Optimisation should be closely related to improvements in technology, several of which can be applied in intensive culture systems. "In feed management, it is how we can use sustainable ingredients and functional feeds, and how we can combine them. In water management, the focus is on online data reporting, and in biosecurity, on minimising disease outbreaks. We can be innovative and integrate culture systems with technology."

He added that several interventions are necessary to reach the goal of optimising productivity. "They include stocking density, genetics, water quality, biosecurity and disease prevention, as well as feed management to control the output of nitrogen and phosphorus. While productivity increases, we want to increase not only farmers' incomes but also product quality and value. It is using technology to be efficient and reduce production cost. It is also getting the protocols right."

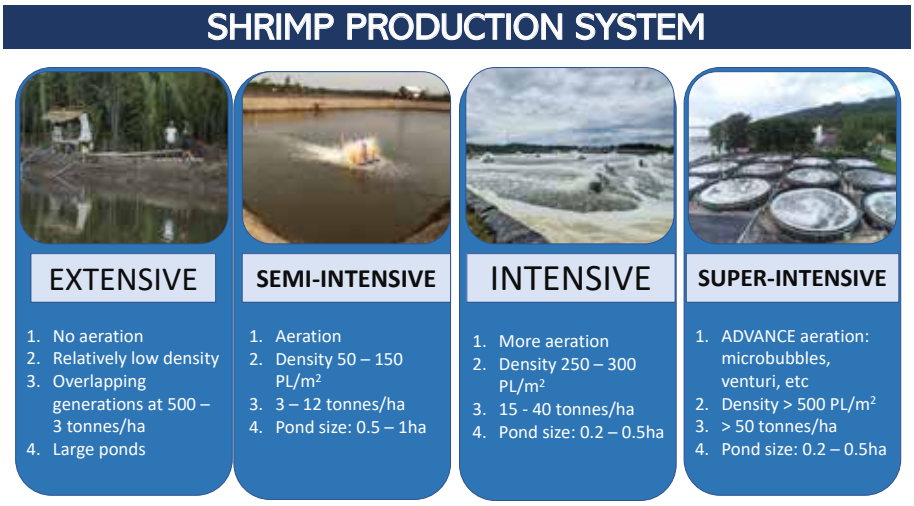


**Figure 1.** Romi Novriadi described the trends in shrimp farming in Asia from extensive to super-intensive systems. These involve increases in stocking density and in aeration changing, paddlewheels to advance systems with microbubbles. Pond sizes decrease from large ponds with multigeneration stocks in extensive systems to 0.2-0.5ha ponds or tanks in intensive or super-intensive culture.

> "In feeds, the reality is that the farmer can be more profitable by managing feed usage rather than the feed mill producing a cheaper formulation."
> - Romi Novriadi

## Managing feed costs

"In feeds, the reality is that the farmer can be more profitable by managing feed usage rather than the feed mill producing a cheaper formulation. Therefore, the focus is on specific nutrient requirements in terms of amino acids and micro ingredients complemented with the proper feed management," said Romi.

Sustainable ingredients can cut costs, such as replacing animal protein meals (especially fish meal) with plant-based protein sources. "Today, with massive research, we can increase the inclusion level of plant protein meals and complement them with additives to supplement and to enhance feed efficiency."

Romi presented an example of research with a local feedmiller to use DDGS as an economical ingredient to replace soybean meal and reduce the feed cost from IDR10,000/kg to IDR9,800/kg. From two trials performed in a private research centre and at the research unit of the feedmiller, there was no significant difference in shrimp growth performance and survival, provided the diet formulation fulfills the specific nutritional requirements for shrimp. However, this must be complemented with a proper feeding system such as sound-based ones.

With regards to disease prevention, there is the use of functional feeds. His latest research is on the use of nucleotides, an immunostimulant, where the recommended dose is 500-1,000mg per tonne of feed. Growth performance improved as well as survival during the challenge test with *Vibrio harveyi* at $10^5$ CFU/mL. A trial using fermented corn with yeast or high protein DDG (HPDDG), to replace fishmeal or soybean meal and corn gluten meal showed improvements in biomass, feed conversion ratio (FCR) and survival compared to the control diets. "The use of fermented yeast can enhance survival when challenged with the AHPND strain of *Vibrio parahaemolyticus*, "said Romi.

## Optimum water quality

According to Romi, "The use of 4.0 technology will make data more visible and data traceability will help in decision-making to optimise productivity. This is maintaining levels of dissolved oxygen in the water at a minimum 4mg/L to more than 6mg/L and keeping to low minimum levels of ammonia in intensive systems. Paddle wheels can be positioned in groups to create a zone of good oxygen concentration (Figure 2)." In wastewater treatment, settling basins with physical, biological, and chemical treatments are used for intensive systems and adding tilapia and milkfish is popular.

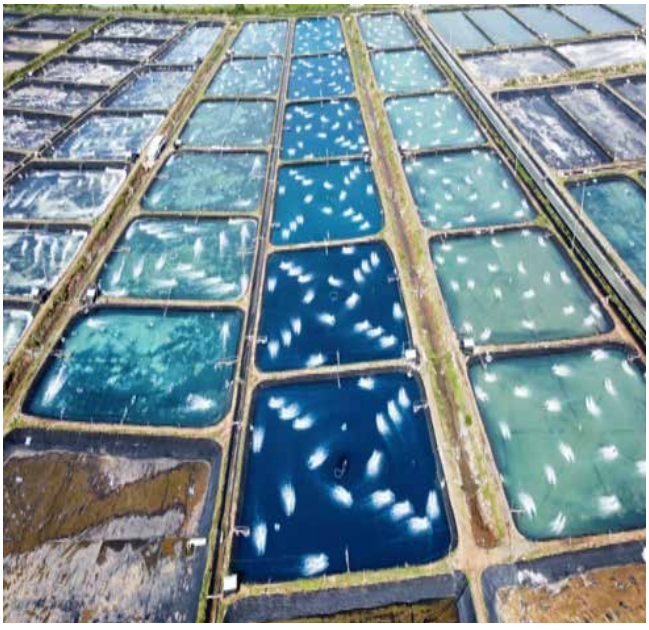

**Figure 2.** Positioning of aerators in groups creates zones where dissolved oxygen is concentrated. The number of paddlewheels (PW) is linked to pond carrying capacity; one PW is used to cover 100-150m² of pond bottom, every 25,000-35,000 post larvae or 400-500kg biomass.

Romi summarised, "If we follow the rules and increase the carrying capacity of the pond, we can increase productivity."

## Millennial farming system in Indonesia

These systems use conventional round tanks with 4.0 data-based culture technology with automatic feeders, IoT water quality monitoring and nanobubble technology. The circular design allows for better water circulation to facilitate removal via a central drain. The production from a 10m diameter pond with 150 PL/m² is 1.3 tonnes, which is equivalent to 41 tonnes/ha.

Romi emphasised, "The use of technology is important to optimise productivity while sustainable ingredients are required to reduce the pressure on the ocean fisheries and for shrimp farming of the future to be considered an economical and environmentally friendly production system. Several active substances can be added into functional feeds to improve shrimp health status. Finally, innovation is very important to enhance the efficiency of intensive production systems."

## Driving innovation through impactful feeding strategy

In his introduction to the above, **Dr Olivier Decamp**, Technical Director Grobest referred to the 2020 GOAL survey which pointed to challenges of disease, aquafeed and production costs. "This is not unique to one country. Diseases are the main issues faced in Asia and Latin America, as shown in Table 1."

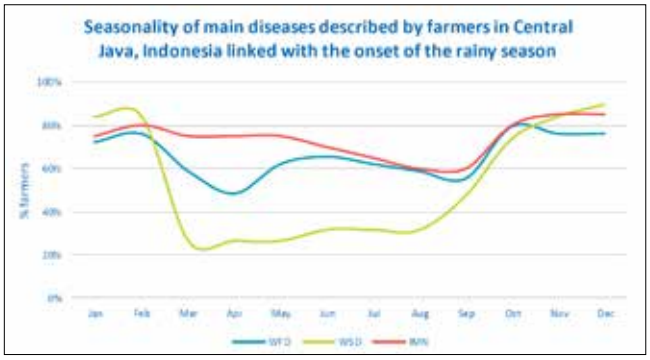


**Figure 3.** The seasonality of main diseases described by farmers in Central Java, Indonesia was linked with the onset of the rainy season. WFD -white faeces disease; WSD-white spot disease and IMN- infectious myonecrosis virus. (Source: Decamp, 2021)

> "It is not a no hope situation. There are ways to help the shrimp get back faster to its healthy status. To reverse the situation, you can look at the value of functional feeds and additives."
> - Olivier Decamp

"These situations require season-specific adaptations," said Decamp as he explained how temperature and salinity can impact the virulence of *Vibrio* associated with early mortality syndrome/acute hepatopancreatic necrosis disease (EMS/AHPND). "There is an impact on the expression of genes associated with the production of EMS toxin and of course, associated mortality. Lopez-Cervantes et al. (2021) concluded that the toxin production is highest for strains of *Vibrio* at 28°C versus 30°C or 33°C."

| Indonesia | India | Ecuador | Thailand | Vietnam | China |
|---|---|---|---|---|---|
| Diseases WSSV, EHP, WFD & IMNV | Diseases EMS/AHPND, RMS & WSSV | Limited oxygen in ponds | Diseases EMS/ AHPND, EHP, WFD & WSSV | Seed stock, quality and availability | Diseases WSSV & EMS/ AHPND |
| Pond environmental control | Seed stock, quality, and availability | Cost of new pumps & cost of pumping | Cost of production | Access to capital | Pond environmental control |
| Infrastructure restrictions | Cost of production | Diseases WSSV | Farm gate prices | Diseases EMS/ AHPND & WSSV | Seed stock, quality, and availability |

**Table 1.** Diseases and other issues faced in Asia and Latin America according to a survey conducted by Grobest, HATCH and Fresh Studios in 2020. WSSV -white spot syndrome virus, EHP- *Enterocytozoon hepatopenaei*, WFD -white faeces disease, IMNV- infectious myonecrosis virus, EMS/AHPND -early mortality syndrome/acute hepatopancreatic necrosis disease, RMS- running mortality syndrome.

While recirculation systems have better biosecurity, salinity will affect the composition of the *Vibrio* community (Bauer et al., 2020). "When shrimp are reared in RAS at 15ppt, there was a higher number of potential pathogens; *Vibrio parahaemolyticus*, *V. owensii* and *V. campbellii*. But at 30ppt, these species of *Vibrio were virtually absent.*"

Recent information connects low temperature and the hepatopancreas status. "We know that temperature is a major factor affecting shrimp metabolism. A study by Wang et al. (2019) showed how the number and volume of B-cells that are responsible for the absorption and digestion of nutrients in the hepatopancreas tubules significantly increase after cold stress. Research showed how the environment has an impact on shrimp growth. But while the hepatopancreas was affected by environment and temperature, it also has high self-repairing ability, and can recover from the temperature-induced damages."

Decamp added, "It is not a no hope situation. There are ways to help the shrimp get back faster to its healthy status. To reverse the situation, you can look at the value of functional feeds and additives."

## Impactful feeding strategy

The expertise of feed producer, Grobest, founded in 1974, is in the development and production of functional additives in Taiwan; these are then included in its feeds. There are four unique additives with benefits - from attractability, immunostimulation, hepatopancreatic to gut health. "They can be combined to produce feed with benefits for daily healthcare, immune enhancement or growth enhancement. They are designed to give the best value to the farmers based on the conditions they are facing at the time. For example, in Indonesia, we showed that functional feeds increased the percentage of good lipid droplets in the hepatopancreas as compared to a standard feed. This leads to improved productivity, from more than 20 tonnes/ha to more than 25 tonnes/ha."

Decamp said that to help farmers, the team in Thailand has ranked the health status of shrimp in three groups, considering the growth rate, the health status and the water quality parameters. "Following this, they will recommend the right functional feed according to the challenges faced by the farmer. Working closely with the farmers, they then document the direct impact of the feed on the health status of the shrimp. This approach led to an improved pond performance in Thai farms: FCR (which improved from 1.26 to 1.20 after 7 days) and, most important to farmers, profitability (which improved from THB73/kg to THB88/kg (Figure 4)."

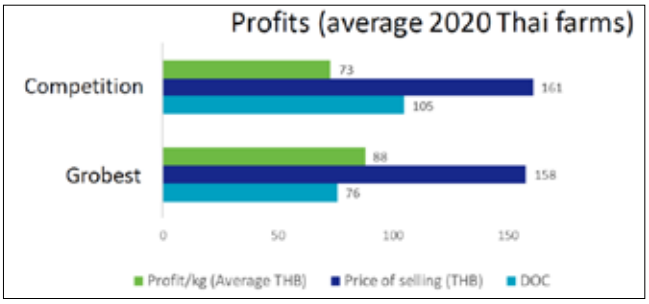


**Figure 4.** Results on average profits and other benefits with the use of a recommended functional feed (Grobest) versus a standard commercial feed in Thailand in 2020.

## Nursery step

In Vietnam, where the nursery system already has good biosecurity, water quality control and post larvae screening, functional feed was added into the rearing protocol to get the extra value with better growth. In a nursery stocking 2,000 PL10/m$^3$ for 20 days, growth improved by up to 17.5% and FCR by 20%.

## Top dressing at farm level

Top dressing in farms negatively impact the stability of the feed when feeds are manually coated with additives. "When the stability of the feed is affected, leaching is obvious, compared to a functional feed (manufactured at the feedmill). When we asked farmers what is important for them, their response with regards to feed performance and quality is the impact on shrimp growth rate, size and size variability, and survival. Concerning physical characteristics, they mentioned feed water stability."

In summary, the benefits of functional additives are: attractability and palatability which are the key consequences to better and faster feed intake. A good feed stability gives reduced leaching. Less waste means less toxic compounds in the soil, less stress on the animals and a lower probability of fast-growing *Vibrio* taking over the microbial community.

"Finally, if you incorporate additives that are known to improve health status of the shrimp you will basically have stronger animals able to cope with challenging conditions. Adding all these together, we have a better crop with a higher profitability."

Decamp concluded, "The challenges faced are not the same in every country and not for every month of the year. Once we understand and identify these issues, we can recommend the right cost-effective solutions."

