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Zuridah Merican

## 2021: The good, the bad and the ugly

increased its share in the US market and Ecuador has pivoted quickly with value added shrimp, and from China to US and EU markets. The notion that Ecuador would always be a HOSO exporter and cannot do value adding cost effectively is no longer true. Integration in Ecuador could be the answer for its success.

Stakeholders have suffered from the disruptions along the supply chain. A New York Times article attributed this to retiring containers in 2020, containers going only one way, trapped containers, log jams and with no idea when this will return to pre-pandemic traffic. An important takeaway is how Asian producers lose with 6 weeks freight time versus 2 weeks for Latin American producers for the US market. Whether the added costs are shared by importers and exporters, it is still higher prices for consumers.

A new risk was introduced into the supply chain, led by China. While the US FDA, European Commission and other countries have always focussed on contaminants in seafood imports, China added inspections for the coronavirus on seafood packaging resulting in more delays.

Escalating prices for soybean meal, wheat and corn since the third quarter of 2020, continued into 2021. Soybean prices rose 57% over the September 2020-May 2021 period. High feed prices hurt more the producers of pangasius and other low value fish. Our May aquafeed report, noted that pangasius feed prices rose by 16% in Vietnam. Recently, the rise in shrimp feed prices in India was 8-12%.

Costs of production have been rising across species. Across supply chains, there are increases in energy, farm inputs and the expectation of more to come.

Despite this, the industry has been living with the pandemic rather well. Open exchange of information was rampant across countries with a proliferation of webinars connecting people as the alternative to face-to-face meetings. Technology-savvy rose across the industry; not only farmers spending time to communicate online and with online training but how innovators have offered solutions. There is still hesitancy among stakeholders on the adoption of digitalisation to improve the 'Internet of Things' but imagine the pace if we did not have lockdowns. In 2021, we saw some IPOs; Barramundi Group was listed on the Euronext Growth Oslo Exchange, and Thai Union Feedmill on the Stock Exchange of Thailand. Both have large expansion plans using IPO proceeds.

In August, we had a successful virtual TARS 2021 covering the shrimp sector. One lesson from this TARS was that while Asia's intensive farming continues to progress, it will be technology that will keep us ahead of competition together with a sustainability story, amicable to our markets. Read the story on pages 4-6.

In 2021, we have seen 'the good (seafood as a winner), the bad (high feed and production costs) and the ugly (supply chain disruptions). In the next editorial in January, we will talk about anticipating a rebound. Happy New Year

If you have any comments,  
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Contrary to our worst fears, in 2021 some shrimp producers have done well, that is if their major market is the US, while uncertainty remains for others. Mass vaccinations have prompted revenge dining and increasing seafood demand.

While US imports for the retail sector have risen as consumers learnt to cook seafood at home, the re-opening of food service has provided a net gain. Angel Rubio, Urner Barry (TARS 2021) predicted that we will soon see the highest shrimp consumption in the US. YTD July 2021, shrimp imports in the UK and EU27 countries are now recovering strongly with volumes above pre-pandemic levels, according to Rabobank's Gorjan Nikolik at the IFFO conference in October. Global shrimp supply in 2021 is expected to be up by 8.4%, or perhaps up by 10% (as the year is still not over), led by Ecuador, according to GOAL 2021, held recently.

Post lockdowns, salmon and shrimp are winners, breaking records. In shrimp supply, India and Ecuador have pushed ahead. India has

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

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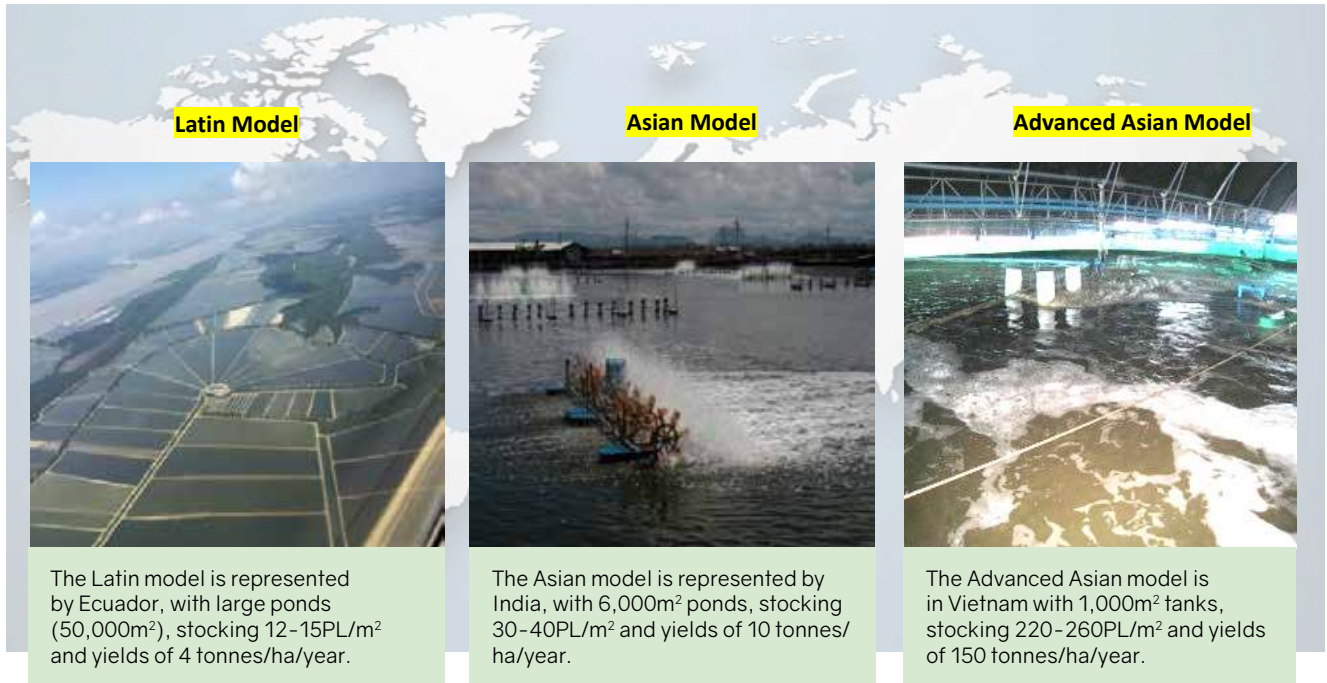
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# Shrimp farming models in Asia and Latin America

SWOT analysis and which future model for a profitable shrimp business in Asia to meet market demand

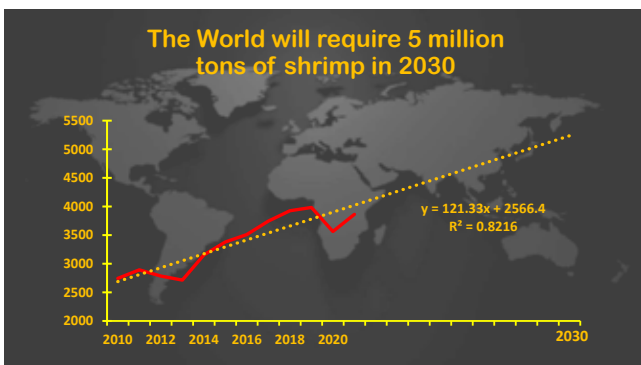


When *Penaeus vannamei* was introduced into Asia, the model was vannamei shrimp *ala* Asia, with intensive systems. While previously farming the black tiger shrimp *Penaeus monodon* at only 30 post larvae (PL)/m<sup>2</sup>, Asian producers began by stocking vannamei shrimp at 80 PL/m<sup>2</sup> to take advantage of the total water column and later up to as high as 500 PL/m<sup>2</sup>. Using the Ecuadorian extensive model as the benchmark, at TARS 2021, an industry panel led by Professor Patrick Sorgeloos, Ghent University, Belgium discussed how sustainable is Asia’s intensive shrimp model.

A SWOT analysis on “Cultured shrimp in 2030: Low density models of the Americas or the more intensive models of Asia” by Robins McIntosh, Executive Vice President, Charoen Pokphand Foods, Bangkok, Thailand and a presentation on “Bringing back black tiger – better or blunder” (see pages 14-17) by Dr Manoj Sharma, Mayank Aquaculture, India, set the stage for this conversation. Industry panellists were Darryl E. Jory, Consultant, USA and Dr Tung Hoang, Principal Research Scientist, CSIRO, Australia.

McIntosh approached the subject by looking at volumes that markets can absorb in the future (2030) and used this to fit production into this future demand. A regression analysis based on 10-years of production gave 5 million tonnes as the target demand by 2030 which is 1.5 million tonnes more than the current production of 3.5 million tonnes (Figure 1). Comparing market share since 2008, McIntosh said that the industry in Latin America has been increasing its market share of world shrimp (Figure 2). “They went from 13% in 2008 to 27% in 2021. Asia had 82% of world production in 2008 and is now down to 63%.”

Latin American production is the story of Ecuador, increasing production at 25% per year. In this presentation, Ecuador became the basis of his analysis to represent the Latin American model. “In Asia, the model is India, Vietnam and Indonesia. They really established the face for what we want to look at in Asia; they gained 13% whereas the rest of Asia declined 4% a year,” added McIntosh. Much of the decline is from the loss of Chinese production which peaked in 2009/2010.



**Figure 1.** Regression analysis of data over 10 years was used to derive the production estimate for 2030.



**Figure 2.** The global shrimp market share from 2008 to 2021.



The session on SWOT Analysis on the Asian shrimp model was moderated by Professor Patrick Sorgeloos, Ghent University, Belgium (top right). Anticlockwise, from the middle, Dr Manoj Sharma, Mayank Aquaculture, India; Dr Tung Hoang, Principal Research Scientist, CSIRO, Australia; Darryl E. Jory, Consultant, USA and Robins McIntosh, CPF, Thailand. TARS 2021 was held from August 19-21 and focused on Shrimp: Markets, Margins and Productivity.

## Farming models

In terms of models, there are three – the Latin American model with large ponds, the Asian model with smaller ponds which Asia started off with and then progressed to the advanced Asian model of even smaller ponds and tanks for more control.

Failure rates are important (Table 1). In Latin America, generally most ponds stocked are harvested. *Enterocytozoon hepatopenaei* (EHP) and other diseases increase failure rates in the Asian model but decrease with better control in smaller tanks (advanced Asian model). Cost of production in Asia's intensive models have gone up, because of high failure rates. Ponds which are not profitable are greater in Asia adding to an overall higher cost. "Back in 2009, Ecuadorian producers were envious of the cost of production in Asia, when we had high survival and high success rates."

**“Technologies are helping industry in Asia, but we cannot continue with 65% survival rates, we need to drive up survival rates up to 90% to drive costs down.”**  
**-Robins McIntosh**

Therefore, the factors to be considered for the shrimp model for the next 10 years will be the amount of additional shrimp. "To increase production, what are the resources available? Land in Latin America will cost much more than in the 1980s when shrimp farming started. The third factor is sustainability - efficiency and technology. Latin America is adopting all three while in the Asian model, technology is key for future success."