## More than a (gut) feeling

**Dr Benedict Standen,** Global Marketing Aquaculture at DSM, said that in aquaculture, we often think of gut health as a new focus but the discussion on gut health first took place a few centuries ago. Aptly with the quote, "Your gut is not Las Vegas. What happens in the gut does not stay in the gut" by Alessio Fasano in 1956, Standen further reiterated the importance of gut health to total human health.
There are three functional aspects to gut health:

- Improving the efficiency of the gut where it maintains permeability for nutrient utilisation and nutrient uptake. A gut barrier prevents the entrance of other substances, toxins and pathogens which means that it is important to maintain these tight junctions and ensure a healthy abundance of microvilli.
- Prevention of disease where the main mucosal surfaces separate the outside world from the inside world. It is a very important or potential portal of entry for several different pathogens. In aquaculture, aquatic animals ingest water, so pathogens from the environment will end up in the gut of the animal and consequently, cause problems or challenges down the production cycle.
- Establish and maintain gut integrity especially after a dysfunction. The gut microbiota is very dynamic and in aquaculture, there may be dramatic shifts in gut microbiota such as following the application of antibiotics. The gut needs to be populated with good bacteria probiotics after such events.

## Eubiosis and dysbiosis

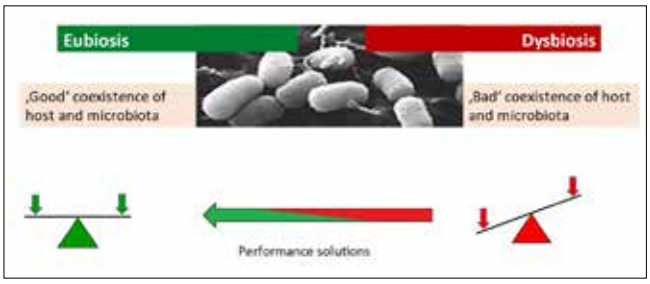


**Figure 5.** The states of gut microbiota. A good balance or a good coexistence of the host and the microbiota in eubiosis and an imbalance with a bad coexistence between the host and the microbiota in dysbiosis.

"Why do we care about gut microbiota? It is well known that if we do not look after our microbiota, then we can end up in a dysbiosis state - an imbalance with a bad coexistence between the host and the microbiota (Figure 5). This leads to negative side effects with poor epithelia, and incorrect uptake and utilisation of nutrients leading to a poor immune system. Following apoptosis, cell replacement takes up energy.

"Therefore, we need to shift towards eubiosis, where there is a good balance or a good coexistence of the host and the microbiota. This is important for optimum nutrition, digestion, functionality of the immune system, barrier functions and direct pathogen antagonism. Aside from this nutritional impact on immunity and disease, it is important to know that for aquatic animals, gut microbiota influence osmoregulation and homeostasis," said Standen.

## Factors effecting gut health

According to Butt et al. (2019, Table 2), there are two distinct factors, intrinsic and extrinsic. "Intrinsic factors relate to the animal itself, which we cannot fully control. Extrinsic factors relate to the production system where we may have more control. It may be difficult to control the environment, but we can influence water and sediment quality with remediation tools."

Standen said, "Feeds and feeding impact gut health in terms of the formulations, ingredients and feeding management. In recent years, research is being done on functional feeds and their positive impact on gut health and ultimately health of the animal."

| Intrinsic Factors | Extrinsic factors |
|---|---|
| Host species/ strain | Environment (temperature, light, salinity etc.) |
| Genetic background | Water & sediment |
| Gender/reproductive stage | Geography |
| Age/ developmental stage | Stocking density & production system |
| Stress/ disease/immune system | Feed & feeding |
| Nutritional status/starvation | |

**Table 2.** Intrinsic and extrinsic factors affecting gut health according to Butt et al. (2019).

## Gut health in the tilapia

Tilapia fed a functional feed with a gut modulator was able to alter the gut microbiota. There was better barrier function and better physiology of the gut with longer and more villi and microvilli.

"There were effects on the immune system. A higher expression of pro-inflammatory and anti- inflammatory cytokines indicated that the immune system in the fish had been elevated to a superior level but was still in balance," said Standen.

| Parameter | Control | Gut health modulator |
|---|---|---|
| **Growth Performance** | | |
| Final weight (g) | 184.5 | 217.0 |
| Survival (%) | 88.0 | 86.6 |
| Biomass (kg) | 39,293 | 45,423 |
| FCR | 1.57 | 1.41 |
| **Economic Performance** | | |
| Revenue (USD) | 54,997 | 63,626 |
| Total feed cost (USD) | 28,217 | 29,979 |
| Revenue – feed cost (USD) | 26,780 | 33,647 |
| Net income (USD) | | 6,867 |
| Net income (USD cents/ fish) | | 3.3 |
| ROI | | 10.8 |
| Breakeven (g/fish) | | 2.2 |

**Table 3.** Gut health in the tilapia: Results from trials in Latin America using a gut modulator in treatment diets (Source: Standen, 2019/2020).

Field trials conducted in Latin America showed better final weights and biomass as fish grew larger (Table 3). Although survival was similar to fish fed commercial diets, a reduction in the feed conversion ratio (FCR) for fish fed the functional feed showed that the latter improved gut efficiency. "This actually means that we can improve profitability with a higher return on investment of 10.8 and a low breakeven point of 2.2."

The key take home message was, "If we look after the gut health of our animals, we can improve profitability. Functional feeds can contribute to the sustainability of the aquaculture sector: environmental sustainability through improved feed efficiency and less waste discharged into the environment, and economic sustainability."

# 2022 Alltech Agri-Food Outlook

World feed production increased by 2.3% to 1.24 billion tonnes and aquafeed production saw continued growth of 3.7%


Despite a year of challenges, feed production grew 2.3% in 2021 with an estimated 1.24 billion tonnes, up from 1.21 billion tonnes in 2020. The 2022 Alltech Agri-Food Outlook from the annual global feed production survey data was released in January 2022.

The global pandemic has had major impacts on the agri-food sector, contributing to supply chain challenges and accelerating the adoption of new technology and environmental sustainability practices. "The results within our 2022 Alltech Agri-Food Outlook reinforce our confidence and optimism about the future of the agri-food sector," said Dr Mark Lyons, President and CEO of Alltech. "We see the resilience of the agri-food sector against the challenges of COVID-19, such as disease and supply chain disruption, and even more importantly, there is evidence of growth, modernisation and the adoption of more sustainable practices occurring in parallel."

## Key observations from the survey

China remains the largest feed producing country and reported the largest growth since 2020. In China, feed production by tonnage increased by 8.9% to 261.42 million tonnes. A key trend resulting in this growth was the continuation of the consolidation and modernisation of the country's feed industry. Swine farms and feed production have moved from utilising food waste to contracting with professional feed mills. As a result, commercial feed tonnage increased, driven particularly by the growth and continued modernisation of the pig sector.

The pig sector has rebounded from African swine fever (ASF), with a 6% increase in feed tonnage. Aquafeed production continues to grow steadily worldwide, with a global increase of 3.7%. The pet sector experienced the largest growth with an impressive 8.2% increase in feed production.

Feed production met local expectations in about half of the countries surveyed while falling short of expectations in about 25% of other countries due to continued restaurant closures, high raw material prices and/or ASF. The remaining 25% of countries exceeded expectations, mainly due to the recovery from COVID-19 lockdowns, including increased exports to re-opening restaurants.

Over the past year, there has been a strong focus on the environment, as governments worldwide have made renewed commitments to reduce greenhouse gas emissions. In Europe and Asia, government policies have been the main drivers in most markets. Whereas in the Americas, the main drivers have been consumers and the private industry. Some markets focus on reducing greenhouse gas (GHG) while others focus on the expected nitrogen regulations.

## Global feed production

Feed production by the top ten producing countries reached 799.1 million tonnes and represented 65% of global production. Feed production in these countries increased 4.4% compared to the overall 2.3% global growth. In terms of species, the annual survey showed the following:

### *Regional feed production*

| Sector | 2020 (million tonnes) | 2021 (million tonnes) | Growth (million tonnes) | Growth % |
|---|---|---|---|---|
| Broiler | 343.098 | 350.921 | 7.823 | 2.3% |
| Pig | 290.904 | 310.214 | 19.310 | 6.6% |
| Layer | 161.073 | 158.789 | (2.285) | -1.4% |
| Dairy | 130.433 | 132.946 | 2.513 | 1.9% |
| Beef | 117.758 | 115.486 | (2.271) | -1.9% |
| Aquaculture | 49.530 | 51.355 | 1.826 | 3.7% |
| Pet | 31.587 | 34.165 | 2.578 | 8.2% |

**Table 1.** Feed production estimations in million tonnes by sector and region

North America saw a steady growth of 1.9% over 2020 and the US remained the second largest feed producing country globally after China. Latin America experienced moderate growth of 0.5%, while Brazil remained the leader in feed production for the region and ranked third overall globally.

Europe saw a decrease of 1.2% in its feed production due to issues such as ASF and high raw material costs, combined with low end product prices, declines in ruminant feed production and COVID-19-related government regulations.

Asia Pacific saw the most significant regional growth of 5.7% and is home to several of the top 10 feed producing countries, including China, India and Japan.

Africa saw a growth of 2.4% despite the challenges caused by high raw material prices, foot and mouth disease and geopolitical tensions that have impacted food exports of animal origin and caused raw material shortages in some areas.

### *By species*

The poultry sector experienced a slight reduction of 1.4% in layer feed tonnage whereas broiler feed production increased by 2.3%. The layer business has been facing challenges in many countries due to the high costs of raw materials, combined with flat/low retail prices for eggs. Animal welfare concerns are also a driver as cage-free and free-range production are on the rise in many countries. Factors that have aided the broiler sector include increased demand for easy-to-cook proteins as restaurants closed during the pandemic and an affordable protein option, as the prices of other meat proteins increased.


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| | Total aquafeed in million tonnes | | | |
|---|---|---|---|---|
| Region | 2020 | 2021 | Change | Growth % |
| Africa | 1.492 | 1.496 | 0.005 | 0.3% |
| Asia Pacific | 36.437 | 37.639 | 1.202 | 3.3% |
| Europe | 4.322 | 4.485 | 0.163 | 3.8% |
| Latin America | 4.889 | 5.327 | 0.438 | 8.9% |
| Middle East | 0.500 | 0.500 | - | 0.0% |
| North America | 1.710 | 1.730 | 0.020 | 1.2% |
| Oceania | 0.180 | 0.190 | 0.010 | 5.6% |
| Grand Total | 49.530 | 51.367 | 1.837 | 3.7% |

**Table 2.** Total aquafeed production by regions in 2021 compared with production in 2020.

Pig feed production increased significantly by 6.6%, primarily boosted by the Asia Pacific's recovery from ASF. Japan, South Korea, Malaysia and China demonstrated just such a recovery from ASF. However, Indonesia, Myanmar, the Philippines, Thailand and Vietnam continued to feel the impact of the disease. In European countries where ASF is not or no longer a problem, they were still impacted by a pork surplus due to reduced demand from China.

Dairy feed tonnage increased slightly by 1.9%. Asia Pacific saw the biggest increase which is mainly attributed to growth in India. As COVID-19 lockdowns eased around the world, the reopening of the hospitality industry and in-person classroom education helped boost milk consumption overall. In Australia and New Zealand, dairy feed tonnages were down 6.7% and 2.5%, respectively.

Beef feed production shrunk by 1.9% globally. The industry continues to be challenged by GHG regulations and perceptions of environmental and health impacts. European markets are primarily focused on reducing GHG emissions to align with COP26, the EU Green Deal and the FEFAC Feed Sustainability Charter 2030. Argentina saw a significant reduction due to reduced exports. High inflation and the devaluation of the local currency also affected Argentinians' purchasing power. However, export regulations are easing and could impact Argentina's outlook for 2022.

Pet feed production had the highest increase among the sectors with an 8.2% rise in production. This significant increase is largely due to the rise in pet ownership amid the COVID-19 pandemic. While some regions remained flat, there were no reported decreases in any region around the world

## Global aquafeed production

The aquaculture industry continued to grow in many markets, and global aquafeed production rose to 51.35 million tonnes from 49.3 million tonnes in 2020.

Asia Pacific's contribution was 37.64 million tonnes, which was 73% of global volumes. However, Asia Pacific's aquafeed production was a marginal 3.3% increase over that in 2020, which in turn was 3% higher than the 2019 production of 35.47 million tonnes. Recirculating aquaculture systems (RAS) are becoming more prevalent and consumer demand for fish is on the rise. Markets with ASF challenges saw additional growth due to their reduced pork supply.

While the Asia Pacific region led in terms of volumes, Latin America had the highest growth at 8.9%, whereas Chile, Brazil, Honduras and Ecuador contributed 5.6%. Latin American aquafeed production was 5.37 million tonnes versus 4.89 million tonnes in 2020. Production by region is presented in Table 2. The report said that sustainability is a key factor in the success of the aquafeed sector. Oceania, led by Australia, continued to increase production and in 2021, volumes were 5.6% more than in 2020 and 11% more than in 2019.

| Country | Tonnes in 2021 | Tonnes in 2020* |
|---|---|---|
| China | 21,703,000 | 22,280,000 |
| Vietnam | 6,012,000 | 4,274,000 |
| India | 2,344,000 | 2,147,000 |
| Indonesia | 1,877,000 | 1,706,000 |
| Philippines | 1,551,000 | 1,551,000 |
| Thailand | 1,211,000 | 1,037,000 |
| Bangladesh | 1,036,000 | 1,546,000 |
| Taiwan | 434,000 | 445,000 |
| Japan | 525,000 | 500,000 |
| Myanmar | 371,000 | 400,000 |
| Korea | 140,000 | 150,000 |
| Malaysia | 78,000 | 128,000 |
| Sri Lanka | 25,000 | 20,000 |
| Pakistan | 20,000 | 20,000 |
| Cambodia | 10,400 | 10,300 |
| Laos | 6,000 | 6,000 |
| Nepal | 22,000 | 10,000 |

**Table 3.** 2021 Aquafeed production in Asia Pacific compared with production in 2020. Source: 2022 Alltech Agri-Food Outlook. January 2022 and Alltech Global Feed Survey 2021. (*Aqua Culture Asia Pacific. May/June 2021. p37-38).

### *Asia Pacific aquafeed production*

China, Asia Pacific's largest aquafeed producer, decreased production to 21.7 million tonnes from 22.3 million tonnes. In contrast, India's production increased to 2.3 million tonnes from 2.1 million tonnes in 2020. This is a significant increase in its aquaculture feed tonnage of 9%. Additionally, Indonesia accounted for 10% of Asia Pacific's growth. Indonesian production rose to 1.88 million tonnes from 1.71 million tonnes in 2020.

Aquafeed production in Bangladesh, Thailand, Myanmar, Taiwan and South Korea showed declines while production in the Philippines remained unchanged. A drop of 39% for Malaysia and, in contrast, a massive 40% increase in aquafeed production in Vietnam was reported. Sri Lanka produced 25,000 tonnes of aquafeeds in 2021, up from 20,000 tonnes in 2020 and only 19,000 tonnes in 2019.

Annually, Alltech works together with feed mills and industry and government entities worldwide to compile data and insights to provide an assessment of feed production each year. Compound feed production and prices were collected by Alltech's global sales team and in partnership with local feed associations in the last quarter of 2021. These figures are estimates and intended to serve as an information resource for industry stakeholders.

*The 2022 Alltech Agri-Food Outlook survey results including species-specific feed production numbers and an interactive global map is available at alltech.com/agri-food-outlook.*

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# New insights on mycotoxins occurrences in 2021 and their impact

## Risks of mycotoxins in 2021 remain unabated; in most cases they have increased, says the World Mycotoxin Report Impact 2022

DSM Animal Nutrition & Health and Romer Labs hosted an exclusive webinar on February 17, 2022, featuring an in-depth discussion on the upcoming mycotoxin threats to the livestock and aquaculture production.

The annual DSM Mycotoxin Survey (formerly the BIOMIN® Mycotoxin Survey) constitutes the longest running and most comprehensive data set of fungal metabolite occurrence in animal feed ingredients. The survey results provide insights on the incidence of the six major mycotoxins in agriculture commodities including corn (maize), wheat, soy, barley, rye, oats, rice, sorghum, millet and their by-products that are used to feed farm animals, notably poultry, swine, ruminants and aquaculture.

Mycotoxins produced by fungi contaminate a wide variety of feed ingredients and have costly negative consequences, affecting health, performance and welfare of farm animals. The survey unveiled mycotoxin results of over 112,000 analyses conducted on more than 24,000 samples of animal feed ingredients and complete feeds, collected from 75 countries in 2021. The webinar also detailed the high importance of sampling to receive accurate testing results and the latest in rapid testing solutions for mycotoxins, threats from their co-occurrences, emerging and masked mycotoxins in feed ingredients across the globe and the dangers posed by their presence.

**Dr Anneliese Mueller,** Product Manager Mycotoxin Risk Management, DSM Animal Nutrition and Health said, "Mycotoxins compromise animal health and gut integrity, increasing the probability of lower health status, poor performance and inefficient use of resources. Having a clear and accurate view of feed contaminants enables the industry to take appropriate counter measures and improve profitability, animal health, welfare and sustainability.

> "Having a clear and accurate view of feed contaminants enables the industry to take appropriate counter measures."
> - Anneliese Mueller

"Risk levels conveyed in the findings indicate the likelihood that farmers confront mycotoxin contamination in the feed. Looking at the latest results, it would be wise for producers everywhere to vigilantly monitor raw commodities and feeds for mycotoxin contamination, and to adopt a robust mycotoxin risk management program."

## Regional trends on mycotoxin-related threats

Overall, mycotoxin-related threats in 2021 to animal protein production remained high compared to 2020. Globally, the average risk level was 61%, which is considered as severe risk. Nearly two-thirds of samples had at least one mycotoxin above recommended levels. On a regional basis, calculated risk levels ranged from a moderate to high 44% in all of Europe to a high of 79% in Asia. More than 64% of samples were contaminated with more than one mycotoxin making the global level of co-contamination high, with incremental effect on animal health from the possible synergistic effect of multiple mycotoxins. The main regional trends are:


**Figure 1.** DSM Mycotoxin Survey gives an overview for mycotoxin prevalence in 2021. In the boxes, the prevalence of the six major mycotoxins by region is shown. Colours signify the overall risks for all of the samples in the regions. For example, yellow means that the risk is moderate, orange is high risk and reaching extreme risk in red. (Note: Afla=aflatoxin; ZEN= zearalenone; DON= deoxynivalenol; T2= trichothecenes; FUM= fumonisins; OTA= Ochratoxin A).

North American corn (maize) has slightly increased concentrations of deoxynivalenol and fumonisins compared to 2020 while showing the same high prevalence as in 2020.

Deoxynivalenol levels are the main potential threat in the European cereal harvest. Western and Southern Europe are the most affected areas in Europe. The prevalence of T-2 toxin increased in Northern Europe as did the prevalence of aflatoxins i n Southern Europe.

Asia Pacific faces a heightened risk of mycotoxins overall and aflatoxins remain a problem in this region. An increase in the abundance of ochratoxin A and T-2 toxin was observed.

In Latin America, fumonisins are still the most prevalent mycotoxins in corn. While there was a slight decrease in concentration levels of fumonisins in South American corn, deoxynivalenol levels increased.

In the Middle East and North Africa, *Fusarium* mycotoxins are highly prevalent. Deoxynivalenol is a main concern in Sub-Saharan Africa.

Mueller added, "We define the risk level for the difference species based on worldwide practical experience, feed trials, scientific publications and regulations. If mycotoxins concentrations reach the threshold levels, there can already be negative effects on the health of animals. We use the number of samples exceeding the threshold levels. If more than 25% of samples with a particular mycotoxin is over the threshold risk level, we will indicate the risk as yellow. If it is more than 75% of the samples, it is extreme risk in red.

"As indicated in the map, China, Taiwan and South Asian countries are at extreme risk of mycotoxins. For East and Southeast Asia, the risk is severe while in Australia, the risk is moderate as in 2020."

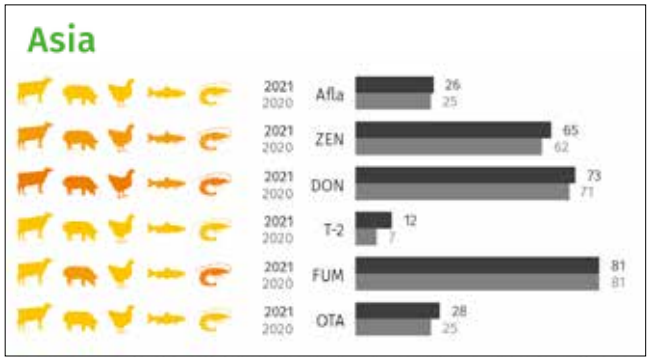



**Figure 2.** Survey findings on mycotoxin prevalence in Asia and risk level according to species in 2021. Animal colours indicate the risk posed to this species by the prevalence and concentration of each mycotoxin in all samples from this region (yellow=moderate to red=extreme; see colour code in figure 1). % Contaminated samples, January–December 2021, January–December 2020.

## Asia Pacific

**Dr Bettina Behler-Wöchtl**, Global Product Manager Mycotoxin Risk Management at DSM ANH, said that for the Asia Pacific region, livestock is under extreme risk of exposure to various mycotoxins. "This was also true in 2020. Risk stayed extreme in China and Taiwan as well as South Asia and remains severe in East and Southeast Asia. Risk in Oceania was moderate, similar as in 2020. Prevalence of all major mycotoxins-aflatoxins, zearalenone, deoxynivalenol, trichothecenes, fumonisins and ochratoxin A, was higher than in 2020, except for the prevalence of fumonisins which was constantly high at 81%.

"Fumonisins were the most prevalent mycotoxins in 2021 in Asia pulled by deoxynivalenol and zearalenone, posing a risk for sensitive species. In all samples, aflatoxin remained high at an average of 47ppb. In corn, prevalence of fumonisins was high at 91% and deoxynivalenol at 83% of corn samples."

| | Total samples: 4, 382 | Afla | ZEN | DON | T-2 | FUM | OTA |
|---|---|---|---|---|---|---|---|
| Total Samples | Number of samples tested | 4,380 | 4,222 | 4,327 | 4,159 | 4,180 | 4,070 |
| | % Contaminated samples | 26% | 65% | 73% | 12% | 81% | 28% |
| | Average of positive (ppb) | 47 | 249 | 942 | 33 | 1,546 | 8 |
| | Median of positive (ppb) | 6 | 70 | 570 | 22 | 548 | 5 |
| | Maximum (ppb) | 1,560 | 28,066 | 56,818 | 1,619 | 17,1491 | 347 |
| Corn | Number of samples tested | 1,069 | 1,068 | 1,069 | 1,066 | 1,069 | 947 |
| | % Contaminated samples | 24% | 73% | 83% | 21% | 91% | 62% |
| | Average of positive (ppb) | 78 | 251 | 1178 | 20 | 3,113 | 6 |
| | Median of positive (ppb) | 23 | 95 | 860 | 16 | 1,395 | 5 |
| | Maximum (ppb) | 1,560 | 13,932 | 14,890 | 96 | 171,491 | 141 |
| Cereals* | Number of samples tested | 388 | 340 | 388 | 340 | 358 | 351 |
| | % Contaminated samples | 9% | 46% | 58% | 34% | 38% | 26% |
| | Average of positive (ppb) | 30 | 175 | 1,099 | 43 | 269 | 8 |
| | Median of positive (ppb) | 5 | 38 | 594 | 34 | 77 | 5 |
| | Maximum (ppb) | 456 | 14,049 | 19,870 | 130 | 8,486 | 82 |

* Cereals include wheat, barley, rye, oats, rice, sorghum, millet.

**Table 1.** Details on the prevalence of mycotoxins in Asian countries in 2021.

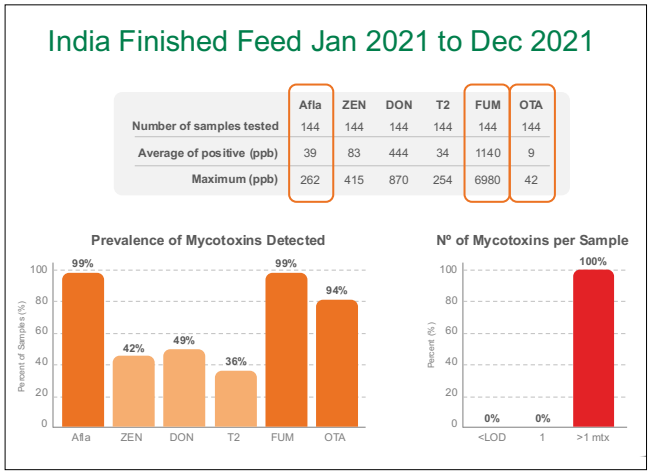



**Figure 3.** The number of samples tested positive samples (%) and maximum concentration (ppb) for finished feed in India in 2021.

## Highlights on threats in Asia Pacific

Figure 3 gives the number of samples tested, the percentage of positive samples and maximum concentration (ppb) for finished feeds in India. Of special concern, is the fact that 100% of samples were contaminated with at least two mycotoxins. The risk for health and performance can potentially increase because of additives and synergistic effects of the mycotoxins.

In Indian finished feeds, nearly all samples were contaminated with aflatoxins, where the average contamination in all positive samples was 39ppb. This clearly exceeds DSM's risk threshold as well as regulatory limits, for example in the European Union. Fumonisins and ochratoxin-A were also very prevalent. In China, corn and corn derived commodities strongly contributed to the mycotoxin burden. There was a high prevalence of zearalenone, deoxynivalenol, fumonisins and ochratoxin A. Aflatoxin was less prevalent, but average of positive samples was very high with 80ppb and the maximum concentration was 1068ppb. Values were also extremely high for zearalenone, deoxynivalenol and fumonisins.

> "Corn derived commodities, contribute very much to the overall risk of mycotoxin exposure in Asia"
> - Bettina Behler-Wöchtl

"These findings are also somehow reflected in the finished feed in China. Average levels of contamination are potentially harmful, and the maximum levels are extremely high with 206ppb for aflatoxin, 7,205ppb for zearalenone and almost 6000ppb for deoxynivalenol and nearly 13,000ppb for fumonisins," said Behler-Wochtl.

"In Southeast Asia, the risk is not extreme but still significant. In Indonesian corn kernels the prevalence of aflatoxins and fumonisins are very high, with extremely high average aflatoxin levels. Zearalenone and deoxynivalenol are less prevalent, but the levels in individual samples are potentially harmful. In Thailand, fumonisins are the biggest issue in corn where the prevalence is 100% and the maximum levels found nearly 12,000ppb."

Summing up, Behler-Wöchtl said, "Corn derived commodities, contribute very much to the overall risk of mycotoxin exposure in Asia. This is not only true for commodities harvested in 2021 but for the last decade. There are constantly high percentages of contamination for *Fusarium* mycotoxins, deoxynivalenol, fumonisins and zearalenone whereas there has been a bit more fluctuation in aflatoxins over the year."

The focus in this online seminar was on corn and derived commodities because of the very high risk and with the frequency of use. The prevalence of ochratoxin and trichothecenes are increasing compared to the years 2012-2021 (Figure 4). Trichothecene T2 is a highly toxic mycotoxin. "Of course, we need to monitor this trend," said Mueller.

Another important commodity is soy. Zearalenone can be found in more than half Asian soybean samples and this of course also contributes to the overall toxin burden. Aflatoxins levels are also very high in soybean.

## Sampling and analytical methods

Mycotoxins are hard to sample since ppb (µg/kg) is such a small amount and difficult to detect, said **Dr Nora Kogelnik,** Product Manager at Romer Labs, who emphasised on the importance of getting good results from good sampling procedures. She said that deviations in results can come from sampling, preparation and analysis. Contaminated grain kernels are not distributed homogenously in a lot and toxins are grouped together in "hot spots" and the sample taken must take this into account.

"The EU has guidelines regarding sampling to promote good sampling practice and thus reduce buyers and seller's risks," added Kogelnik. "Particle size also affects test results. A study showed that coefficient of variation is very low for a sample of 10g where 97% passed through 20 mesh screens."