	Latin American	Asian Typical	Asian Advanced
<b>Yield (tonnes/ha/crop)</b>	2.0-3.0	7-18	25-50
<b>Survival (%)</b>	65	60	75
<b>Failure rate (%)</b>	<5	10-30	<10
<b>FCR</b>	1.2-1.4	1.2-1.6	1.25-1.4
<b>Land efficiency (ha/tonne/year)</b>	0.8	0.1	0.02
<b>Energy efficiency (GJ/tonne)</b>	50	30	20
<b>Water efficiency (tonnes/tonne shrimp)</b>	50,000	5,000	300

**Table 1.** Comparison of average performance for the three models.

## SWOT

With regards to the Latin American model (Ecuador's model), the strength is less disease but all the pathogens present in Asia are also present in ponds in Latin America. But these pathogens do not express as disease as they do in Asia because of lower stresses in the large ponds which are largely photosynthetic.

The weakness is lower production vis-a-vis land use and with large ponds, biosecurity is not possible. Without developing new ponds, increasing shrimp supply is difficult. "They do have a better story for their shrimp. But the threat is an inability to maintain market position as shrimp markets expand," said McIntosh.

“In Asia’s intensive systems in Thailand and Vietnam, with less land, we produce more shrimp. With more technology, it can be more intensive. With specific pathogen free (SPF) broodstock, we can have more phenotypic improvements and growth rates when evolving SPF stocks versus all pathogen exposed (APE) broodstock. The weakness is more pond stress. The opportunity is new technologies. The biggest threats are increased risks of emerging pathogens due to stresses. We need to always evolve new technologies and genetics as well as management of systems, to offset environmental issues. Technology is helping industry in Asia, but we cannot continue with 65% survival rate, we need to drive up survival rates up to 90% to drive costs down.”

### APE versus SPF

The domestication and tolerance approach in APE has been successful for low density farming while hard to improve characteristics such as growth and survival. McIntosh added, “The ADG (average daily growth) with APE broodstock is 0.135-0.20g which is very far from the growth improvements achieved in Asia with SPF programs. In the Camanor farm in Brazil, which CPF has shares, it has been difficult to use non-SPF post larvae in high density farming where disease such as Infectious myonecrosis virus (IMNV) and EHP are present but in large ponds with low density farming, there is less disease stress.”

On the use of SPF advancing in Latin America, McIntosh said, “In the 1990s, the SPF broodstock in Ecuador, came from Hawaii but with low robustness. The later SPF developed in Latin America, are disease free and robust. The evolution to SPF in Latin America may occur when the needs arise for more production.”

### Land efficiency

With the Asian model to produce 5 million tonnes in 10 years, would require 35,000ha. “The Latin American model will require 1.75 million ha. However, the Latin American industry is not standing still and are slowly being intensified such as with aerators, autofeeders and shrimp toilets in Ecuadorian farms as well as in other countries. As they have not transitioned away from APE, this will become a limitation.”

It is also possible to retrofit large sized ponds into the Asian-type model. In Guatemala, large ponds have been converted into smaller ponds to yield 120 tonnes/ha/year at survival of 75%, whereas the 2014 model yielded 8 tonnes/ha/year with 45% survival.

### Technology driven Asian models

In contrast, the Asian model is technology driven and has been shown to be deflationary (lower cost). “Shrimp prices have dropped over time but as we intensify, we increase efficiency in land use, water and energy use. The technology has been in breeding, from phenotypic to genotypic selection, opening up more in terms of tolerance and improvements in survival in stress situations. We are also using more analytics in management,” said McIntosh.

“Intensive farms also have a green story; we can return the coastal lands back to mangroves. We can collect waste and

dispose responsibly. In Vietnam we use biogas digesters and dewatering equipment.”

### Into the future

In discussing market share for this future 5 million tonnes of global production by 2030, which is only a projection based on previous data, McIntosh predicted that Latin America with their clean environmental model will have 40% market share. He added that 70% of Latin American production will come from farms using the Asian model using SPF shrimp. Asia will have 48% market share, with 95% using intensive Asian models. Other shrimp producing countries such as the Middle East will contribute 600,000 tonnes using the Asian model.

**The Prediction : World in 2030**

	Tons of Shrimp ('000)	Market Share (%)	Prevalent Model	% of Production Asian
Latin America	2,000	40	Asian	70
Asia	2,400	48	Asian	95
Other	600	12	Asian	80

*The prediction on market share in 2030 as presented by McIntosh at TARS 2021*

“Monitoring markets is essential,” said Tung. “Markets have been growing at 7-8% while supply at 10%. Many producers feel that they are already saturating the market as profitability is getting smaller and risks are getting higher. In the end, I believe that the extensive model and advanced (super) intensive model may prevail since the risk of diseases is lower or well controlled. According to a top monodon processor in Vietnam, the world needs monodon shrimp, but at cheap prices at only 1.2x higher as compared to vannamei shrimp. Perhaps we need to produce less but quality shrimp.”

Aside from Latin America, Jory noted that concerns are on markets and production capacity. “Globally, the industry has the installed capacity to produce more shrimp. There are signs that the shrimp farmers in China are doing better. Many suppliers are targeting China’s market. Africa may have the potential of Latin American type ponds. Areas with the potential to expand shrimp production include Brazil, Colombia, Venezuela and parts of Central America, granted that logistics and infrastructure support are not there today.”

Finally, as markets are so critical on sustainability, Sorgeloos noted that in Ecuador, farmers have joined forces to give credibility to their shrimp product. Can this be a model to follow? Comparing the two large producers, India and Ecuador, Manoj said that in India, dominated by small scale farmers, running a program on certification is a huge task but Ecuador already has a strong edge on this with large and integrated farms.

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# Advanced maturation feeds for biosecure production of robust nauplii

Advanced maturation diets that supplement and replace high-risk traditional feeds support cost effective and biosecure production of quality nauplii

By Mark Rowel Napulan, Ramir Lee, Peter Van Wyk, Chris Stock and Craig L. Browdy



Attractability, palatability and consumption are key attributes for replacement live and fresh feeds.

The global export of specific pathogen free (SPF) *Penaeus vannamei* broodstock was estimated to be 1.4 million animals in 2019. This equates to USD77 million in trade at USD55 per animal. The majority of *P. vannamei* broodstock is exported from the Americas to Asia where 80% of world shrimp production is carried out. The use of SPF shrimp broodstock in Asia is driven by the regional use of small, biosecure pond systems.

Shrimp maturation protocols in Asia are dominated by the use of live and fresh feeds due to their perceived benefits in improving the fecundity of broodstock. These natural feeds, however, pose significant biosecurity risks. Polychaetes, an important dietary component in shrimp maturation, are confirmed carriers of *Enterocytozoon hepatopenaei* (EHP) and pathogenic *Vibrio parahaemolyticus*, the early mortality syndrome/acute hepatopancreatic necrosis disease (EMS/AHPND) causing bacteria. In fact, EMS/AHPND was first reported to have been transferred from China to Thailand through the live polychaete trade, subsequently spreading throughout Asia.

Imported live SPF polychaetes from Europe have gained popularity and are often used as supplements for cost efficiency. Recently, many large companies have invested in the production of live SPF polychaetes. These types of production systems have high fixed and variable costs.

Polychaete farms must be frequently monitored to maintain SPF status and so far, no standard third party certification bodies exist to verify the status of these facilities. Moreover, the nutritional quality of SPF polychaetes varies depending on feeds used and culture techniques.

Understanding nutritional requirements of broodstock during maturation and spawning is complex and remains obscure. Feed companies are racing to develop alternative biosecure artificial diets to supplement live SPF polychaetes and to replace a portion of non-biosecure fresh feeds. In the end, a new nutrient dense artificial diet that has greater attractability, delivers better performance and improved biosecurity can be a great benefit, helping the industry to move forward.



Live polychaetes are one of the most significant hatchery biosecurity risks.



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## New specialised maturation diet

Leading global broodstock providers invest significant resources to ensure their animals are free from pathogens which means they rely exclusively on manufactured diets. It is only upon arrival at the customer's facilities that higher risk diets enter the feeding protocol.

Disease occurrence due to breaches in biosecurity becomes a cyclical pattern and a continuing challenge to the shrimp industry. Major diseases have been shown to enter shrimp maturation systems via fresh and live feeds. Practically, there is a need to pursue a balance between using biosecure feeds combined with lower risk fresh diets that satisfy the shrimp nutritional requirements while achieving maturation expectations. Strategies for risk management include using the following:

- Low risk verified SPF fresh feeds cleaned, treated and frozen (e.g. squid).
- Frozen polychaetes for a short period of time has been shown to kill some pathogens (although extended freezing can cause leaching of critical enzymes and nutrients).
- Live SPF polychaetes.
- Biosecure manufactured diet that is proven to supplement or replace fresh/live feeds.

Zeigler Bros., Inc (USA) has invested years of research to replace live and fresh feeds and improve biosecurity in shrimp maturation systems by developing a specialised semi-moist fresh feed replacement diet that reduces costs and boosts performance and increases hatchery profitability. Zeigler's Redi-Mate, a semi-moist artificial diet has been specifically designed for maturation and spawning penaeid shrimps and has proven to deliver excellent results as shown in the field and commercial studies in both Asia and Latin America.

## The Latin American approach: Replacement

It must be noted that most shrimp maturation facilities in Latin America (LATAM) do not use live polychaetes, but rely instead on frozen polychaetes, krill, bivalves, squids etc. Redi-Mate has been tested in commercial trials in large hatcheries in LATAM and has successfully replaced fresh feeds with the highest risk of introducing pathogens.

To demonstrate the efficacy of this semi-moist artificial diet, a commercial trial in Central America was established. Three maturation tanks were fed a control diet consisting of squid, mussels, Artemia biomass, frozen polychaetes and a dry maturation diet, while the other three tanks were fed a diet in which 59% of fresh feed was replaced with Redi-Mate.

In the experimental tanks, fresh and live feed inclusion rates were significantly reduced by the incorporation of Redi-Mate in the protocol. Complete (100%) replacement of frozen polychaetes was achieved along with reducing the amount of mussels, Artemia biomass and squid at levels of -43%, -43% and -20% respectively. The semi-moist artificial diet Redi-Mate was accepted well by shrimp which readily consumed more than 5% of their biomass per day on a wet weight basis. Table 1 summarises the daily feeding rates based on dry weight for each component of the maturation diets of the control and experimental tanks.

All tanks were stocked with 360 ablated females and 300 males from a population of *P. vannamei* broodstock from the same batch and genetic line. The reproductive output from the three control tanks and the three treatment tanks was monitored for 6 weeks.

Feed item	Control		Redi-Mate	
	Dry weight %	% of diet (dry weight basis)	Dry weight %	% of diet (dry weight basis)
Squid	2.20%	31.43%	1.80%	25.71%
Mussels	1.20%	17.14%	0.70%	10.00%
Artemia biomass	0.70%	10.00%	0.40%	5.71%
Dry diet	1.84%	26.29%	0.00%	0.00%
Polychaetes	1.06%	15.14%	0.00%	0.00%
Redi-Mate	0.00%	0.00%	4.10%	58.57%
<b>Total per day</b>	<b>7.00%</b>	<b>100%</b>	<b>7.00%</b>	<b>100%</b>

**Table 1.** Feeding rates of constituent feed items for the Control and Redi-Mate tanks expressed as a percentage of biomass fed per day [(dry weight fed per day/biomass of maturation tank) x 100%].