The Spectrum top 50+ method was developed by Romer Labs and introduced to the market in 2018. In that year, analyses were for around 500 samples. In 2021, over 3,400 samples worldwide were analysed. "So, we have a good dataset on occurrences of different mycotoxins and their metabolites," said Mueller. "This is a multi-mycotoxin analysis method measuring over 50 main mycotoxins, emerging and masked mycotoxins in one run. It takes ten working days for the results. This is longer than conventional tests, but this method has other advantages. The analysis for single mycotoxins can underestimate the synergistic detrimental effects of mycotoxins on animal health and performance."

The long-term monitoring of mycotoxins in different commodities shows the co-occurrence is the rule and not the exception. This method is very sensitive to detect moderate concentrations of mycotoxins and analysis of finished feed is possible. The main mycotoxins detected are aflatoxins, zearalenone metabolites, trichothecenes A and B, fumonisins, ochratoxins and ergot alkaloids. Emerging mycotoxins and other secondary metabolites are also detected such as *Fusarium* metabolites and penicillin toxins.

*Nora Kogelnik emphasised on the importance of getting good results from good sampling procedures.*

## Emerging and masked mycotoxins

Mueller discussed the threats of emerging mycotoxins and how they pose threats to food security globally. These are frequently found on agricultural commodities. Some scientific studies already suggested toxic effects and the European Food Safety Authority has started to publish reports on some of the emerging mycotoxins. Masked mycotoxins are so called because they cannot be detected by conventional analysis methods. These are formed when as plant-defense mechanism, sugar molecules are added to mycotoxins, forming compounds such as DON- glucoside. When the animal consumes the contaminated feed, the sugar is cleaved, releasing the mycotoxin and increasing its bioavailability.

The mycotoxin survey is part of the technical services offered to customers. Data was collected from feed samples of customers to help understand contamination of the main mycotoxins, their concentrations and potential impact to their animals. More on the survey at www.dsm.com/anh

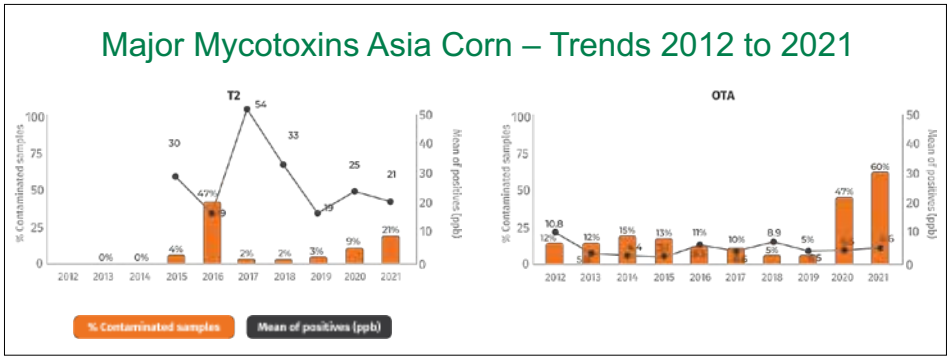



**Figure 4.** The trends in 2012 -2021 for contamination of T2 (trichothecenes) and OTA (Ochratoxin A).

# IPRS for marine fish and tilapia

## Amidst constraints from biofouling in marine and brackishwater fish culture, there is potential to increase production capacity through IPRS

*Concrete type Marine IPRS in Ninghai, Zhejiang Province, China*

In 2013, the US Soybean Export Council (USSEC) modified its In Pond Raceway System or IPRS for freshwater fish culture in China. Since then, 9,000 IPRS fish production cells (where one cell = one raceway or trough) have been developed worldwide with 90% of them in Asia. In China, the system was well received to overcome constraints (such as limited land and water resources) to increase fish production.

IPRS is an advanced approach to pond aquaculture which combines the management benefits of fish in a small section of the pond with the production capacity of a flowing water system. Essentially, IPRS create a flowing river within a pond, allowing water to mix and move like a riverine system. "This significantly increases the production capacity of the pond (USSEC, 2022), such as up to three times the yield in China, where farmers are unable to expand farming area and reduce effluents from ponds," said Lukas Manomaitis, Southeast Asian Technical Director, USSEC.

## IPRS in marine environment

The transfer of IPRS to brackishwater farming of tilapia has been demonstrated in Thailand by Tanakorn Lothaka. Manomaitis noted that freshwater IPRS and brackishwater IPRS are not the same but both require technological adaptations and specific infrastructure such as power sources. Key to high production is waste removal equipment.

"Although still in the development and adaptation stages in many countries in Southeast Asia, there is potential of the system being adopted for marine aquaculture," said Hsiang Pin Lan, Asia Marine Aquaculture Specialist, US Soybean Export Council during a virtual workshop on "In Pond Raceway System-Marine Sector", to introduce the system into the marine environment and discuss field experiences.

## Considerations for marine environments

Lan explained that a concrete type marine IPRS in Ninghai, Zhejiang Province, China showed that water quality and water circulation in IPRS aquaculture are critical elements. Fish production is not only closely related to water quality in the open pond but also dependent on water and exchange rate. In this farm, three IPRS cells were installed to farm pompano *Trachinotus blochii*, brown croaker *Miichthys miiuy* and Japanese sea bass *Lateolabrax japonicus*. The farm operator Mr. Li shared his observation on counter current swimming behaviour of pompano and sea bass.

The recommended flow rate ranges from 8-10cm/sec (0.29~0.36km/h). The water in each cell should be exchanged once every 4-6 minutes depending on the fish species cultured and total biomass in the system. If the water flow is too fast, it will flush the fish waste and faeces out of the system. If water flow is too slow, fish faeces will sink to the bottom of the cell, polluting the system. The water current is critical to keep the fish in high density in this system and also to aerate the water.

"When we move the IPRS from freshwater to seawater, water chemistry changes. Dissolved oxygen saturation is at the range of 7.2 to 7.7mg/L at temperatures of 28-30°C with 2-8ppt salinity. At higher temperatures and higher salinities, the water will hold less and less oxygen (e.g. 6.5 to 6.7mg/L at 30°C and 20-28ppt, buzzardsbay.org) while in comparison in freshwater, the DO will be 7.8-7.9mg/L. These values will affect stocking density," said Lan and added that with the fast water flow, a perception is that there is strong aeration and high DO but most of the DO is generated by photosynthesis. The airlift devices help to push and aerate water but do not increase the DO compared to what the algae can do. It is important to note that freshwater is less dense than seawater. White Water Units (WWU) generate smaller air bubbles which provide larger surface area for oxygen saturation. However, when the oxygen bubbles are smaller, there is less lifting force to push water around. Lan explained that part of the components of IPRS is the aeration device which creates the water current by airlift force. The air bubbles and foam on the water surface generated by the aeration device, appear as white water; therefore the device is called WWU.

"One of the issues in seawater systems is biofouling which impacts system operations and energy use. Equipment/tools with fouling organisms would significantly impact fish health status and fish appearance for marketing. In addition, biofouling which creates obstacles to water current force may impact aeration efficiency," said Lan. The biofouling of IPRS cell walls and fish cage nets can be with barnacles and shellfish which then disrupts water flow. So far, using epoxy paint is one way to overcome biofouling.

"Our experience with net mesh issue is to use PE grid nets. In 2004-2005 at an offshore cage project, we used ship bottom paint to prevent/reduce biofouling on the HDPE cage pipe. I would encourage operators to try different paints to see for themselves the technical and economic feasibility of options," said Lan. However, in IPRS ponds, they will need to research on toxicity of these antifouling materials which also contain heavy metals.

Marine IPRS also provides the opportunity in nursing larger fingerlings for offshore pen aquaculture stocking. The stocking size for offshore pen aquaculture from the past 10 years has increased from 30g to 100g, or even larger to obtain better survival rates during on-growing.

## Commercial IPRS in Vietnam

"Vietnam is the first country to test out the IPRS concept in Southeast Asia. Today, there are 100 freshwater fish farms with 300 raceways in Vietnam. In 2021, in the central region, a fixed IPRS for marine fish was constructed for the pompano *Trachinotus* sp, spotted butter fish *Scatophagus argus* and hybrid grouper. The IPRS comprises five raceways with a water volume of 50,000m$^3$," said Dr Bui Ngoc Thanh, USSEC Aquaculture Technical Manager-Northern and Central Vietnam. Water salinity was 15-20ppt. "Pond construction began in June 2021 and by September, cells were stocked with fish (Table 1). Three species were stocked; two cells were stocked with pompano, one with hybrid grouper and another was stocked with butter fish. Growth performance was good and mortality low when small-size fish were stocked," said Thanh. "Pompano showed fast growth from 170 to 250g after one month."

*In the central region of Vietnam, a fixed IPRS for marine fish was constructed for the pompano, spotted butter fish and hybrid grouper in 2021 comprising of five raceways with a water volume of 50,000m.$^3$*

| Cell | Species | Stocking date in 2021 | Stocking numbers | Stocking size (g) | Current size (Jan 2022) |
|---|---|---|---|---|---|
| 1 | Pompano | October 5 | 17,000 | 5-6 | 50-80 |
| 2 | Pompano | September 25 | 10,000 | 170 | 300-500 |
| 3 | Grouper | October 20 | 9,000 | 5-6 | 15-20 |
| 4 | Butter fish | October 26 | 7,500 | 5-10 | 20 |

**Table 1.** Some data on growth performance in the IPRS in Vietnam.

According to Thanh, in terms of species, pompano, seabass and cobia may be the most suitable for IPRS in marine ponds. The fish size should be at least 50g; if the stocking size is too small, fish may gather at the end of the raceway. Fish are fed floating pellets. Overfeeding in this farm was rampant. There are several problems which need to be addressed. Biofouling was very serious after 2 months of operation and fish escaped into the open ponds. Nevertheless, Thanh summarised that IPRS is a good culture system for marine and brackishwater environments, but more research is required on fish species and floating feeds, since in Vietnam, marine fish are fed with slow sinking extruded feeds. Maintenance of nets, which is more of a problem in areas with salinity fluctuations also require more studies.

## Tilapia in brackishwater ponds in Thailand

Tanakorn Lothaka, USSEC IPRS Demo Manager in Thailand has been testing out the system at Manit Farms in Petchaburi Province in Thailand. This demo farm started as a freshwater IPRS but because of its close location to the Gulf of Thailand, it became a brackishwater IPRS at 5ppt salinity. There are three operational cells separated by concrete walls in a larger pond (Figure 1). The solid waste is sent to three treatment tanks and to a trough with aquatic plants. Lothaka said that in this way water can be reused. Fingerlings of 140g are stocked at different densities in the cells to reduce the culture period and reach the target market size of 1kg faster.

Production results (Table 2) showed that fish reached average weights of close to 1kg in 4 months when partial harvesting starts. The highest biomass was 25 tonnes which

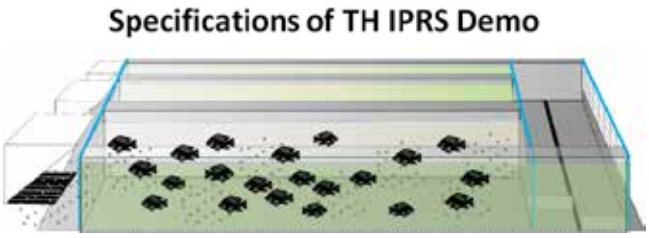



**Figure 1.** The three cells in the brackish water tilapia IPRS at Manit Farms, Thailand.

translated to 115kg/m$^3$. Interestingly, Lothaka said that at the start of the cycle in one cell, the coefficient variation of fish was high at 26.13% and this reduced to 6.03% at harvest. This uniformity was attributed to feeding to 90% satiation and spreading the fish around the cell. Flesh quality, texture and sensory assessments carried out at Kasetsart University did not show any off- flavour.

There are several essential maintenance activities. Among them are measurements of DO, pH and temperature twice a day at 6am and 4pm. Waste removal includes that of floating wastes and wastes blocking water flow. Lothaka described the 90% satiation method in the 5-10 days feeding cycle. Biweekly checks include that of the WWUs in the cells, air pump filters and the removal of trash hindering water flow. Biofouling is an issue and nets need to be checked biweekly. Another routine is the collection of pond bottom mud which can show sedimentation of uneaten feed on the pond bottom. Early in the trial, Lothaka noticed blackish mud indicating settling of uneaten feed; by changing to hand feeding, instead of autofeeders, the condition of bottom mud improved and so did water quality.

Some data collected over the two years showed several relationships which are useful for future operations. Mortality was linked to temperature and the highest mortality occurred between June and August. This implied that farmers could strengthen fish immunity during these months. The pH and alkalinity profile data can be used to indicate high decomposition with high alkalinity and that pH 7-8 prevents a risk of ammonia toxicity.

The brackishwater IPRS was designed for the tilapia but may be applicable to Asian seabass farming.

| Batch I | Cell A | Cell B | Cell C | |
|---|---|---|---|---|
| Stocking Number (pieces) | 22,500 | 18,620 | 17,414 | |
| Initial Body weight (kg) | 0.140 | 0.140 | 0.167 | CV: 26.13% |
| Harvested Body Weight (kg) | 1.156 | 1.032 | 1.013 | CV: 6.03% |
| Harvested Biomass (kg) | 25,319 | 18,875 | 16,525 | |
| Survival Rate (%) | 97.30 | 98.08 | 93.72 | |

**Table 2.** Production results for the brackish water tilapia IPRS Demo at Manit Farms, Thailand.

# An update on the marine ecosystem landscape

## Masahiko Yamada talks on industry's uptake of Umitron's innovations and what's next on its agenda

In the September/October 2020 edition, we published an interview with **Masahiko Yamada**, the co-founder/Managing Director of the Singapore/Japan deep tech company UMITRON Pte Ltd. He and his team have been making waves with a series of developments and solutions in addressing difficult problems to accelerate sustainable mariculture using computerised technology. Back then, Masahiko said that he and Umitron's founders have experiences in both the aerospace industry and software engineering. Consequently, Umitron took the marine aquaculture path considering that "since oceans cover 70% of the earth's surface, advances in satellite observations and data analytics could potentially have a huge impact in this area".

Since 2016, Umitron has launched several innovations; the first was an IoT based smart feeding system for cage culture. The company followed this with the world's first real-time ocean-based fish appetite detection system, FAI or Fish Appetite Index, an algorithm that automatically evaluates feeding conditions using artificial intelligence (AI).

In the marine ecosystem landscape, Umitron launched PULSE, a worldwide high-resolution satellite ocean data map for aquaculture farmers. Since its first release in 2019, the service has undergone a few significant updates. It now incorporates a more comprehensive dataset, allowing users to access more environmental parameters and long-term historical data.

More recently, the company finally disclosed information on the development of technology for shrimp, which is the world's first real-time AI-based analytics solution for shrimp farming to keep track of the shrimp production conditions.

## Feed efficiency

**AAP:** With feed costs rising, feed efficiency becomes critical. There are also environmental sustainability practices being promoted. How can the UMITRON CELL and FAI help marine cage farmers in these aspects?


**Masahiko:** Feeding has always been a vital part of farming operations and makes up a significant portion of daily work. Poorly executed protocols can result in unnecessary feed wastage that pollutes the site and adversely impacts production costs. When used in combination with UMITRON CELL, FAI helps the farmers keep a close eye on what's happening during the feeding process across the entire site and notifies them of any changes in the feeding behaviour, allowing them to make quick adjustments.


*Umitron's Masahiko Yamada: We are big on sharing knowledge and promoting the value of data to producers*

Our bespoke AI algorithms are already automating the feeding process to automatically adjust and streamline the protocols based on said behaviour. Since fish are fed based on their appetite level, there is minimal feed wasted, and any pellets dispensed go straight to growth conversion (resulting in improved FCR). The benefits extend to other areas as well. For example, the extra time gained by offloading the feeding process to AI means that employees now have more time to focus on other more if not equally important tasks, such as improving fish welfare and disease mitigation.

## Ocean aquaculture and ecosystem

**AAP:** The UMITRON PULSE is now available for free to users. Tell us how is the uptake and how do you gather information from users to improve on your data analytics?

**Masahiko:** The response has been good so far. We now have over 600 users worldwide. We are fortunate to have highly motivated partners who provide feedback to us regularly, based on their user experience via dedicated feedback sessions and other means.

Meanwhile, UMITRON PULSE has undergone an overhaul and now boasts a brand-new UI, two new parameters and long-term access to historical data. With wind and ocean current data included the number of parameters available for users to access is now seven instead of the previous five.

From now and for a limited time, all PULSE users will also be able to freely access up to 2 years of historical data via the desktop version and up to one month of historical data if they access the service via the mobile app (iOS and Android).

**AAP:** What do you think are future add-ons or improvements?

**Masahiko:** We are now working on an alert system that will send users notifications based on customised thresholds for the currently available 48-hour forecast period. Farmers will be able to set individual parameter limits for their site, and they will receive a warning if PULSE detects any data beyond those pre-set values. Coupled with our predictive data modelling, farms now have a 2-day window to take proactive measures when faced with upcoming adverse conditions, which has previously proved to be difficult by relying on conventional monitoring using in-situ sensors.

**AAP:** What are the benefits of PULSE for your paid users?

**Masahiko:** Most paid users were already using the real-time and forecast data for daily farm management and taking mitigation measures when necessary. With the recent introduction of long-term data, now they can also analyse and identify trends and potential triggers that have previously negatively impacted their production.

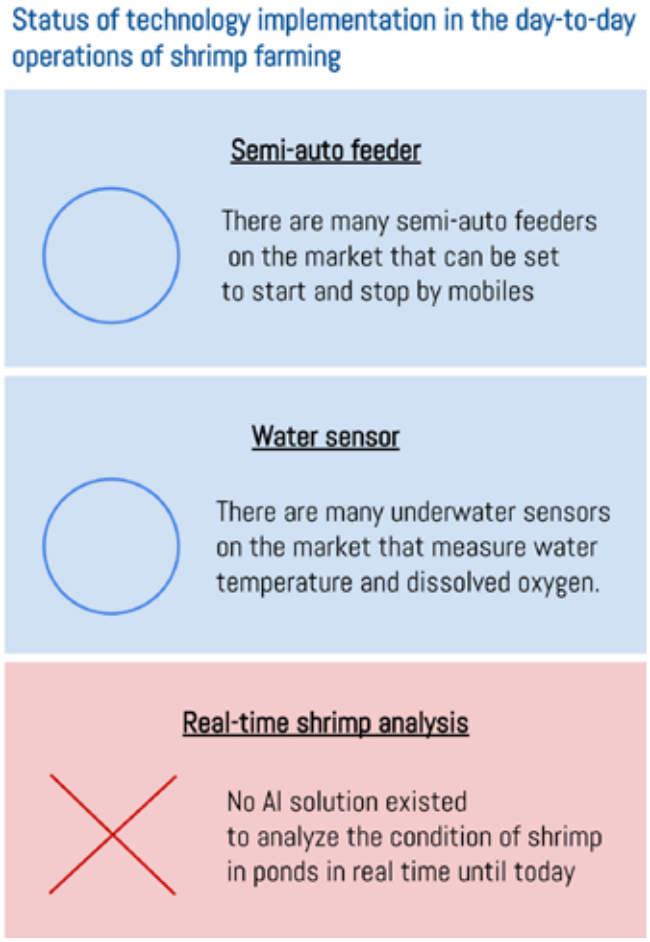
These insights have been invaluable and allowed them to take on pre-emptive measures should such events occur again in the future. For example, by comparing the data across multiple parameters, shellfish farmers have been able to use the previously identified trends to determine the ideal harvest period and sequence for multiple production sites.

We are big on knowledge-sharing and helping producers understand the value of data, which is why we decided to start by giving free access to the long-term data feature so all users can play around and experiment with the data before we roll it out to the paid plan.

## Shrimp farming solution

**AAP:** Are you able to share more about your latest development in the shrimp space**?**

**Masahiko:** To date, the global industry has been primarily centred around an almost singular species, the Pacific white shrimp (*Litopenaeus vannamei*). However, despite seeing exceptional growth in the sector, the industry is still plagued by a myriad of issues ranging from disease outbreaks, general health management and poor environmental management protocols that can lead to mass mortality events and disrupt the supply chain.




One of the main reasons is the lack of adoption of digital technology for shrimp farming compared to the fish aquaculture industry. With regards to technologies related to shrimp farming, automatic feeders that can remotely start and stop feeding and sensors that detect water quality parameters already exist, but these cannot analyse the state of the shrimp themselves in a low transparent pond in real time and digital transformation using AI has been limited for shrimp farming.

Via a previously announced partnership with Charoen Pokphand Foods (CPF), we have developed the world's first solution to assess shrimp production conditions in real-time using our customised AI algorithms. These include but are not limited to appetite analysis, health and growth conditions and biomass. In this way, we aim to achieve a more sustainable production environment and footprint in super-intensive farming conditions.

# A game-changer for Asia's high value marine fish segment

## Global retail demand for alternative whitefish could favour marine fish from Asia

By Zuridah Merican

The pandemic has not ended, and the situation is still volatile particularly for Asia's producers of high value marine fish. Although, since mid-2021, the opening of food service and tourism has helped to increase local demand, it is still questionable whether the traditional markets in Southeast Asia, namely of the Asian seabass *Lates calcarifer* or barramundi, various groupers *Epinephelus* spp and snappers *Lutjanus* spp should continue to be with higher price live fish sales, targeting domestic and regional markets. Also in question is the resilience of the lucrative export market of live fish, particularly hybrid and other groupers, to Hong Kong and China, via direct collection of fish from cage farms. For the latter, throughout the pandemic years, there has been a total absence of well boats plying regional waters and for the former, the problem is with the closure, albeit erratic, of seafood restaurants and absence of tourists.

As prices dropped, farmers opted to hold fish in cages anticipating better prices but at high production costs for feeds. In Taiwan, the farming of cheaper fish such as the threadfin in lieu of giant groupers rose. The case with olive flounder farming in Korea underpins the impact along the supply chain; despite demand in the offing for live fish for sashimi, a slow start up at the hatchery level has affected grow-out and vice versa (see box). Mohamed Razali, CEO, Aquagrow International with three hatcheries in Malaysia indicated problems in fry supply to farms in Iran, Qatar and UAE.

## Impact of COVID-19 on demand of live fish

In Indonesia, almost 90% of humpback grouper or *Cromileptes altivelis* (kerapu bebek in the Indonesian language) and grouper hybrids are exported live via well boats. Prior to 2020, regulations already prevented these exports, but the pandemic worsens the situation (ICAI, 2021). In Riau Islands, the Regional Secretary Arif Fadillah, said that harvest from marine fish cages, are usually sold to Malaysia, Singapore and Hong Kong. Since the pandemic, there were no exports of groupers. Fish went to local consumers (republika.co.id). "Before the pandemic, groupers were sold at IDR120,000/kg (USD8.4/kg) while during the pandemic, prices dropped to IDR70,000/kg (USD4.9/kg). Meanwhile, prices for the barramundi and pompano remained unchanged at IDR70,000/kg. We used to have a dynamic demand from hotels and restaurants to cater for tourists."

"In Malaysia, demand from restaurants came to a standstill, which affected the supply chain, and farmers were not harvesting and restocking fry. But then demand shifted from food service (Horeca) to retail in hypermarkets but demand also shifted to cheaper fish such as the tilapia and pangasius, as household incomes dropped. Marine fish farmers were "lucky" as they could keep the fish in cages or ponds but gradually cost of feeding became prohibitive and they had to dispose of the stock at very low prices," said Mohamed Razali at an October 2021 USCI-CORAA webinar.

## Food security

In Singapore, imports of marine fish were disrupted with closures of borders and the Singapore Food Agency fast tracked its "30 by 30" goal (30% local food production by 2030). EcoArk has started its production of barramundi, red snapper and pearl grouper in a recirculating aquaculture system (RAS) floating barge. Singapore Aquaculture Technologies will produce on a smart floating fish farm. Apollo Aquaculture Group has developed a multi-tier vertical farming facility using RAS that allows the farm to culture multiple species such as shrimp, groupers and coral trout (Lim et al., 2020).

## Salmon in Asia

Air flown salmon has a strong position as a high-end seafood, both in retail and food service among Asia Pacific consumers. In 2021, main producers, Norway and Chile increased production by 3% and 13%, respectively to a total of 2.17 million tonnes (Kontali, 2021). In 2021, supply grew 9% and volumes to the EU and UK grew 8% and to the US, an impressive 14%. In the third quarter 2021, Globefish reported market recovery for salmon in China bound for food service.

A new wave is bringing salmon farming closer to consumers in Asia such as RAS Salmon in Singapore which has targeted an annual production of 1,000 tonnes. In December 2020, Nordic Aqua Partners A/S, a Norwegian company with a subsidiary in Ningbo, Zhejiang province, announced it will begin construction of China's first land based salmon farm in 2021 (thechinaguys.com) to produce 40,000 tonnes of salmon annually for the Chinese market. FAO reported that in Southeast Asia, the retail price of fresh salmon fillets and steaks is high at USD20-30/kg in May 2021 (Globefish, 2021).

## Marine fish production

The total 2019 production of various marine fish in Asia was 2.33 million tonnes and almost half comprised high value marine fish (FAO, 2021). These were namely the groupers, sea bass and sea bream, and trout and salmon in China (Zhao et al. 2021); yellow tail and seabream in Japan; olive flounder and rockfish in Korea (see box); groupers and cobia in Taiwan and barramundi, groupers, pompano, cobia and snappers in Southeast Asia.

China's production of marine fish in 2019 totalled 1.66 million tonnes comprising the following volumes and percentages: large yellow croaker (225,549 tonnes, 23%), groupers (183,127 tonnes, 19%) and seabass (180,173 tonnes, 19%) according to Yang (2021). Industry reported a shift in 2020 with 250,740 tonnes of eels, 180,076 tonnes of pompano, 195,246 of seabass and 500,000 tonnes of largemouth bass (Xu, 2021). In Japan, the annual production of yellowtail was 100,000 tonnes (Kitagama, 2021).

In 2019, Southeast Asian production of high value fish totalled 68,900 tonnes. At an IFFO webinar in July 2021, Dr Tran Dinh Luan, Director General of the Directorate of Fisheries at the Ministry of Agriculture and Rural Development, Vietnam, said that Vietnam produced 58,000 tonnes of marine fish whereby 15% comprised the groupers, 30% cobia and 8% barramundi. In 2020, Indonesia produced up to 7,250 tonnes of barramundi and 16,461 tonnes of grouper down from 18,490 tonnes and 7,688 tonnes, respectively in 2019 (ICAI, 2021). Across Australia and Singapore, the Barramundi Group produced 2,237 tonnes in 2020 (barramundi.com).

At GOAL 2019, the projection was just under 130,000 tonnes in 2021 for barramundi production in Australia, Indonesia, Malaysia, Thailand, Taiwan and Vietnam. The projected production of groupers totalled almost 200,000 tonnes in 2021 for China, Malaysia, Thailand and Taiwan (Figures 1 and 2).

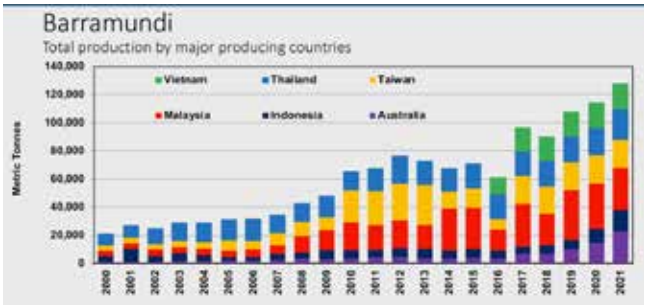



**Figure 1.** Projections on barramundi production for Australia, Indonesia, Malaysia, Thailand, Taiwan and Vietnam. Presented by Tveteras et al at GOAL 2019, October 2019.