The result in Table 2 shows that Redi-Mate, when fed at close to 60% of the entire diet while replacing 100% of the polychaetes and nearly 50% of the mussels and Artemia biomass in the diet, supported excellent levels of nauplii production. Moreover, 24% higher survival of the broodstock was observed as pathogen introduction with frozen polychaetes was eliminated by the replacement strategy.

Parameters	Control	Redi-Mate	% Difference*
Percent spawning/night	12.30%	11.50%	-6.30%
Egg/spawn	240,136	240,434	0.12%
Nauplii/spawn	114,271	116,882	2.28%
**Nauplii/female per night	13,871	13,352	-3.74%
Broodstock survival	78.6%	97.5%	24.03%
Total nauplii x10 <sup>6</sup>	147.60	158.20	7.14%

\*% Difference = ((Value<sub>Redi-Mate</sub> - Value<sub>Control</sub>) / Value<sub>Control</sub>) X 100%

\*\* This value is the Nauplii Production Index, the unit is nauplii per female per night. This is the total number of nauplii produced over a period of time divided by the number female production nights. It is sometimes expressed as nauplii per 100 females per night, in which case the numbers in the table would be multiplied by 100.

**Table 2.** Summary of maturation production results from a trial in a commercial Latin American hatchery.



Spawners fed Redi-Mate (left) show significantly improved ovary colouration indicating enhanced pigment uptake into ripe oocytes.

### The Asian approach: Supplementation

In Asia, spawn size and fecundity of breeders have been emphasised over biosecurity. Zeigler has tested replacing up to 50% of live polychaetes in commercial maturation systems demonstrating Redi-Mate efficacy in reducing costs of live SPF polychaetes without compromising on production.

Commercial Trial (Asia)	Control (live polychaetes)	Redi-Mate
% Feeding rate (wet weight)	18%	9%
% Diet (wet weight)	100%	50%
No. pairs	150	150%

**Table 3.** Feeding rate of live polychaetes versus Redi-Mate trial in Asia.

Parameters	Control	Redi-Mate	% Difference*
Initial weight	61g	61g	0%
Final weight	67g	71g	5.60%
Average nauplii/spawn	144,000	138,000	-4.30%
Mating rate	13%	15%	13.30%

**Table 4.** Performance of Redi-Mate demonstrating 50% live polychaetes replacement.

Table 4 shows that in this trial, the semi-moist artificial diet Redi-Mate demonstrated no significant difference in performance against a control that used 100% live polychaetes. It was clearly displayed in the trial that this semi-moist artificial diet can potentially replace up to 50% of live polychaetes without compromising reproductive performance or fecundity. Across Asia, hatcheries are now increasing the use of supplementation strategies after a series of successful trials.

### Dry weight versus wet weight

The real value of a maturation feed must be measured by the nutrients it provides. Moisture has no nutrient value, so the real cost and benefit of maturation feed must be measured in terms of dry weight. To understand and compare different feeding regimes used in various hatcheries around the world in terms of the actual nutrients fed, feed amounts and feed costs, each must be measured in terms of dry weight.

Maturation feed	Amount of food	Percent dry weight	Actual dry weight fed
Polychaetes	1kg	17%	170g
Squid	1kg	20%	200g
Redi-Mate	1kg	73%	730g

**Table 5.** Dry weight of commonly used maturation feed.

As shown in Table 5, 1kg of polychaetes would provide only 170g of nutrient dry weight. Similarly, 1kg of squid delivers about 200g, while 1kg of Redi-Mate makes up 730g of dry weight. Technicians may feel that consumption of the compound feed is lower than that of a fresh feed because of the amount that they are feeding. The fact is that shrimp must consume 3.5 to 4 times as much polychaetes or squid to get the same nutrient content as that of Redi-Mate. Similarly, costs should be measured in terms of dollars per kilogram of dry weight.

The real cost of ingredients must be considered relative to nutrient delivery. The key is the consumption of essential nutrients and how these nutrients are being balanced in the formulation. When it comes to manufactured feed, if the shrimp do not eat, it will not provide any benefits. In developing Redi-Mate, considerable attention was paid to attractability. Moreover, it includes antioxidants and Vpak to boost immunity, making it an optimal pathway to deliver supplements and gut health additives.

### Maturation feed calculator, a technical support tool

To simplify the development of feeding protocols when using prepared feeds, the Zeigler Aquaculture Research Center (Z-ARC) team has developed a maturation feed calculator.



Chris Stock (right) demonstrates the use of the maturation feed calculator to a customer in Indonesia.

The feed calculator is based on wet weight to dry weight ratios of different kinds of feeds. Users input the number of female and male broodstock and their approximate average body weight, to calculate the biomass. Then, the manager enters the feeding regime in terms of percent body weight per day of different maturation feed types used. In Figure 1, this hatchery is using 10% polychaetes, 15% squid and 5% mussels.

Population			
Numbers of female breeders per tank			105
Average weight- females (g)			45
Numbers of male breeders per tank			110
Average weight- males (g)			38
Broodstock biomass (g)			8,905

Control tank			
Feed type	% BW (wet weight)	g/day (wet weight)	% BW/day (dry weight)
Polychaetes	10.00%	891	1.70%
Squid	15.00%	1,336	3.00%
Mussels	5.00%	445	1.00%
<b>Daily Total</b>	<b>30.00%</b>	<b>2,672</b>	<b>5.70%</b>

Redi-Mate tank			
Feed type	% BW (wet weight)	g/day (wet weight)	% BW/day (dry weight)
Zeigler Redi-Mate	3.01%	268	2.11%
Polychaetes	7.00%	623	1.19%
Squid	12.00%	1069	2.40%
<b>Daily Total</b>	<b>22.00%</b>	<b>1,960</b>	<b>5.70%</b>

**Figure 1.** An example of the maturation feed calculator interface.

The program calculates the percent body weight per day of dry weight fed; in this case, 5.7% per day. The calculator recommends the right amount of Redi-Mate to replace a certain fresh feed, based on the dry weight. To achieve best results, the semi-moist artificial diet must be fed at rates of 2.5% to 3% per day based on total biomass. In this example we recommend reducing the polychaetes from 10% to 7% wet weight and squid from 15% to 12% wet weight per day and replace with Redi-Mate. The overall dry feed rate remains at 5.7%. Zeigler's technical team is ready to discuss current practices and make recommendations on how to incorporate Redi-Mate into the hatchery's maturation system.

**Variability in the industry: East vs West**

The Zeigler team has been using the maturation calculator to support shrimp hatcheries globally. Interestingly, much has been learnt on the variability in practices from one hatchery to another. For example, in LATAM, live polychaetes are not fed and in Ecuador most hatcheries do not use polychaetes at all. Many use frozen Artemia biomass or even beef liver. On the other hand, in Asia, nearly all hatcheries use live polychaetes with the goal of increasing spawn size.

A key index for understanding feeding rates is the total dry weight of maturation feeds offered for a given biomass of broodstock per day. This number informs us if the maturation system is being overfed or underfed. Feed intake can be related to the health and productivity of the broodstock hence, depending on the type of feed consumed, it will manifest later in overall performance.

	1	2	3	4	5
<b>Ecuador</b>	6.64%	5.98%	5.59%	5.11%	4.14%
	Most hatcheries do not feed polychaetes, most feed frozen Artemia biomass, some mussels, liver				
<b>Indonesia</b>	6.35%	6.30%	5.84%	5.40%	5.10%
	Most hatcheries use live polychaetes, frozen squid, mussels, no Artemia biomass				

**Table 6.** Variability in % feed rate (dry weight) in maturation systems.

In Table 6, Ecuador has variable range from 6.64% (dry weight) down to 4.14%, while in Indonesia, the amount of feed used ranges from 6.35% to 5.1%. On average, most systems are between 5.5 and 6% dry weight per day based on total biomass.

**Wean and train**

To successfully achieve adequate inclusion rates for prepared diets the following steps are recommended when acclimating broodstock:

1. Feed 100% prepared diet for the first 3-5 days. Whenever possible, try to provide the same feed last provided by the broodstock supplier.
2. On day 4-6, begin incorporating fresh feed from 1 feeding per day to 3-4 feedings to achieve a ratio of four meals fresh feed to two meals of prepared diet.
3. Alternate fresh feeds and artificial diets between feedings.

For older broodstock, it is necessary to train them back to accepting pellets. During the initial introduction, it is advised to skip one meal before introducing Redi-Mate to enhance appetite. Ensure to feed the semi-moist artificial diet right after water exchange, leaving no signs of fresh feed such that only Redi-Mate's attractants dominate.

**An industry perspective**

Hatcheries in Asia pay premium prices for quality SPF broodstock. For the industry to be sustainable, it is imperative that growers balance biosecurity demands with the desire to maximise spawn size and nauplii production numbers. The long list of diseases that have decimated shrimp aquaculture for decades, along with new emerging threats Taura syndrome virus (TSV), white spot syndrome virus (WSSV), EMS/AHPND, EHP, shrimp haemocyte iridescent virus (SHIV), viral covert mortality disease (VCMD) etc. must motivate our industry to do better.

Experience provides ample evidence that maturation is the first entry point of disease. With new and improved prepared maturation diets now readily available, managers have the options to achieve biosecurity without sacrificing productivity. Development of well considered, cost effective feeding regimes incorporating attractive prepared feeds like Redi-Mate that delivers nutritional and health advantages have been shown to provide higher broodstock survivability, better longevity and higher quality nauplii.

We all must challenge industry norms and profitability based on short term objectives. By developing and applying new maturation protocols and technologies that enhance biosecurity, we can ensure consistency, responsibility, and sustainability through all phases of shrimp production.



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## Black tiger shrimp: Better or Blunder

The pull for a return to its farming is the availability of SPF broodstock but a concern is competition with the large vannamei shrimp



Harvested monodon shrimp in September 2021

Back in 2014, Dr Manoj M Sharma, Director at Mayank Aquaculture Pte Ltd (MAPL) came to the TARS conference to explain his way to farm *Penaeus vannamei*, the monodon way, producing large size shrimp (40-50g) at low stocking density of 15-20 PL/m<sup>2</sup> in Gujarat, India. This year Manoj has reverted to farming black tiger shrimp (*Penaeus monodon*) which became possible with the recent availability of post larvae from specific pathogen free (SPF) broodstock in India.

As a longtime advocate of farming the monodon shrimp, given the right conditions, Manoj decided to test whether “bringing back the black tiger shrimp is better or a blunder” for him. During TARS 2021, he discussed his reasons for bringing back monodon shrimp production although there is concern on its export potential.

SPF and domesticated monodon broodstock are now available in the region, which Robins McIntosh, CPF, Thailand referred to as the push for the successful expansion of monodon farming in China, Malaysia and Vietnam. Dr Tung Hoang, CSIRO, Australia said that Vietnam produces 250,000 tonnes of monodon shrimp annually using extensive culture models where stocking at 0.5 PL/m<sup>2</sup> produces 100g in 90 days and stocking at 1 PL/m<sup>2</sup> produces >100g shrimp in >120 days.

For Manoj, farming monodon in bio-secured farms using the present vannamei model should not be a problem. However, there is a need to keep a close watch on monodon growth and survival, as the carrying capacity of farms has been severely reduced due to repeated vannamei shrimp farming. When vannamei shrimp farming began in Asia, it was supposed to occupy the smaller size (100/kg to 50/kg) shrimp market but gradually, with partial harvesting, it can now occupy all size segments. Therefore, it is essential that he and other farmers understand the market for the monodon shrimp.