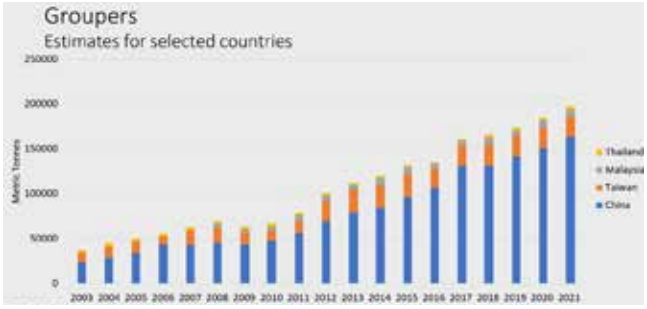



**Figure 2.** Projections on production of groupers for China, Malaysia, Thailand and Taiwan, Presented by Tveteras et al at GOAL 2019, October 2019.

## Changes in consumer preferences

In September 2021, at USSEC's webinar on marine cage aquaculture, Shirlene M. Anthonysamy, Infofish described some changes. "As consumers went into lockdown, quarantine and work from home, they wanted to eat well and prioritise food safety issues. Therefore, the trend was towards frozen and shelf stable seafood as well as organic seafood." She added that consumers were willing to pay premium prices for quality products of up to USD73/kg for the leopard coral trout. The digital technology helped in marketing, as the new generation preferred having their fish packaged and sent to homes and pay less than at a traditional market.

Zhengyong Yang (2021) said that in China, there were live broadcasts to promote the consumption and marketing of marine fish during the pandemic. China Aquatic Products Processing and Marketing Alliance (CAPPMA) has a new channel on WeChat allowing farmers, processors and buyers to share information on pricing and seafood availability, reported SeafoodSource.com.

At the same webinar, Apimeleki Cokanasiga, Infofish, said that in 2021, US consumers increased consumption particularly for high value fish by 8.3%. The drop in grouper sales in 2020 was due to heavy reliance on the restaurant trade and air freight in 2020 but skyrocketed in January to March 2021 when restaurants and live fish markets reopened. In Hong Kong, imports of tiger grouper rose to 120 tonnes (valued at USD0.8 million) in January-March 2021 as compared to annual imports of 385 tonnes (valued at USD2.5 million) in 2020.

## Integration

Several reports indicated that the reopening is increasing consumption in the restaurant segment which is a bonus for Asia's producers of high value marine fish. However, the new normal may also steer them toward retail markets for frozen fish and perhaps ready to cook, ready to heat and ready to eat processed seafood. For producers, the opportunity is to integrate the supply chain.

In Taiwan, frozen processed seafood requiring minimal preparation and storage appeal to Taiwan shoppers with a busy lifestyle (USDA, 2021). On the contrary, in Indonesia, with the high costs of production, producers need to secure the high price for live fish and therefore are not interested in the frozen fish segment (ICAI, 2021).

Targeting retail markets require integration. Indonesia's Manik Segara Group, Agus Suhaemi (Bali Post, 2021) said, "For the past two years, the group has relied on domestic sales of frozen fish and the development of grouper fillets. In the past, the live fish price was IDR100,000/kg (USD6.9/kg) and for export. For two years, the price has decreased to IDR65,000/kg (USD4.5/kg)." To help the company integrate the supply chain, the Directorate General of Strengthening the Competitiveness of Marine and Fishery Products, Ministry of Marine Affairs and Fisheries aided in post-harvest management and facilities to help the group process more effectively and maintain quality. Agus added, "With prices still going down, it really helps. With refrigerated vehicles and processing tents, we can reduce shipping costs and maintain quality."

*Farming of yellowtail in Kagoshima, Japan. Picture credit. Hsiang Pin Lan, USSEC*

# Recovery in demand for the olive flounder in Korea

## Demand for live marine fish for sashimi is a sign of recovery in Korea but production remains low

*Market size olive flounder (©National Institute of Fisheries Science)*

There is a recovery trend of domestic consumption post COVID-19 in Korea. The demand for sashimi is increasing, but then market size production is insufficient. One reason for the increase in demand is the new culture of food delivery. Supply of other live fish was down too despite increases in ex-farm prices. Redlip mullet *Chelon haematocheilus* and other alternative species replaced the olive flounder and rockfish. In 2021, olive flounder prices were around KRW15,845/kg (USD12.9/kg), an increase of 29% as compared to 2020 (Figure 1).

There was a supply chain effect. Despite better prices, since October 2020, olive flounder farms faced and continue to face a shortage of market sized production. A lower hatchery production of juveniles was due to the low ex-farm price during 2019-2020.

The article was prepared with information provided by AquaInfo Co., Ltd, Korea.

Marine fish production in Korea increased slightly by 4% in 2021 to 91,850 tonnes. The rise in value was significant at 17.7% to KRW1,088.8 billion (USD885,725). The leading high value marine fish species are the olive flounder *Paralichthys olivaceus* and Korean rockfish *Sebastes schlegelii*, but both saw declining production and value in 2021.

The olive flounder is the most valuable aquaculture species in Korea, comprising almost 46% of total fish production in 2021. The fish is usually consumed raw because of its flavour and firm texture, and in the main local market 1.2kg fish is used in the food service for sashimi. Prior to the pandemic, together with other flatfish, the olive flounder was exported to the US, Japan, China, Taiwan, Singapore, Malaysia, UAE, Canada, Hong Kong and Vietnam. The US requires at least 2kg fish which takes 18 months and the European markets, a minimum size of 3kg which will take 22 months.

| Production of olive flounder in Korea (tonnes) | | | | | | |
|---|---|---|---|---|---|---|
| Year | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Volumes | 41,613 | 41,207 | 37,241 | 43,360 | 43,813 | 42,599 |

**Table 1.** Production of olive flounder in Korea in 2016-2021.

## Olive flounder supply chain

Farmed production of the olive flounder dropped 4.6% to 42,599 tonnes in 2021 as compared to 43,813 tonnes in 2020 (Table 1). In 2020, prices dropped drastically to nearly KRW12,000/kg (USD9.7/kg) in the early days of the pandemic when the food service demand dropped with closures of restaurants. Although Korea was quick to open in mid-2020 leading to better prices for the fish towards the end of 2020, production volumes remained low.

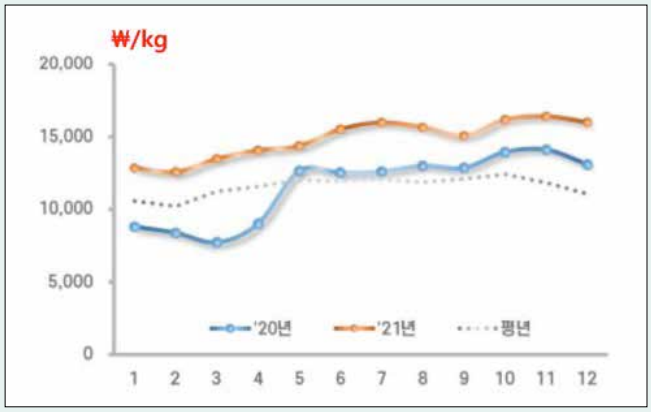



**Figure 1.** Monthly ex-farm prices for the olive flounder in Korea during 2020-2021. Source. Korea Maritime Institute, 19 January 2022.

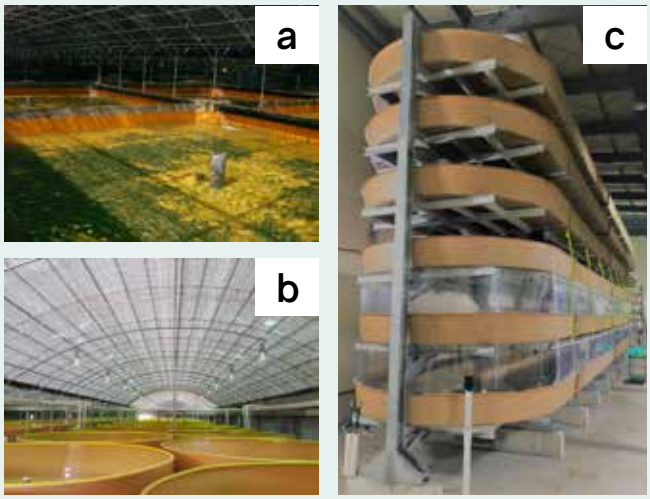
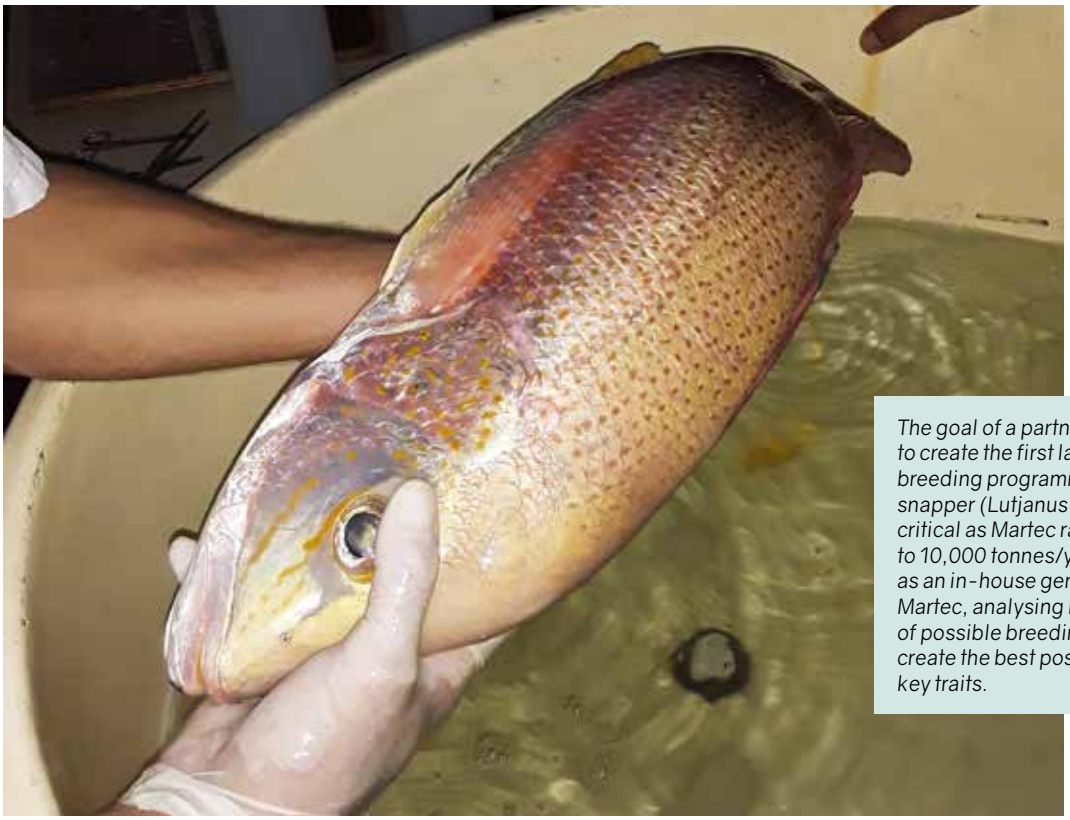



**Figure 3a-c.** Some systems to produce the olive flounder in Korea. a. On-growing of the olive flounder in flow through systems (©AquaInfo). b. RAS hatchery (©ChunJung) and c. RAS for on-growing (©AquaInfo).

# Genetic diversity gets a big boost from breeding programmes for more species



*The goal of a partnership with Martec is to create the first large-scale genetic breeding programme for spotted rose snapper (Lutjanus guttatus). This will be critical as Martec ramps up production to 10,000 tonnes/year. Xelect will work as an in-house genetics department for Martec, analysing hundreds of thousands of possible breeding combinations to create the best possible improvements in key traits.*

Despite the huge diversity of species and tastes globally, most of the genetic effort has, until now, been focused on just a handful of species. This is beginning to change with the help of genetic experts at Xelect.

Genetics has a powerful role to play in aquaculture, helping to develop fish and shellfish that grow faster, are more robust and thrive in local production environments that can range from the middle of the Arabian desert to the glacial waters of Iceland. However, since the genetics boom of the 1980s just a handful of species, such as Atlantic salmon, shrimp and trout, have commanded most of the large-scale commercial attention.

There are many important reasons for Xelect to broaden the net, to secure a sustainable future for aquaculture and embrace the diverse range of native fish species that have thrived around the world naturally for millennia:

- **Sustainable, local supply:** Disruptive events such as the outbreak of COVID-19 are exposing the frailties not having a regional self-sufficiency when it comes to food production, increasing the appeal of developing regional breeding programmes.
- **Reducing environmental damage:** There is now an increasing focus on the environmental impact of shipping goods over long-distances.
- **Our changing planet:** Climate conditions are changing faster than expected, bringing new challenges to aquaculture production and challenging some environments more than others.
- **A diversity of tastes:** Production needs to reflect the diverse global appetite for a range of different fish, that appeals to the local market.

## Does genetics make that much of a difference?

The answer is "absolutely". In fact, it is likely that we will see big improvements in neglected species very quickly, precisely because they have received so little attention so far. Just some of the benefits include:

1. **Faster growth:** With careful selection it is not uncommon to see improvements in growth of between 10% and 15%. That can make a big difference in terms of speed of production and overall profits.
2. **Controlled inbreeding:** Without genetic management it is highly likely that existing broodstock will be comprised simply of the best performing animals – which means there is a significantly increased risk that those animals are, in fact, related. Typically, this can give improvements for a generation or two, but quickly results in 'inbreeding depression' – increased deformity, a loss of energy and stunted performance.
3. **Disease resistance:** In many parts of the world farmers are painfully exposed to disease outbreaks, often decimating entire crops. The risk of different diseases can vary dramatically from region to region. A modern genetic breeding programme can select for natural resistance, greatly reducing losses due to common pathogens.
4. **Fish designed to thrive in local conditions:** The big, centralised breeding programmes have undoubtedly made great progress, but farmers can quickly realise that genetic lines designed to thrive in a RAS facility on the other side of the world perform very differently in their own production conditions.

Since genetic gains are generational, there are some species that are expected to make very rapid progress. Whereas the generational interval for Atlantic salmon is typically around 4 years, for a tilapia, gains can occur in as fast as 9 months. Therefore, companies that are amongst the first to incorporate genetics in their production will rapidly pull ahead of their competitors and will also be much more likely to appeal to investors.