### History of the monodon shrimp in India

In India, shrimp farming started with its endemic monodon shrimp from 1985 to 2009, until the white spot syndrome virus (WSSV) devastated production, from its peak of 120,000 tonnes in 2005 to less than 80,000 tonnes in 2008.

“Back then, our biggest limitation was the quality of both broodstock and post larvae. We had repeated diseases; WSSV, loose shell, hepatopancreatic virus (HPV), poor growth and external fouling with slow growth. To reach 30 count/kg took 150-200 days. We were desperate until farming of the vannamei shrimp was allowed and the biggest highlight of this was the availability of SPF/SPR (specific pathogen resistant), disease free and high health broodstock.” Manoj added, “Of course the attraction was the size range accepted by markets and that production can extend to 10 tonnes/ha.”

In India, vannamei shrimp farming began in 2010 and since then, production has been phenomenal. In 2020, 95% of production was vannamei shrimp from 75 billion post larvae. Today, there is hardly any supply of monodon post larvae. “We reached 800,000 tonnes in 2019 and the 20% decline in 2020 was definitely due to production issues as much as the Covid-19 pandemic.”

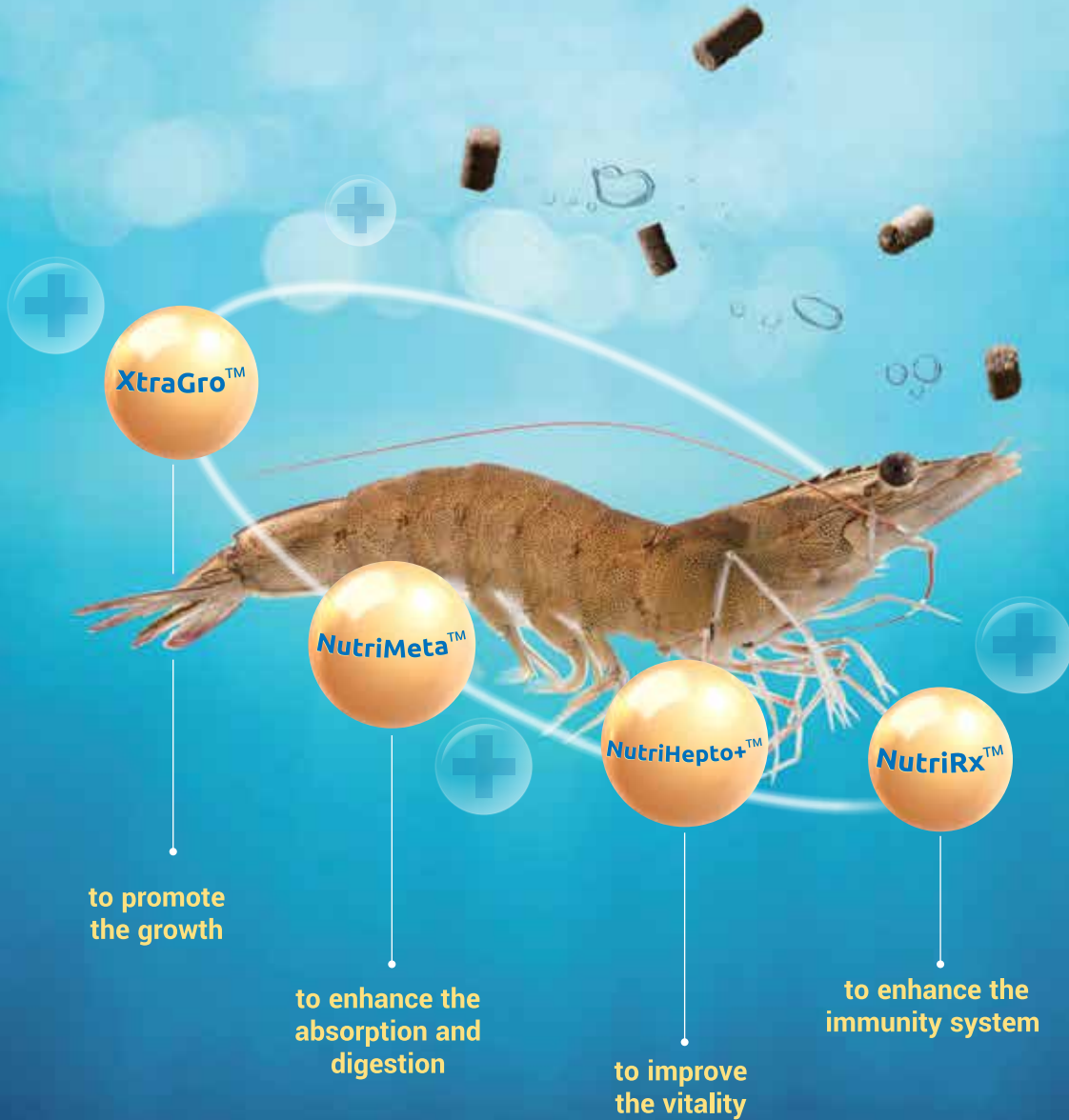
### Increasing costs of production

The problems with vannamei shrimp farming range from lower survival rate to slower growth, higher feed conversion ratio (FCR) and rampant disease outbreaks from *Enterocytozoon hepatopenaei* (EHP), *Vibrio*, atrophy of hepatopancreas, running mortality syndrome (RMS) in 5-10g shrimp, white faeces disease (WFD) and more recently, infectious myonecrosis virus (IMNV). WSSV remains the biggest threat with 50-60% of farmers reporting the disease, especially during the post-monsoon season. With the pandemic, disruptions led to drastic increases in costs. In the last three months (since May 2021), shrimp feed prices have increased 8-12%.

Manoj listed issues such as high stocking density and high salinity compounded with high organic load as the recipe for disaster in shrimp farming. It was not only production versus pond carrying capacity but also production area versus water source carrying capacity (Sharma, 2019). “I call this whitewashing in shrimp farming - in summer, it is WFD and in winter and monsoon season, WSSV!”



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**“To stay in the competition, here in Gujarat, we need to produce large size shrimp, be it vannamei or monodon shrimp.”**  
- Manoj Sharma

### Disparity in COP

In India, there are clear disparities in the cost of production (COP) between farms in Andhra Pradesh, the leading producing state with 70% of the annual production and the rest of India, in particular Gujarat (Table 1). “Post larvae cost in Andhra Pradesh is almost half that for the rest of India and feed cost is lower. COP in Andhra Pradesh is USD1 less than the rest of India. But international buyers see India as one country,” said Manoj.

Based on costs to produce 70 to 20 count/kg shrimp, Manoj said that achieving a return on investment (ROI) of at least 40% is difficult with small size shrimp. In Andhra Pradesh, farmers have been able to sustain because of better prices for small size shrimp. In August 2021, the ex-farm price for 100 count/kg was INR 180/kg (USD 2.43/kg). However, he added, “To stay in the competition, here in Gujarat, we need to produce large size shrimp, be it vannamei or monodon shrimp.”

Cost component in INR/kg	Rest of India (Gujarat)	Andhra Pradesh
Pond preparation	10	10
Seed (PL 35 to 40)	30	15
Feed	145	135
Health products	30	30
Staff and labour salary	35	35
Diesel and electricity	45	20
Repair and maintenance	12	12
Others	10	10
Total COP (calculated for shrimp count 30-40/kg)	317 (USD 4.27)	267 (USD 3.59)

**Table 1.** Comparison of cost of production in Andhra Pradesh and the rest of India, calculated for shrimp count 30-40/kg.




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Count/kg	COP/kg (INR)				Ex-farm price (INR)	Gross profit/kg (INR)	ROI (%)
	Seed	Feed	Others	Total			
70	56	82	62	200	240-230	40-30	20-15
60	49	90	71	210	250-240	40-30	19-14
50	42	98	90	230	300-250	70-20	30-8.5
40	35	107	108	250	380-280	130-30	52-12
30	27	115	118	260	500-350	240-90	92-35
25	22	123	135	280	580-450	300-170	107-60
20	17	136	147	300	680-550	380-250	127-85

**Table 2.** Comparison of cost of production for 70 to 20 count/kg. Note: Return on investment should be at least 40%.

## More on Gujarat

Until recently, Gujarat was the second largest shrimp producing state in India. It won accolades as the most productive with 95% success rates. West Bengal and Odisha have overtaken Gujarat because of hot temperatures during the latter's summer crop. "Gujarat is famous for the production of size 30-45g shrimp, which I have been promoting aggressively – farming vannamei shrimp the tiger way," said Manoj.

"Farms in Gujarat used to produce 85% of 20-30 count/kg shrimp until 2017. The downtrend came with slow growth of shrimp. In 2020, production declined to only 20,000 tonnes, versus 50,000 tonnes in 2016 with average 40-50 count/kg (15-20g). Outbreaks of WFD, EHP and RMS affected farms. "With production and profitability issues, the farming fraternity in Gujarat and Maharashtra are thinking of going back to farming the monodon shrimp."

## Fast growing and SPF monodon shrimp

"We now have this option of fast-growing SPF monodon shrimp such as those from Moana and domesticated broodstock from Madagascar. While wild monodon shrimp has an average daily growth (ADG) of 0.27g, SPF monodon grows 50% faster at 0.47g. I can get 50g shrimp in 120 days as compared with 200 days with post larvae from wild broodstock," said Manoj.

However, reverting to monodon shrimp farming also comes with uncertainties, from success rate, negative carrying capacity, markets and prices. Of course, there is always the issue of diseases. In his checklist are issues such as broodstock and post larvae quality but most important is the export potential as the vannamei shrimp has already occupied the 5-50g shrimp market. Currently, Vietnam and Bangladesh dominate the monodon shrimp markets in Japan and Europe.

"We then need to reinvent the monodon market and ensure supply, volume and consistency. We need to tie up with the right partners, the right certification program and traceability of antibiotic free monodon shrimp."

## Monodon shrimp at MAPL

In 2021, MAPL ran a monodon shrimp crop using four groups of ponds, each with 10 ponds and modifying stocking density from 10 PL/m<sup>2</sup> to 20 PL/m<sup>2</sup> (Table 3).

Total no. of ponds	Stocking density (PL / m <sup>2</sup> )	DOC	Average body weight (AWG)	Average daily growth (ADG)
10	20	104	29-33g	0.30g
10	15	96	30-33g	0.32g
10	12	70	22-25g	0.35g
10	10	102	36-38g	0.39g

**Table 3.** Results of trials with SPF monodon shrimp at MAPL in 2021 up to August 2021.



In September, the harvesting of four ponds revealed the following: at stocking density of 15 PL/m<sup>2</sup>, shrimp grew to 13-19 count/kg (52-77g) in 135 days with an average production of 5.8 tonnes/ha. Survival was 65-70% and feed conversion ratio was 1.4. "We also managed to have 10 count/kg (100g) in 160 days," said Manoj.

"For us farmers, the key is our business survival. This move is to produce larger shrimp with good margins; we have seen the rise and fall of monodon shrimp farming and the rising cost of producing 50-60 count/kg vannamei shrimp in Gujarat. To stay in the game, I would prefer to produce two tonnes of monodon shrimp with high margins.