## Breaking down the barriers: Is change coming?

The simple answer is that change is essential. The increasing demand for fish and shellfish cannot be met just by turning up the dial on existing production. A sustainable, vibrant aquaculture industry requires innovation, embracing a broader range of species and production hubs.

The good news is that genetics is now more accessible and affordable than ever. It is no longer the preserve of those with the deepest pockets.

Xelect's CEO, Professor Ian Johnston, attributes this to a new wave of disruptive genetics players, who are able to respond quickly to implement new programmes. "Independent, agile companies like Xelect are perfectly placed to be the catalyst for change. It is just not practical for many producers to build their own genetic capability from scratch. You need a highly diverse team of experts in everything from biology to computer programming, access to the latest R&D and an advanced laboratory. We effectively allow even small producers to have access to their own in-house genetics team at a fraction of the cost."

"We did not originally set out to work with such a wide range of species, but it is becoming something of a speciality for Xelect and something we are truly passionate about. In the last year alone, we have started to work with 3 new species. Because we have no vested interest, we can apply our knowledge and technology to absolutely all fish or shellfish. We can now build the genetic toolkit we need to start working with a new species in a little over a month", explains Dr Tom Ashton, Operations Director.

## What's on the horizon?

For a while Xelect has been working with emergent species such as tilapia, monodon shrimp and pangasius. There is also significant interest in African catfish which the company is exploring opportunities. However, there are three recent projects to showcase the increasing diversity in aquaculture.

### Case study 1: Tilapia in Sub Saharan Africa

Tilapia production in Sub-Saharan Africa is growing fast, however it remains in need of more development. Xelect has recently agreed a partnership with a major producer in Zambia and Uganda, to apply modern genetic selection techniques to their indigenous strains. This will bring security of supply, independence from foreign egg producers, and crucially it will allow them to tailor their programme to the specific demands of their region.

Local, independent genetics programmes are going to play a vital role in the future of this essential staple food source in Africa. Xelect is also working with several other leading producers of tilapia in the Lake Victoria region to plan genetics programmes under the umbrella of the Msingi East Africa aid funding programme. Msingi aims to invest in long-term economic sustainability and local selective breeding fits that brief perfectly.

### Case study 2: Spotted rose snapper, Costa Rica

Xelect has signed a contract with Martec, a leading producer of rose spotted grouper *Lutjanus guttatus* in Central America. The partnership will focus on the development of a new selective breeding programme for this emerging species. The first stage is to use genomic sequencing to develop a suite of genetic markers and then to use these tools to identify the founding broodstock. Successive rounds of selection will drive continuous gains in commercial traits, making the rose spotted grouper a local commercial success in Central America.

### Case study 3: Rohu carp, Myanmar

Xelect is a partner with De Heus and Fresh Studio in a programme to modernise production of rohu carp *Roho labeo* in Myanmar, in efforts to establish a sustainable, profitable breeding programme for this highly popular yet under-developed species. Work began with the development of new genetic tools for the rohu, followed by a detailed survey of available genetic broodstock. This will enable the genetic team to construct a founding population with all the genetic potential needed to run a long-term breeding programme that delivers solid economic returns and food security into the future.

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# Implementation of ROV is reducing the reliance on costly divers in aquaculture

Deep Trekker: a robotics company based in Ontario, Canada is successfully changing the world's reliance on divers in the aquaculture industry. Founded in 2010, Deep Trekker has been on a mission to create portable, affordable, and easy to use Remote Operated Vehicles (ROVs). By implementing ROVs, farms are able to conduct net inspections, monitor for parasites, observe feeding, sample key environmental levels, and assist in mort removals; all while the pilot operates safely from a dry position.

## Saving farms time and money

### *Net inspections*

Maintaining net health is an integral part of efficient aquaculture practices. Regular inspection ensures for irregularities to be caught early, before a catastrophe such as an escape can take place. ROVs offer an incredibly streamlined approach to inspection compared to divers. For farms utilising predator nets, deep trekker ROVs play a large role in monitoring these exterior nets for breaches and ensure repairs are made swiftly.

Thanks to innovations in automation technologies, Deep Trekker is working to develop "Resident ROVs" capable of permanently remaining underwater. Theoretically, these vehicles will routinely scan the entirety of a net, utilise AI to assess net health and identify tears, and automatically run analysis reports for operators. A pilot will be able to assume control of the ROV from anywhere in the world. These features would greatly enhance the pilot's use of time, allowing for undivided focus on camera feeds during inspections.

### *Parasitic evaluation*

Parasites such as sea lice are a common issue in open-net pen farming. Disease management is one of the biggest concerns and constraints to the industry, costing billions of dollars each year, especially for farmed salmon. Having a Deep Trekker ROV on hand gives farmers the ability to quickly and easily evaluate their stock for sea lice. This allows for quicker and more targeted preventative treatments against the problematic crustaceans. ROVs also provide insight into the treatments themselves. By having a consistent visual on their stock, farmers can monitor treatments for effectiveness, as well as observe for potential health effects on the stock.

## Feed monitoring

Fish feed represents 50% to 70% of fish farmers' production costs, making even a small amount of waste a vital pitfall. Farms can make use of their ROV to routinely keep a close eye on their stock. During temperature fluctuations, fish adjust their feeding habits and if feed distribution remains unaltered, this can result in some groups being underfed. By consistently monitoring feeding patterns, farmers can confidently optimise their stock's nutrition year-round.

## Environmental Sampling

Infectious diseases among fish are the source of billions of dollars in loss annually. A Deep Trekker ROV makes sampling water/sediment for optimal fish health an easy task. Traditionally, sampling is time-consuming and raises the cortisol level of fish. During times of the year when oxygen levels are lower, farms try to minimise handling to prevent losses.

Both the DTG3 and REVOLUTION can be equipped with heading, depth, temperature, and oxygen sensors, making them a powerful tool for understanding the environment in which fish live. Deep Trekker has also partnered with Aquatroll to integrate their multiparameter sonde onto either of the DTG3 or Revolution. The sonde can simultaneously carry up to four sensors to monitor potentially dangerous compounds, like chlorophyll or phosphorus. By utilising these ROV add-ons, farmers can consistently monitor fish health, while not meaningfully affecting cortisol levels.

## Mort Removal

There are several things that cause morts, many of them beyond the farmer's control. Mort uplift systems are useful, but most morts do not end up being automatically uplifted and need assistance. Historically divers were used for this, but this methodology is accompanied by some inherent risk and a high price ceiling. In modern practice, many farms have shifted to ROVs due to the time and cost benefits. A DTG3 or a Revolution equipped with a Mort Pusher is a very efficient and perfectly safe way to move morts into the uplift.

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***Trade Show Contact: mario@marevent.com***

# Diana Aqua is now Symrise Aqua Feed

Diana Aqua, a business unit of Symrise Taste, Nutrition & Health, has announced that it has begun operating under a new name. The key player in producing functional ingredients and palatability enhancers that help aquafeed manufacturers to develop high performance feeds with reliable and proven solutions will operate under the name of Symrise Aqua Feed, effective January 1, 2022.

This rebranding strategy reflects both the evolution of the company as well as its vision for the future. As part of Symrise AG since 2014, the Aqua Feed Business Unit of the Taste, Nutrition & Health segment benefits from the notoriety and resources of Symrise. They will help opening additional markets worldwide.

The rebrand includes the name change, the Symrise logo and a website relaunch. The website will go online in the coming months. It will highlight the product range (Extrapal, Actipal and Nutri) and help to provide a greater level of communication for existing and prospective clients.

Vincent Percier, Marketing & Strategic Development Director at Symrise Aqua Feed, commented, "In 2021, we changed our range and product names portfolio for more clarity and simplification. In the beginning of 2022, we continue our journey by becoming Symrise Aqua Feed. This represents the next step toward simplicity and easier understanding of our identity. Our name change reflects our dedication to the aquafeed industry and the endorsement of Symrise, a global brand carrying great visibility, great reputation and strength."

Sylvain Lacladere, General Manager at Symrise Aqua Feed, added: "This forms a major milestone for the aquaculture division. Moving from Diana Aqua to Symrise Aqua Feed includes a change of name and also signifies a confirmation of the willingness by Symrise to continually invest on providing innovative and sustainable solutions to our customers all around the world. We will start writing a new page and I feel excited to set out on this adventure."

# Independent ISO certification for intelligent sustainability service Sustell

Royal DSM, a global purpose-led science-based company, has achieved International Organisation Standard (ISO) lifecycle assessment assurance by DNV for its intelligent sustainability service Sustell™. The independent, third-party verification by DNV in accordance with ISO 14040:2006 and 14044:2006 underscores the robustness of the Sustell lifecycle assessment methodology co-developed with experts at Blonk Consultants that accurately measures the environmental footprint of animal protein production. Precise measurement is the first step in improving the environmental impact of food and agricultural production. Third-party verification serves to assure DSM customers that Sustell footprint calculations are reliable and credible. In addition to providing an accurate footprint measurement, Sustell provides actionable farm-level solutions to reduce environmental emissions from livestock and improve farm profitability.

In January 2022, DSM signed a Memorandum of Understanding (MoU) with Charoen Pokphand Foods (Thailand) with an aim to measure and improve the environmental footprint of animal protein production through the use of Sustell.

David Nickell, Vice President Sustainability & Business Solutions at DSM Animal Nutrition and Health, commented, "Sustell offers unique value for our customers, and this certification further proves the robustness and integrity of our approach. This is another example of how we support our customers and deliver on our strategic initiative, We Make It Possible, that aims to lead a robust and achievable worldwide transformation in sustainable animal farming."

Nico Irrgang, Head of Sustainability for Germany at DNV – Supply Chain and Product Assurance, said, "It is becoming increasingly important for companies not only to deliver products and services that they say are environmentally friendly and socially compliant throughout their lifecycle, but to provide hard evidence too. We are delighted to have helped DSM assure that its Sustell platform is in line with the ISO requirements (ISO 14040:2006 and 14044:2006), providing DSM's customers with greater trust and allowing them to be better informed about how the services they use are aligned with their ESG strategies and corporate values."

Developed with Blonk Consultants, Sustell™ is a first-of-its-kind intelligent sustainability service that delivers accurate, simple, and actionable farm-level solutions to improve animal protein production's environmental footprint and profitability. By catalysing sustainable value chains and enabling environmental transparency and supply chain to differentiate, Sustell helps producers achieve their sustainability commitments.

# A practical guide for setting up correct feed and feed additives trials in fish and shrimp

Over the last 10 years, an overwhelming number of new products which claim to improve the performance of fish or shrimp or improve their disease resistance, are entering the aquaculture market. To prove or verify the effectiveness of a new (functional) feed or a new feed additive, it is necessary to set up well designed scientifically based laboratory or field trials. It is necessary to create an experimental setup, where all controllable variables are kept equal among the different treatments except the one being evaluated.

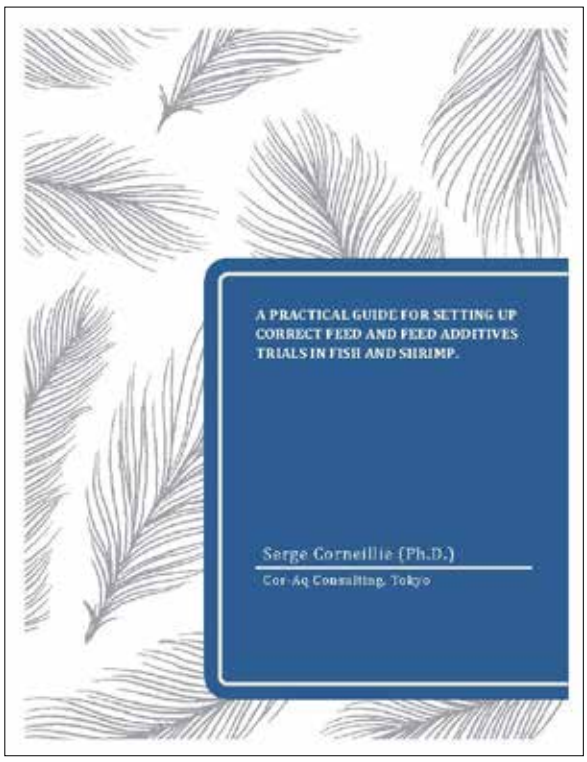
Written by Serge Corneillie, PhD, this 84-page manual covers the different critical factors in setting up scientifically based trials to validate the benefits of a new feed or a feed additive both in fish and shrimp. Corneillie has over 30 years working in the aquaculture industry, managing seabass and seabream hatchery and grow out farm in Southern Europe and a yellowtail grow out farm in Japan (MOWI). He worked for major animal feed companies (Nutreco, Cargill, ADM) and feed additives companies (Alltech, Diamond V) in Asia. Corneillie has set up and overviewed numerous trials with fish and shrimp in laboratory environments and in the field, in many countries in Europe and in the Asia Pacific region. He wrote this manual because he noticed that too many trials failed or gave reduced output, due to incomplete or wrong protocols.

The first chapter looks at defining the trial objectives and the trial hypothesis. The second chapter describes how to set up correctly the different replicates of each treatment group. There is a special focus on how to set up fish identical in genetical origin in each replicate and on the importance of having replicates with average start weight as close as possible. "We also look at the different parameters (pre-adaptation to the new diets, sex ratio, minimum trial length, feeding frequency, photoperiod, etc.) that need to be controlled in order to create identical conditions between the different experimental groups. Clear distinction is made between setting up trials in small tanks/aquaria and the challenge in setting up relevant trials in large cages/ponds," says Corneillie.

In chapter 3, the same points as in chapter 2 are covered but for the setup of shrimp trials in tanks and again in large ponds as well a discussion on differences with fish trials. The fourth chapter covers all the different water quality and performance parameters that are needed to monitor and measure. Finally, a way to construct a feeding table based on growth ration analysis is explained.

In chapter 5, the five distinct levels of immune response in fish and shrimp are explained, followed by the different immune parameters to measure in order to evaluate the effect of a new feed or feed additive on the immune responses. The last chapter briefly discusses some histological data and microbiota that can be compared between the different treatment groups. Finally, in the appendix, are examples of a professional protocol for shrimp and for fish trials.