"Now we can go back to *P. monodon*. Infrastructure-wise, we are ready to revert to this shrimp, but can we produce it smartly and sustainably? This is the key factor to bring back the beauty of the black tiger shrimp."

## References

Manoj M Sharma, 2019. The good, the bad and the ugly of shrimp farming. Aqua Culture Asia Pacific, March/April, p8-13.

# Operation plan: Back to the black tiger shrimp

Culture models to revitalise its farming in the Philippines

**Oplan Balik Sugpo Program**

This program generally aims to bring back the *Penaeus monodon* industry of the Philippines and help farmers revive their hopes and venture again into shrimp culture.

- To implement enhanced biosecurity measures and proactive disease monitoring in shrimp hatchery operations
- To integrate environment friendly schemes, enhanced biosecurity features, proactive disease monitoring, and use of probiotics in grow-out operations

Dr Leobert D de la Pena shared information on hatchery operations. Only disease-free post larvae tested at all three stages (PL5, PL10 and PL15) are stocked into ponds.

During the 11<sup>th</sup> Philippines Shrimp Congress in 2017, Southeast Asia Fisheries Development Centre Aquaculture Department (SEAFDEC/AQD) Chief Dan Baliao introduced the “Oplan Balik Sugpo” program, a joint effort with the Bureau of Fisheries and Aquatic Resources (BFAR) to bring back *Penaeus monodon* farming. Similar to other countries in Southeast Asia, white spot syndrome virus (WSSV) decimated its farming in 1997. Production hovered at around 40,000 tonnes for several years (Mamaug et al., 2021) and led to the introduction of *Penaeus vannamei* farming in 2007. Industry estimated only 5,000 tonnes were produced in 2020, in contrast with 55,000 tonnes of vannamei shrimp (Hipon, 2021). Despite this much larger production of the vannamei shrimp, in Japan, the Philippines is still identified with the monodon shrimp.

The aim of this program is to develop eco-friendly culture models, with enhanced biosecurity and proactive disease monitoring at hatcheries to encourage farmers to venture again into monodon shrimp farming. At the virtual 13<sup>th</sup> Philippines Shrimp Congress held from November 9-12, Dr Leobert D de la Pena, Head, Research Division, AQD, described the hatchery operations at the monodon shrimp spawner/broodstock facility in Iloilo. “In disease monitoring of broodstock, WSSV was prevalent in wild broodstock at almost 60% in 2020. Hatcheries then screen post larvae at PL5, PL10 and PL15 stages and only disease-free post larvae tested at all three stages are stocked into ponds. PL18-20 are transported for grow-out at the Dumangas Brackishwater Station in Iloilo.”

**2021**

Stocking density (per sq m.)	15-20
ABW (g)	29-30
DOC	123-126
Biomass (kg)/ha	4,500
Survival (%)	85
FCR	2.0

Dr Roger Edward P Mamaug described the success to date in grow-out using low-water exchange.

## Grow-out trials

Dr Roger Edward P Mamauag, Head Technology Verification and Extension Division, AQD said, "We use three ponds ranging from 5,000 to 7,000m<sup>2</sup> for grow-out and two ponds of the same size as reservoirs. We keep water in reservoir ponds for at least a week before use. Water salinity is 18-20ppt since lower salinity prevents the growth of luminous bacteria."

The environmentally friendly farming protocol includes the use of biomanipulators in reservoir ponds – milkfish, grey mullet and all male saline tilapia. These help to reduce the growth of harmful bacteria. Grow-out ponds have central sludge collectors. Biofilters in the sedimentation ponds include mussels, oysters and seaweeds. Mamauag also discussed the use of substrates to reduce negative effects of high stocking densities as well as provide larger surface areas, maintain water quality and act as a food source. These are installed during the first 45-50 days of culture.


At a stocking density of 20-25 PL/m<sup>2</sup>, the average body weight (ABW) was 30g at 113-120 days of culture (DOC) in 2019 and 28g at DOC 121 in 2020. In 2021, at a stocking density of 15-20 PL/m<sup>2</sup>, ABW was 29-30g at DOC 123-126. Overall, crop yields were high at 4.5 to 5.6 tonnes/ha and survival rates ranged from 85% to 93%. In 2020, BFAR registered 771 monodon shrimp farms. According to Maria Abegail A. Albaladejo, Chief, Fisheries Planning and Economics Division, BFAR, the goal is a steady increase of 1,000 tonnes annually, from 2021 to 2025 and subsequently, 2,000 tonnes annually.

Mamauag concluded that the long-term plan is to focus on disease diagnostics, vaccine and specific pathogen free (SPF) broodstock development. BFAR will have a broodstock multiplication centre for the vannamei shrimp at its new hatchery complex in Mindoro and the plan is also to include the monodon shrimp. The panel at the hatchery and nursery session, led by Dr Emilia Tobias Quinto, stressed that the Philippines should not give up farming its indigenous monodon shrimp as the demand is for large shrimp. Furthermore, countries like India are resuming monodon shrimp farming using SPF broodstock such as from Moana.




Source: SEAFDEC/AQD

More information: Mamauag, R.E, Dan Baliao, D., dela Cruz, J.M. 2021. Black Tiger Shrimp Culture Rejuvenation: the OPLAN Balik Sugpo of SEAFDEC/AQD. Volume 19 Number 2: 2021. repository. seafdec.org/bitstream/handle/20.500.12066/6694/Black-tiger-shrimp.pdf?sequence=1&isAllowed=y




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# 30 years of tilapia breeding programs

An essential contribution for a healthy and profitable industry

By Rajesh Joshi, Anders Skaarud and Anne Vik Mariussen



Tilapia aquaculture has grown tremendously in the past 30 years from barely 400,000 tonnes in the early 1990s to around 7 million tonnes in 2021. Nile tilapia is today the most widely farmed single fish species in finfish aquaculture, playing an important role in food security and generating income and employment in many parts of rural Asia, Latin America and Africa.

## Among the most important input factors

Behind this impressive development, there is an increasing adoption of tilapia farming due to the expansion of farming areas and new methods used. Of all farm input technologies, breeding and genetics are among the most important contributors to improvements in productivity. Several of today's tilapia breeds far exceed the performance of their original wild ancestors. Breeding technology has resulted in accumulative gains that contribute to a healthy and profitable industry.

We, GenoMar Genetics Group, have been at the forefront of this development by consistently investing, innovating and managing tilapia breeding programs and disseminating genetic progress to farmers. Under the brands GenoMar, Aquabel and AquaAmerica, we currently distribute more than 500 million fish to customers in Asia and Latin America annually and this number is growing rapidly every year.

In 2021, we are celebrating the 30th anniversary of work with Nile tilapia breeding and we have prepared a couple of articles to divulgate this important achievement.

In this first article we focus on the breeding programs and the evolution and future of our selection goals. A second article will concentrate on the effect of traditional and novel selection methods.

## Breeding programs for different farming conditions

A breeding program is a structured set of activities aimed at generating genetic improvement in a specific plant or animal population. GenoMar manages three independent breeding programs using the GenoMar (1991), Aquabel (2006) and AquaAmerica (2010) selection lines as the reference. By working with different selection lines, that differ in origin, geographical specialisation and selection traits, breeding companies are able to maintain genetic diversity and have the flexibility to develop different products that suit the needs of each market.

These selection lines are kept in specially designed and highly biosecure facilities called breeding nuclei to secure high-health status. Selection takes place in a relatively small group of fish (pedigree) using multiple sources of information from nucleus, laboratory and commercial environments (test groups). Generation interval is minimised and currently down to 6-9 months enabling more than one generation per year. The genetic progress obtained in the breeding nucleus is disseminated to the value chain via a pyramidal scheme with "multiplying generations" so the favourable genes of a few high merit individuals can be "trickled down" into billions of production fish at the farms (Figure 1).

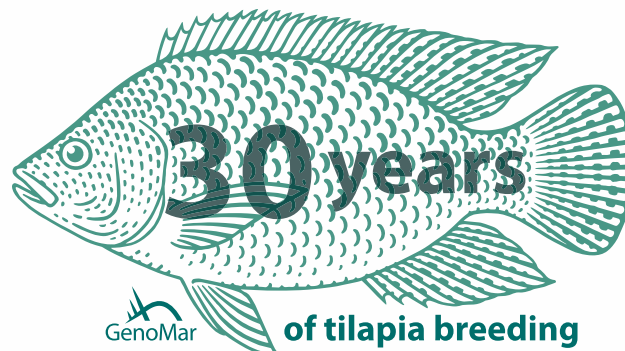
# Better growth and survival start with the right genes

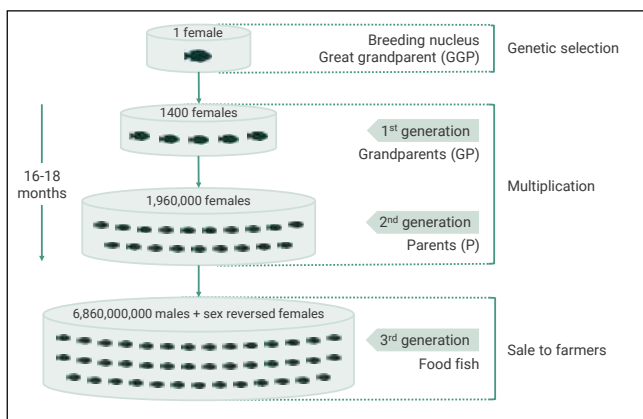
GenoMar Genetics is committed to professional and innovative tilapia breeding of the continued populations collected from Africa and Asia in 1988.

We have just finalised the 30<sup>th</sup> generation of selective breeding to support a healthy and profitable tilapia farming industry worldwide.

Our genetically improved fingerlings and juveniles are delivered all year round and have documented superior traits for:

- Growth rate
- Fillet yield
- Robustness
- Specific disease resistance





**Figure 1.** Number of commercial tilapia fish that can be obtained from a single genetically selected female of the breeding nucleus after a series of multiplication steps towards sale to the farmers.

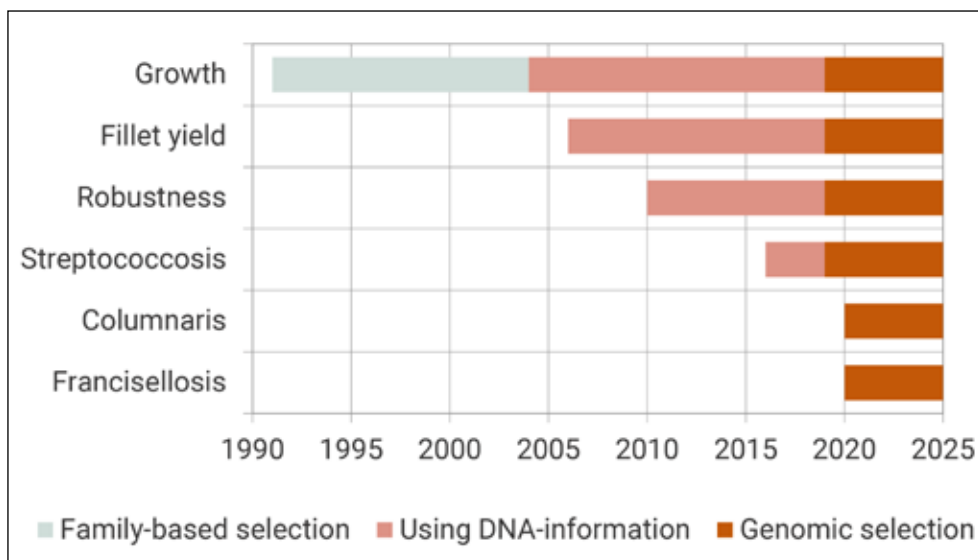
### Sustainable breeding goals

Tilapia aquaculture fulfils a primary function that is to produce animal protein for human consumption. Thus, the primary goal of a tilapia genetic improvement program must produce fish that has the following properties:

- Fast growth to bring the product to market as quickly as possible, to improve fixed asset utilisation and reduce risk
- Attractive body shape, maximise the proportion (fillet yield) and quality of edible meat
- High survival and welfare in different production systems (adaptive fitness) to limit losses, reduce use of therapeutants and maximise biomass and biomass value at harvest
- Lowest possible feed conversion ratio (FCR) and feed cost which accounts for 50-80% of the production cost depending on the system

### From narrow to broad selection goals and from a single product to the differentiated product portfolio

GenoMar has been a pioneer to include and measure various traits of commercial interest for selection in tilapia breeding programs including fillet yield and specific disease resistance (Figure 2). Our global presence gives us a unique position for wide-ranging Genetics x Environment testing for growth and survival.



**Figure 2.** Adoption of different breeding goals and selection methods in the GenoMar breeding program. It also shows the actual and tentative dates of the inclusion of various traits in the routine genetic evaluation.

### First 16 generations: Selection for growth

After the successful establishment and acquisition of the GIFT breeding program, the selection goal remained focus on improved growth rates. Hence, during the first 16 generations, fast growth was the number one trait and the only selection criterion. The combination of high genetic variation, high heritability and the fact that growth is easy to measure on a large number of selection candidates, generated a solid fundament for rapid genetic progress and transformed GenoMar into the industry reference for fast-growing tilapia strains.

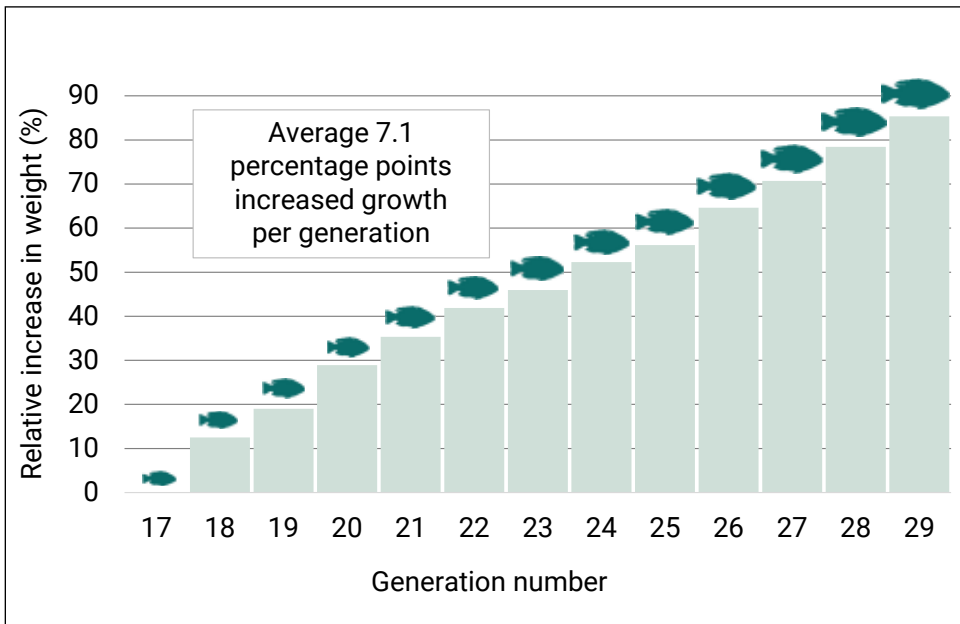
The way we measure growth has however changed over time to capture the complexity in production systems and market requirements. Thus, today our growth is a multifaceted index where information from cage and pond is collected at various locations around the world. Various weight points to select fish for various market requirements, either table or large fish market are also considered.

### Several traits from generation 17

New traits like fillet yield, general robustness and specific disease resistance were successively introduced from generation 17 to respond to the changing needs in the industry. The primary objective was to balance selection towards traits that add robustness and obtain fish with greater levels of resistance to stressors and adaptation to changes. The growth trait is still important and relevant, which has been weighted around 40-50% in the selection index and delivering average gains on 7.1 percentage points per generation (Figure 3).

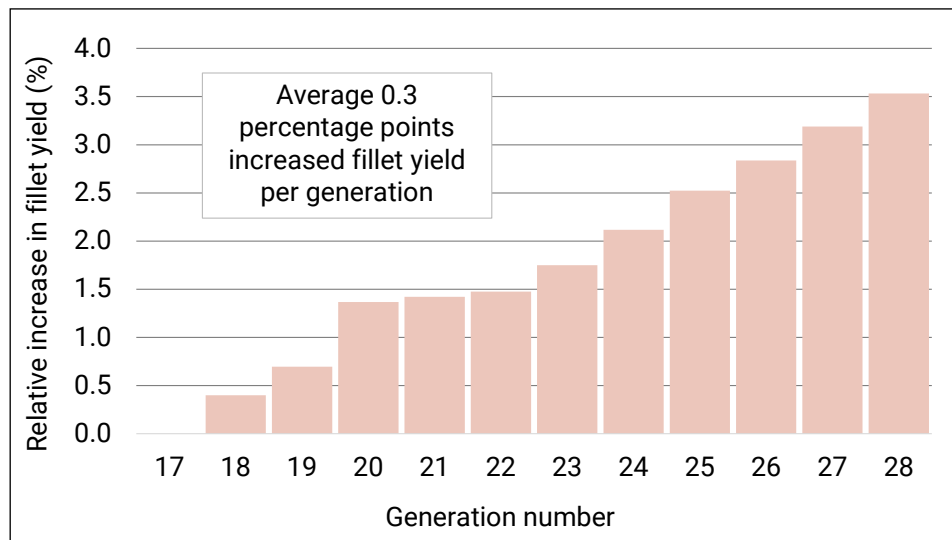
### Why do we need broad selection goals?

In the breeding nucleus, the best performing individuals are selected as the parents of the next generation, thereby producing the genetic gain in the population. To identify the best fish, the breeding candidates are ranked from best to worst and the best fitted individuals are then selected. The fish, which is best for one trait, may not be the best for another trait, depending on the genes responsible for the trait (called "genetic correlation" of the traits). Hence, if we are selecting for one trait there might not be any improvement in another trait (if the genetic correlation is 0), or we might even be selecting against another trait (if the genetic correlation is negative).



**Figure 3.** The relative increase (percentage points) in body weight in the recent 12 generations of GenoMar tilapia breeding populations. The 17th generation is used as the baseline for calculating the increased body weight per succeeding generation. Growth has been weighted around 40-50% and other traits are weighted for the remaining 50-60% when selecting for the next generations.

**Figure 4.** The relative increase (percentage points) in fillet yield in the recent 11 generations of GenoMar tilapia breeding populations. The 17th generation (the generation we started selecting for fillet yield) is used as the baseline for calculating the increased fillet yield per succeeding generation. Fillet yield has been weighted around 20-50% and other traits are weighted for the remaining 50-80% when selecting for the next generations.



**“Unfortunately, genetic progress in fillet yield is slow because heritability is low and because fillet yield information can only be obtained on relatives.”**

In tilapia, the genetic correlation of growth and fillet yield has been reported around zero or even slightly negative. Therefore, selecting for growth only may not increase the fillet yield or may even slightly decrease the fillet yield of the selected population. Similarly, the genetic correlation for growth and robustness and different specific diseases are reported from negative values to zero. Hence, broad selection goals with all these traits are required to improve the performance of the fish for production and functional traits.

### Fillet yield

An increasing trend in various tilapia markets is the industrial processing of tilapia carcasses to obtain tilapia fillets and loins. In such markets, fillet yield is a critical trait with large impacts on the profitability of processors and integrated companies. We started selection for fillet yield (ratio of fillet weight over whole body weight) in generation 17 and since then has been a permanent feature of our breeding program (Figure 4). Unfortunately, genetic progress in fillet yield is slow because heritability is low and because fillet yield information can only be obtained on relatives.

## Developing higher robustness and tolerance to diseases

As a consequence of increased intensification, water quality degradation and climate-related events, mortality is becoming the biggest problem affecting tilapia farmers around the world. Old and new pathogens are causing fish disease outbreaks and losses. Hence, robustness and survival against specific diseases have become critical selection objectives and have gained importance as target traits in the GenoMar tilapia breeding programs.

General robustness, measured as overall survival in selection candidates during the breeding period, was included in the breeding goal in 2010. Because the highly biosecure breeding environment does not represent commercial realities, we are gradually including survival data obtained from sibling testing in different commercial production environments. In this way we can account for Genetics x Environment interactions and increase the accuracy of selection for survival.

Specific resistance against *Streptococcus agalactiae*, the major causative agent of streptococcosis, was implemented as a goal in the GenoMar and Aquabel breeding program in 2016 and 2017, respectively. Since then, for each generation, representatives from all families are experimentally challenged with *S. agalactiae* to document genetic variance in resistance to the disease and to rank the families according to survival. These tests show clear and consistent variability in mortality between the families ranging from 4 to 75% and this variability has formed the basis for the selection of families with better survival. In addition, our geneticists can determine the underlying genetic components associated with the differences in mortality, using a technology called genomic selection.

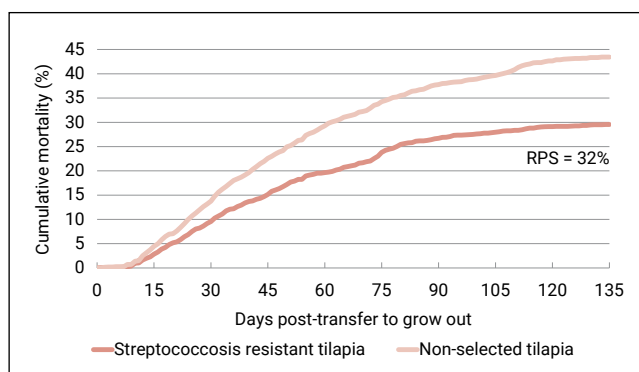
### GenoMar Strong

After three generations of selection for streptococcosis resistance and several validation studies we launched GenoMar Strong in 2021. Natural infection under industrial field conditions is an important prerequisite to confirm the validity of protection found in laboratory tests. In 2020 tilapia selected for streptococcosis resistance and non-selected tilapia were placed together in cages in a commercial farm to test the different groups under industrial-scale conditions and natural outbreaks.

At 135 days post-transfer to grow out, the cumulative mortality was on average 29.6% for the selected fish and 43.4% for the non-selected fish (Figure 5). This result is in line with laboratory validation tests and demonstrates the possibilities of selective breeding for improved fitness and survival.

**“Today’s tilapia breeding criteria are well balanced between production and functional traits to deliver genotypes that can perform well in a variety of production environments and climates.”**

Besides resistance against streptococcosis, specific resistance against columnaris (*Flavobacterium*) and francisellosis have also been incorporated in our breeding programs of GenoMar, Aquabel and AquaAmerica since 2020.