To obtain an ecopy, send request to sergecorneillie@gmail.com



SHRIMP 2022

# INFOFISH WORLD SHRIMP TRADE CONFERENCE AND EXHIBITION (VIRTUAL)

## "Recovery through resilience and innovation"

## 8-10 June 2022

Jointly Organised by:

INFOFISH

Department of Fisheries

NACA
Network of Aquaculture Centres in Asia-Pacific (NACA)

China Aquatic Products Processing and Marketing Alliance (CAPPMA)

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www.shrimp.infofish.org

# INFOFISH announces SHRIMP 2022

This is the 6th INFOFISH World Shrimp Conference and Exposition. This will be a virtual event from June 8-10, 2022.


With the theme, *Recovery through Resilience and Innovation*, the conference will discuss, among others, the global shrimp production and trade, issues and challenges faced by the industry during the COVID-19 pandemic, market access and certification, diversification of markets and seafood products, technology and innovation, feed and nutrition, advancing biosecurity and disease prevention, sustainability and recovery pathway through partnership and investment.

Organisers have also announced the Chairman of the Conference as **Jose Antonio Camposano**, Executive President, National Chamber of Aquaculture, Ecuador.

This premier global shrimp industry conference and exhibition is expected to gather over 250 top industry leaders including representatives from leading multinational companies, shrimp buyers and sellers, equipment manufacturers and suppliers, policy makers and planners, experts, media professionals etc. around the globe to discuss, to debate and most importantly, to network with all the sectors that make shrimp production and trade the billion-dollar industry it is today.

The keynote address "Resilience, Innovation and Resurgence in the Global Shrimp Industry: What's next?" will be delivered by **Dr Patrick Sorgeloos**, Emeritus Professor of Aquaculture, University of Ghent, Belgium.

Some of the topics at the conference will include:

- A global overview of the farmed and wild caught shrimp sectors
- Current production and expansion plans in the major producing countries and regions
- A global overview of the major shrimp markets and trade flows
- Aquaculture innovations and technologies for sustainable intensification
- Digitalisation of aquaculture for better productivity, superior monitoring and greater transparency
- Advancing feed and nutrition, biosecurity and disease management
- Meeting COVID-19 challenges in the shrimp post-harvest sector including processing and packaging
- Sustainability in action
- Growth recovery through partnership and investment

SHRIMP 2022 is jointly organised by INFOFISH, Department of Fisheries, Thailand, Network of Aquaculture Centres in Asia Pacific (NACA) and China Aquatic Products Processing and Marketing Alliance (CAPPMA). Media partners for this mega event are Aqua Culture Asia Pacific, Aquafeed.com, Hatchery Feed & Management and World Aquaculture Society (WAS). I&V BIO Co., Ltd is the Gold Sponsor of this event.

Although SHRIMP 2022 will be virtual, participants will still be able to enjoy interactive sessions, one-to-one networking opportunities and additional benefits, as well as showcase leading shrimp brands. Programme updates, registration, sponsorship and exhibition details are available at http://shrimp.infofish.org. Email: sujit@infofish.org or syahir@infofish.org

# Practical Short Course on Extruded Pet Foods and Treats

June 27- July 1, 2022

As several events continue to be postponed, moved online, or cancelled altogether as a result of COVID-19 concerns in the US, Texas A&M University (TAMU) has announced its 7th Annual Practical Short Course on Extruded Pet Food and Treats, will be held in hybrid format (face to face as well as virtually - Live-Online) from June 27- July 1, 2022.

This one-week Practical Short Course on Extruded Pet Foods and Treats will be presented by staff, industry representatives and consultants. The program will cover information on pet food nutrition, material handling, preconditioning, extrusion of pet foods, extruded and non-extruded treats, baked pet treats, raw material, extrusion hardware, automation, product analysis, meat handling in pet food, drying, cooling, and enrobing, food safety, pet food and treat shelf life, trouble shooting and pet food related class activities. Reservations are accepted on a first-come basis. Information on programs and application forms: Email: mnriaz@tamu.edu (Dr Mian Riaz); Web: https://foodscience.tamu.edu/https://teesedge.tamu.edu/online/extrusion

# Investing in sustainable aquaculture for protein security and ocean health

The Blue Food Innovation summit is a new chapter from the hosts of World Agri-Tech, Future Food-Tech and Animal Ag-Tech, to catalyse innovation and investment in aquaculture. **The inaugural Blue Food Innovation Summit will be in London on June 14-15.**

Livestreamed to a global audience, the summit will connect global technology leaders, start-ups, investors, retailers and aquaculture producers to build new partnerships, focus on the transformative potential of new technologies and encourage collaboration and partnership between stakeholders across the value chain.

Key themes for the summit include:

- Sustainable aquafeed: Scaling alternative and novel feed ingredients
- Seaweed and algae commercialisation: Food, feed and biorefining
- Farm optimisation: Accelerating adoption of sensors, imaging and digital platforms
- RAS: Overcoming challenges to scale and diversification across species
- Fish health and welfare: Tackling disease through vaccines, feed additives and fortification
- Restorative aquaculture: Replenishing our oceans through nature-based solutions
- From egg to plate: Building transparency and traceability across the supply chain
- The blue carbon economy: The viability of carbon capture as a revenue stream
- Offshore aquaculture: The role of automation and robotics in deep water farming
- Circular systems: Closing the loop through waste utilisation and resource optimisation
- Investment models: Attracting ESG, VC and growth capital into blue food production
- The edge of innovation: A deep dive into production technologies a decade from now

## Keynote Speaker

Organisers have announced that Professor **Manuel Barange**, Director of Fisheries and Aquaculture Division, FAO will give the opening keynote address "Realising the full potential of the blue food economy." Barange will set the scene for two days of collaborative discussion and networking to accelerate technologies in sustainable aquaculture and ocean health. Barange shares, "As we move towards a world of 10 billion people, aquatic foods are progressively under the spotlight. Transforming the aquatic foods sector, from expanding aquaculture, improving capture fisheries and developing fish value chains is increasingly crucial to reduce growing poverty and hunger around the world."

Through plenary discussions, start-up showcases, fireside chats and 1-1 networking, the summit's conversations will look across species at how to create more circular systems and reduce the carbon footprint of aquatic foods, whilst increasing health, welfare and yield. Registration is available to join the summit in person or virtually. www.bluefoodinnovation.com

*Professor Manuel Barange, Director of Fisheries and Aquaculture Division, FAO will give the opening keynote address "Realising the full potential of the blue food economy."*

# Tropical AgTech CONFERENCE

**Tropical AgTech Conference will be held on June 22-23, 2022, at the University of Hawaii-Hilo. The focus on tropical agriculture differentiates the conference from other agricultural technology conferences around the world.**

The mission of HIplan, a 501c3 educational non-profit based in Hilo is to develop the entrepreneur ecosystem on Hawaii Island, USA. Hawaii has a long history of innovation in agriculture, horticulture and aquaculture. But, high production costs, a small local consumer market and distance to larger markets make Hawaii's agriculture uncompetitive in global markets and result in Hawaii importing 85% of its food.

HIplan has conducted business plan competitions for Hawaii companies for the last five years, mentored more than 200 companies and awarded USD 200,000 in prizes. More than 50% of all entries to the competition, and four of five grand prize winners, were agriculture-related companies. Therefore, HIplan is placing emphasis on supporting agricultural business development and will convene an international conference on tropical agriculture technology.

This two-day Tropical AgTech Conference will be held on June 22-23, 2022, at the University of Hawaii-Hilo. This will be a hybrid event - in-person and streamed. Organisers have gathered an impressive array of thought leaders in agricultural technology and challenged them to tailor their talks towards using AgTech to develop solutions for tropical agriculture. The range of speakers include David Slaughter (University of California, Davis) to Rahul Thakkar (AWS). For aquaculture, there will be Robbert Blonk, Hendrix Genetics Aquaculture, B.V. and Toru Mitsuboshi, Nippon Suisan Kaisha, Ltd. (Nissui). The two-day agenda includes sessions on Hawaii Resources, Biological AgTech including breeding developments, Digital AgTech and Climate Smart Farming.

Among the goals for the conference are to stimulate development of a local AgTech ecosystem and a technology-enabled sustainable agricultural industry, improve agriculture productivity to achieve higher profits (higher yields and margins) with higher paying jobs, younger workforce and higher value crops and attract investment to agriculture in Hawaii.
www.TropAgTech.com

NEW DATES

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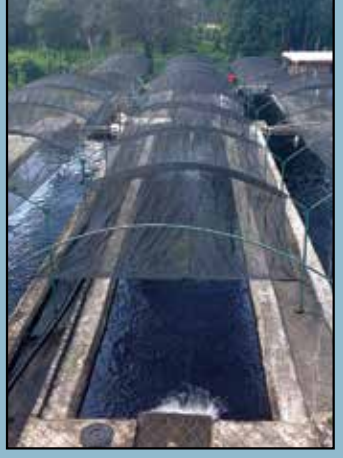

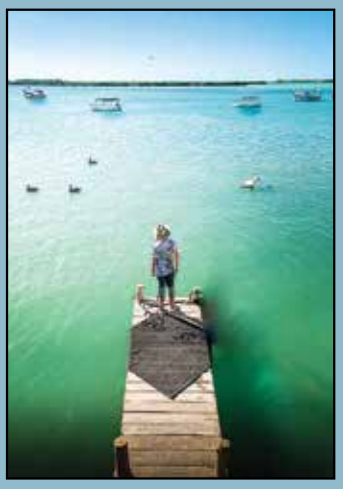

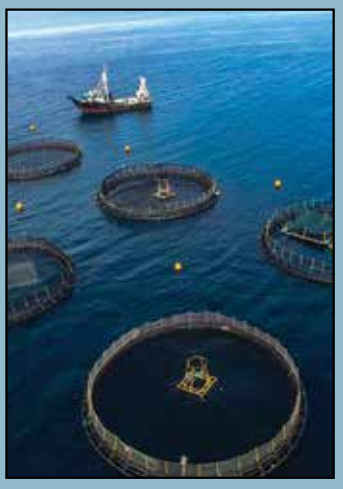

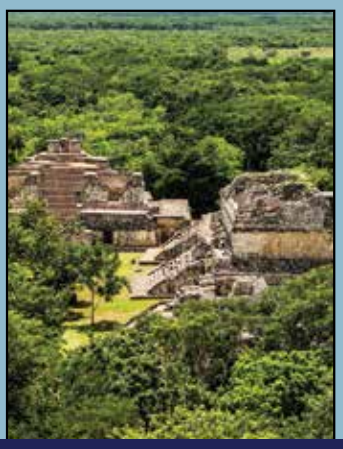


For More Information Contact:

Conference Manager

P.O. Box 2302 | Valley Center, CA 92082 USA

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## 11th Symposium on Diseases in Aquaculture (DAA11)

**This conference and trade show will be a hybrid event from August 23-26 in Kuching, Sarawak, Malaysia. The venue will be the Borneo Convention Centre (BCC).**

This Diseases in Asian Aquaculture Symposium (DAA) series is held once in every three years by the Fish Health Section of the Asian Fisheries Society (AFS-FHS) which sees this as a hub to cover core aspects of aquatic animal health including current research developments, trends, the future of the aquatic animal health industry and many more. DAA symposiums provide a forum for interaction among professionals, academicians and experts in the fields of aquatic animal health With the chosen theme: "Land of Adventure: Exploring Aquatic Animal Health for Sustainable Aquaculture", this DAA11 symposium aims to combine intellectual stimulation while exploring the nature of Sarawak. Local organiser, the Department of Fisheries, Malaysia, anticipates the attendance of 400-500 delegates from 20-30 countries.

The scientific programme will comprise two plenaries and 6 technical sessions as below:

| 2 Plenaries | |
|---|---|
| I | State of Aquaculture |
| II | Drivers and Pathways of Disease Emergence in Aquaculture |

| 6 Sessions | |
|---|---|
| I | Biosecurity in Aquaculture |
| II | Epidemiology (Parasitic, Bacterial & Viral diseases) |
| III | Detection Methods/Diagnostic (Parasitic, Bacterial & Viral diseases) |
| IV | Prevention & Control Measures |
| V | Trends in Fish Health Management |
| VI | Trends in Shrimp Health Management |

FHS wants to ensure innovative research in fish and shrimp health management are presented at DAA11. There will be ample time scheduled for networking, field trips and social functions during the symposium. Trade displays will be exhibited throughout the Symposium.

Some important dates are given below. www.daa11.org

| | |
|---|---|
| Abstract Submission Deadline | March 31, 2022 |
| Notification of Abstract Acceptance | June 1, 2022 |
| Early Registration Deadline | June 3, 2022 |
| Normal Registration | July 15, 2022 |

# 2022

**March 30-31**
RAStech 2022
South Carolina, USA
www.ras-tec.com

**April 26-28**
Seafood Expo Global
Barcelona, Spain
www.seafoodexpo.com/global/

**May 24-27**
World Aquaculture
Merida, Mexico
www.was.org

**May 31-June 2**
13 AFAF – Asian Fisheries Aquaculture Forum
Tainan, Taiwan
https://13afaf.tw/index.php

**June 8-10**
SHRIMP 2022-INFOFISH (Virtual)
www.shrimp.infofish.org

**June 14-15**
Blue Food Innovation Summit
London, UK
www. bluefoodinnovation.com

**June 22-23**
Tropical AgTech Conference, Hilo Hawaii, USA
www.tropagtech.com

**June 27- July 1**
Short Course on
Extruded Pet Foods and Treats

**June 27- July 1, 2022**
Texas A&M, USA
https://foodscience.tamu.edu

**August 23-26**
DAA11
Kuching, Malaysia
www.daa11.org (Hybrid)

**September 7-9**
Nutrition and Health Asia/Victam 2022
Bangkok, Thailand
https://victamasia.com/

**September 13-15**
SPACE
Rennes, France
www.space.fr

**September 27-30**
Aquaculture Europe 2022
Rimini- Italy
www.aquaeas.eu

**October 5-6**
TARS 2022: Aquafeeds
Ho Chi Minh City, Vietnam
www.tarsaquaculture.com

**November 9-11**
Aquatica Asia
Jakarta- Indonesia
https://aquaticaasia.com/

**November 29-December 2**
World Aquaculture Singapore
www.was.org

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- Fax: +84-274-3790819
- Email: aquafeed@upvn.com.vn


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