**Figure 5.** Daily, cumulative mortality in a field trial with tilapia selected for streptococcosis resistance and non-selected tilapia, 135 days post-transfer to grow out. Both groups consisting of around 2,000 fish each, were mixed, individually tagged, and raised together in cages at a commercial farm in Malaysia. The level of protection is calculated as relative percent survival (RPS).

### Past, present and future goals

From a single focus on growth, the selecting goal in modern tilapia breeding programs has changed in scope and complexity to respond to industry changes and the needs of the farmers, processors and animal welfare. Today’s tilapia breeding criteria are well balanced between production and functional traits to deliver genotypes that can perform well in a variety of production environments and climates. In the coming years, we will direct our focus on the following areas to offer the most value-added products ever to support a more profitable and sustainable tilapia industry worldwide:

- Expanding our Genetics x Environment testing program to capture a wider range of environments and systems
- Adding specific disease resistance testing to other pathogens of interest
- Delivering simple, reliable and non-destructive methods for evaluation of carcass composition and yield

References are available on request.

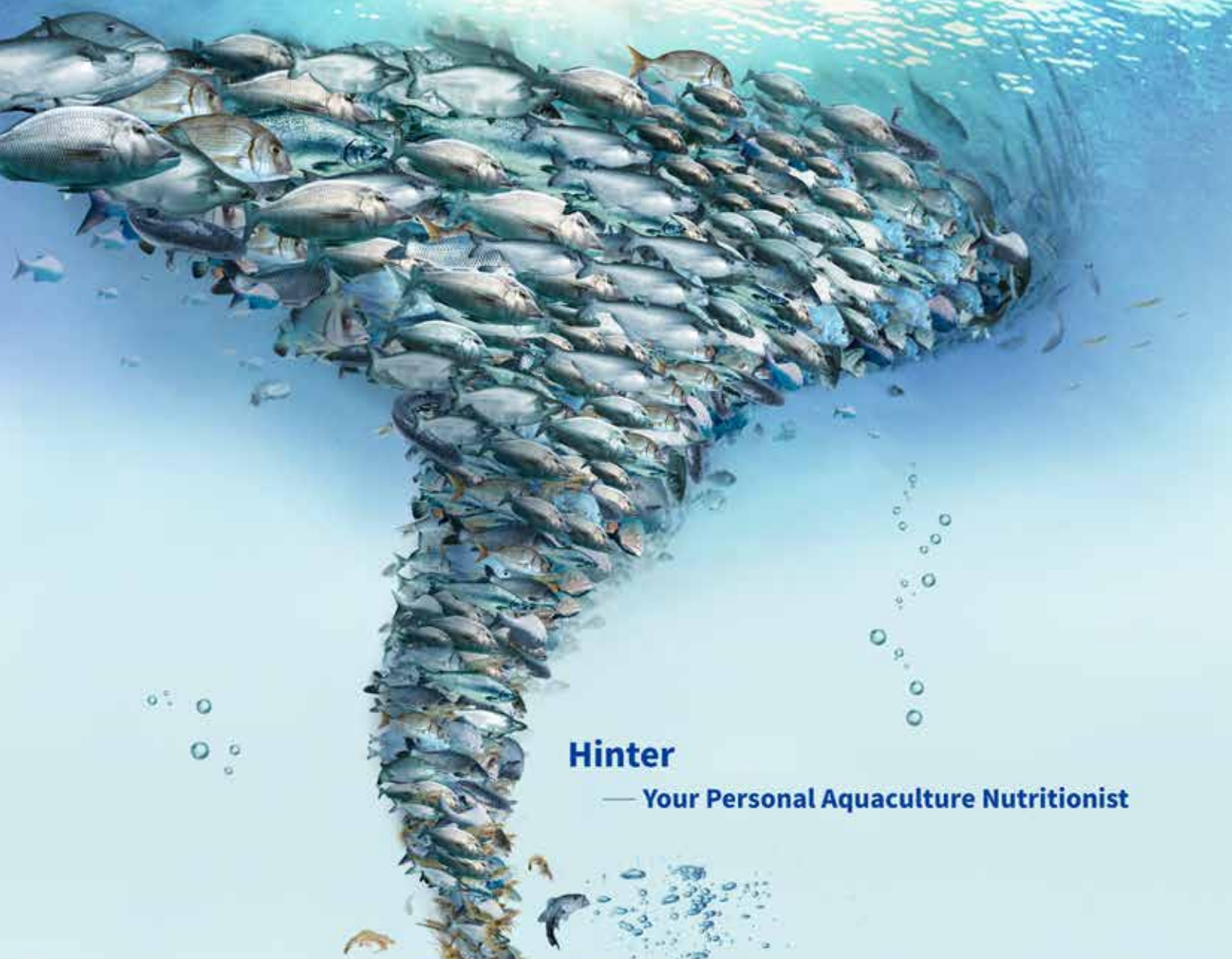


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# A view on freshwater fish farming in India

The second-largest freshwater fish producer in the world has potential for further development.

By B. Laxmappa



Almost 80% of farmed freshwater fish comprise the three Indian Major Carps (IMC). Picture shows a harvest of catla.

In India, freshwater fish production from aquaculture has increased 6.5-fold over the last two decades and contributed to more than 95% of the total inland fish production. Production is led by the three Indian Major Carps (IMC), catla (*Gibelion catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) at around 80% of the total farmed freshwater fish production. Other leading species are the exotic carps, namely silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*). Pangasius (*Pangasius hypophthalmus*) and tilapia (*Oreochromis spp*) are also farmed widely.

In 2018, India produced 7 million tonnes of farmed freshwater fish which is 8.61% of the global farmed fish production (Table 1). The very high level of technology developed for induced breeding of these carps and the abundance of agricultural by-products used as feed ingredients resulted in this rapid development of freshwater aquaculture in the country.

## Trends in freshwater fish aquaculture

Freshwater aquaculture systems are mainly ponds and tanks. Ponds in eastern India are typically homestead ponds of less than 1ha in size, while the watersheds in the west are larger, covering between 15-25ha each. In the north, open waters with in-flows are common, while in the south, watersheds, termed as tanks, are largely used for crop irrigation. In several parts of the country, ponds and tanks are state-owned or communal and are leased out for 3-5 years.

Usually, ponds of 0.1-1ha with an average water depth of 1.5-2.5m are preferred for polyculture of the major carps.

However, seasonal tanks and ponds with 5-6 months holding 1-1.5m water depth are also used. Farm practices in carp polyculture, catfish culture and air-breathers (snakehead and anabas) culture involve environmental and biological manipulations to obtain high production levels.

Most farmers have not considered other culture systems which could greatly increase fish production. Recently, a few states/provinces in India have taken up cage farming, pen culture, raft culture and recirculation aquaculture systems (RAS) to increase production. They can also adopt many other modern systems to significantly increase production while conserving water and land usage and optimising inputs such as feed, power, fuel and other inputs.

Today, several farmers of Andhra Pradesh, West Bengal and other parts of the country are producing as high as 8-12 tonnes/ha/year, which means that many fish farmers are still producing fish at less than the national average of 3 tonnes/ha/year.

Year	Production in tonnes	Percentage of global fish production
1995	1,658,800	6.80%
2000	1,942,500	5.99%
2005	2,967,400	6.70%
2010	3,785,800	6.56%
2015	5,260,000	7.23%
2018	7,066,000	8.61%

Table 1. Freshwater aquaculture trends in India.

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Bag feeding of carps in large ponds.

In IMC polyculture, the standard stocking density ranges from 6,000–8,000 fingerlings/ha for a production target of 4–5 tonnes/ha/year. Stocking densities of 8,000–10,000 fingerlings/ha increase production to 5–8 tonnes/ha/year. In seasonal ponds, or where the water level becomes limited during the summers, stocking is reduced to 3,000 fingerlings/ha to obtain a higher growth rate. In Andhra Pradesh, fingerlings of 10–15cm size are suitable for stocking. Although the IMC is expected to reach an average of 1.0kg in the first year, the growth rate is invariably reduced at higher stocking densities.

### Species diversification

Aside from the carps, species with good market demand and consumer preference include the pangasius, magur (*Clarias magur*), pacu (*Piaractus brachypomus*), murrel

or snakeheads (*Channa spp*), anabas or climbing perch (*Anabas testudineus*), pabda (*Ompok spp*), etc. This also applies to minor carps (such as *Labeo calbasu*, *L. fimbriatus*, *L. gonius* and *L. bata*) and barbs (such as *Puntius gonionotus* and *P. sarana*), etc.

The growth in pangasius farming was aligned with the introduction of extruded feeds. The feed-based system has clearly led to some recent but small developments in species diversification efforts. Modern feed mills produce high-protein, high-energy feeds for freshwater species like snakeheads (*Channa striatus*) and various marine fish and this is seen as an encouragement for farming new species in the country. By 2018, there were 30 fish feedmills in India with a collective installed capacity of 2 million tonnes per year.

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Carp fingerlings

### Stocking of quality fish fingerlings

While quality fish fingerlings in adequate quantities are crucial, this is a limiting factor compelling farmers to stock ponds with fry size (20-25mm) instead of fingerlings (35-100mm). The survival rate of fingerlings is always higher in grow-out ponds as they are less susceptible to predation, less vulnerable to diseases and more tolerant to environmental fluctuations. This leads to higher production and productivity due to a better growth rate. Advanced fingerlings (101-150mm) take less time to reach marketable size, which is ideal for multiple stocking and harvesting. Ranching of advanced fish fingerlings in a natural environment, particularly large water bodies, gives better performance. The subsequent growth of the advanced fingerlings up to marketable size is definitely rapid.

### Feeds and its management

In traditional carp farming, combinations of various feedstuffs together with formulated feed are used. When the farm gate price of carps is economical to the farmer, the carps are fed with high-priced formulated feed. However, when prices fluctuate and decrease, the fish are fed with low-cost feed ingredients. These are usually mixtures of groundnut/mustard oil cake and rice bran at 1:1 by weight. This combination is often fortified with vitamins and minerals. It is observed that stocked species also obtain around 50% protein, 8% lipid and 27% carbohydrate and 4kcal/g gross energy from natural food organisms.

Feed is usually provided at 5% of the stocked biomass in the first month of culture and gradually reduced to 1% within 6-8 months of culture. Supplementary feeding enhances fish production, permitting a higher stocking density. Fish biomass is estimated by monthly sampling and the daily feed ration is calculated accordingly. Survival of 80% is usually used for the estimation of biomass. Feed intake is often reduced during cloudy weather conditions and the winter season. Therefore, the daily ration is then modified following the consumption pattern of the previous meal.

For feeding fingerlings or growers, feed dough or dry pellets are provided in check-trays, feeding baskets or in perforated gunny-bags, which are tied to bamboo poles, and these are kept suspended in pond water at several points. Each of these bags can hold about 10-20kg of feed. When fish nibbles near the holes in the bag, a certain amount of feed mixture comes out, thus acting as a demand feeder. Such feeding practices are common in carp farms of Andhra Pradesh.

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A harvest of pacu, an exotic fish popular among consumers.



Pellet feed broadcasting of pangasius

rich in minerals and further supplements with vitamins and minerals. Interlinking of artificial feeding with natural fish food organisms (plankton) has been found beneficial as the latter influences dietary efficiency and economic utilisation of the former. There has been a rapid shift from traditional feeding to pellet feeding for nutritionally complete diets.

So far, most of the small and marginal fish farmers who form the majority, use mash feed for carp culture, where the feed conversion ratio (FCR) is about 3:1, whereas pelleted feeds are 1:1.1-1.5. With optimum pond management as well as feeding commercial feeds, it has been possible to increase aquaculture production to as high as 10-15 tonnes/ha/year for carps in 8-10 months.

In Andhra Pradesh, farmers use de-oiled rice bran (DORB) and groundnut oil cake (GNC) in a 7:3 ratio, while a farmer in Punjab is reported to enrich his traditional cake bran mixture with animal protein, sugar industry by-products

The traditional use of rice bran and oil cake mixture as fish feed is being gradually replaced with nutritionally balanced extruded feeds. Floating pellets are given to catfish and tilapia for feeding in cages, RAS and ponds in the country. Most of the country's aquafeed production is used for the farming of pangasius and pacu, which are aggressive feeders.

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Cage culture in a reservoir

## Potential of cage culture and RAS

Cage culture in large water bodies such as reservoirs is an emerging culture system and has received substantial attention from researchers, entrepreneurs and policy makers in recent years. The states of Jharkhand, Chhattisgarh, Madhya Pradesh, Maharashtra, Odisha, Telangana and Andhra Pradesh have widely adopted and cage culture technology in the country.

The government is also substantially promoting cage farming. It has subsidies for farmers to install cages and inputs. The vast water resources and conducive environmental conditions in the reservoirs are excellent for large-scale cage farming. Young entrepreneurs in India are now looking at cage farming as a lucrative business opportunity.

RAS is seen as an intensification of culture practices under the Integrated National Fisheries Action Plan. Assam, Bihar, Chhattisgarh, Haryana, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh and West Bengal have been identified to ensure the visible impact of this activity.

## Perspectives

With abundant inland water resources in the country, there is a huge potential for the development of freshwater aquaculture in India. These include 9.2 million ha of freshwater ponds and tanks, 4.03 million ha of reservoirs and 0.25 million km of rivers and canals. Currently, only 40% of the available area is used for fish farming. Additionally, there is potential for cold-water fish farming. India has considerable cold-water resources, high and low altitude lakes in addition to man-made lakes.

It is estimated that only 10-15% of India's freshwater fish production uses feed-based farming systems. A majority of freshwater aquaculture can be converted to fed systems which, when addressed well, will contribute more to resource savings and increase fish production at the same time. Converting farmers from traditional farming methods to modern farming methods will increase fish production, address environmental sustainability, uplift the socio-economic status of the farming communities and provide direct and indirect employment opportunities in the country.

The new and improved strain of some fish, such as the rohu and tilapia, could have enormous benefits if adequate fish seed is available. This would enable the production of

fast-growing, high-yielding, low-cost fish species that are more adapted to the needs of India's aquaculture ecosystem.

Increasing species diversification seems to be the key for India to march forward not only on feed utilisation but also to increase fish production and address farm gate price stability. At present, species-specific diets are being developed for the different life stages of fish. Nevertheless, in India, only about 20-30% of the fish farmers still use fish feed. Therefore, there is tremendous scope for feed-based aquaculture to enhance fish production in the country and meet the nutritional security of the ever-growing human population as well.

## References:

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The State of World Fisheries and Aquaculture 2020, Sustainability in action: FAO, Rome.



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# Relative bioavailability of DL-methionine and methionine hydroxy analogue in aquaculture

Influenced by chemical composition and fish digestive physiology, the best methionine source is important for precise nutrition and cost optimisation.

By Nguyen Van Tien and Pradeep Krishnan

**M**ethionine (Met) is one of the most important amino acids in aquaculture nutrition and plays a vital role in maintaining the health of a wide variety of farmed fish and shrimp species. Aquaculture feeds today are formulated with low or no fishmeal and with higher inclusion levels of plant protein sources. These changes result in Met being typically the first limiting amino acid (AA) - one that is in insufficient amounts - in the fish and shrimp diets. It is therefore, required to include a supplemental source of Met to meet the feeds' specifications, targeting the animal's requirement for this essential amino acid. While evaluating supplemental nutrients or additives for use in feed formulation, three parameters need to be considered: (i) nutritional value (biological effectiveness) of the supplemental nutrient, (ii) stability, homogeneity etc. during the feed production process and (iii) physical properties of the nutrient source during feeding practice.

Both terrestrial and aquatic animals can utilise crystalline AA such as Met; however, the biological availability of the different Met sources differ greatly. The difference in biological availability reflects differences in product matrix, digestibility, transport mechanism and metabolic conversion requirements. There are several commercially available Met sources in the market, however, in this article we focus on three sources and their respective relative biological values (RBV) in aquaculture diets.

- DL-Methionine (DL-Met, a 50:50 mixture of D and L isomers with 99% purity);
- Methionine hydroxy analogue-free acid (liquid MHA-FA, 88% active substance); and
- Methionine hydroxy analogue calcium salt (MHA-Ca, 84% active substance).

Both hydroxy methyl butanoic acid (HMB, MHA-FA/MHA-Ca) and D-Met isomer need to be converted to L-Met before they can be utilised by animals. The conversion of D-Met to L-Met is not a limiting process due to the existence of substantial D-amino acid oxidase and various transaminases activity in different tissues, such as kidney, liver, stomach, and intestine of aquatic animals. Although both DL-Met and HMB allow for accurate balancing of the dietary amino acid profile, they greatly differ regarding their chemical and physical properties leading to variation in biological availability to fish and shrimp species.

## Biological availability of Met sources

Biological availability is a relative value that compares the nutritional potency or efficacy of a given nutrient with a defined standard. The performance parameters commonly used when evaluating different Met sources include weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR), and feed efficiency (FE). The relative bioavailability (RBV) is comparable when a Met deficient diet is supplemented with graded levels of either Met or HMB based on the equal weight of active

substances in a way that every part of performance curve is met.

National Research Council (NRC, 2011) reported that based on available experimental evidence, it is reasonable to assume that the RBV of HMB for fish is about 75 to 80% that of DL-Met on an equimolar basis. Because weight-to-weight basis is popularly used in feed formulation, the conversion from equimolar basis to weight-to-weight basis will elucidate the benefit of these sources.

The RBV of MHA-Ca on weight-to-weight basis based on the NRC report (2011) can be calculated as follows:

- 84% purity x 75% availability/99% purity of DL-Met = 63.63%; and
- 84% purity x 80% availability/99% purity of DL-Met = 67.87%.

The RBV of MHA-FA on weight-to-weight basis can be calculated as follows:

- 88% purity x 75% availability / 99% purity of DL-Met = 66.66%; and
- 88% purity x 80% availability /99% purity of DL-Met = 71.11%.

In other words, the RBV of 100g MHA-Ca is equivalent to **63.36g to 67.87g** DL-Met, and that of 100g MHA-FA is equivalent to **66.66g to 71.11g** DL-Met.

A meta-analysis from 11 publications (Table 1) showed that the RBV of HMB is lower compared to DL-Met for all parameters examined, such as WG, FCR, FE, and SGR.



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**“In addition to the difference in the chemical composition of HMB (65% monomer and 23% polymers in MHA-FA), lower RBV of HMB compared to DL-Met could be due to poorer absorption and transportation across the intestine.”**

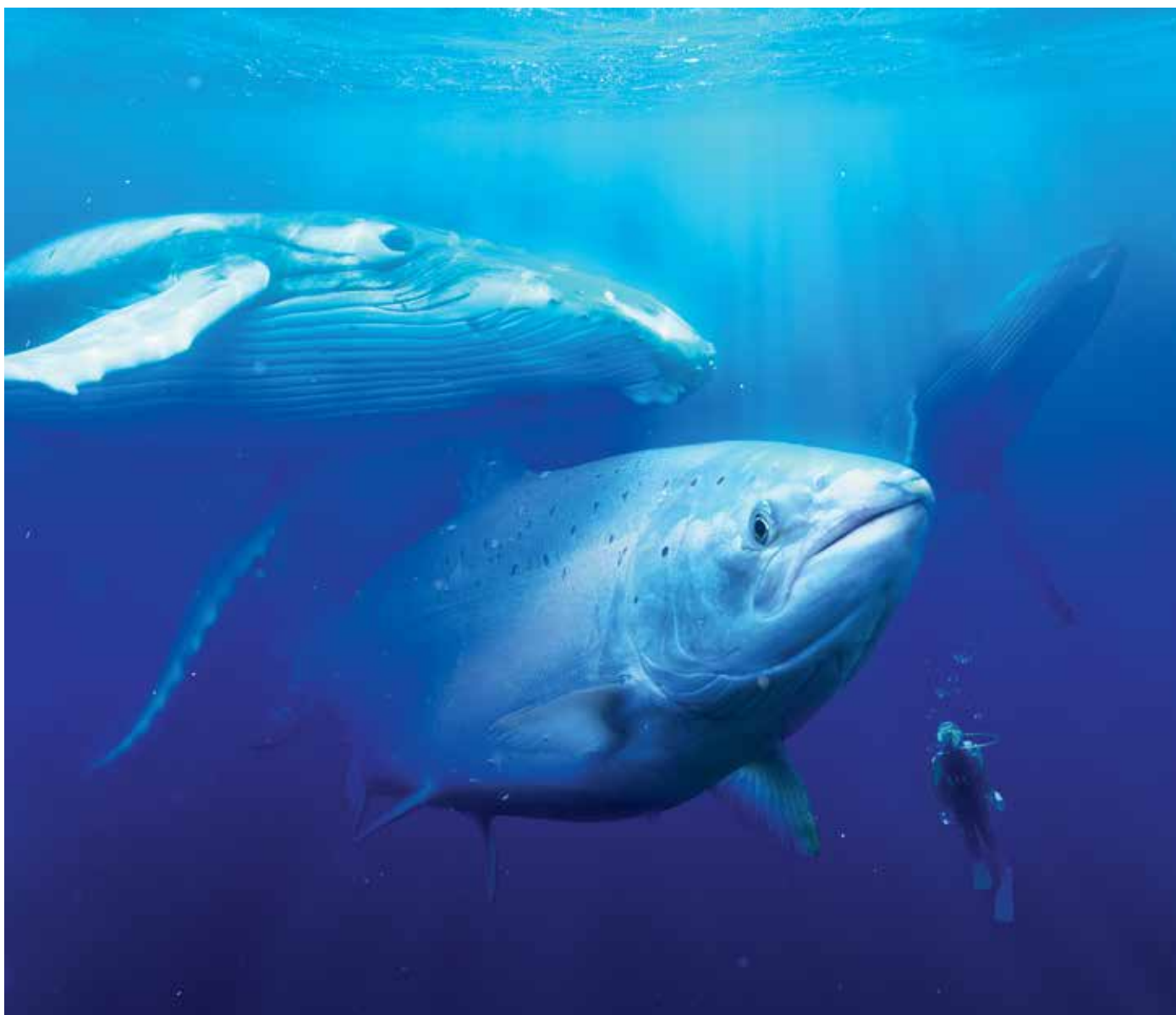
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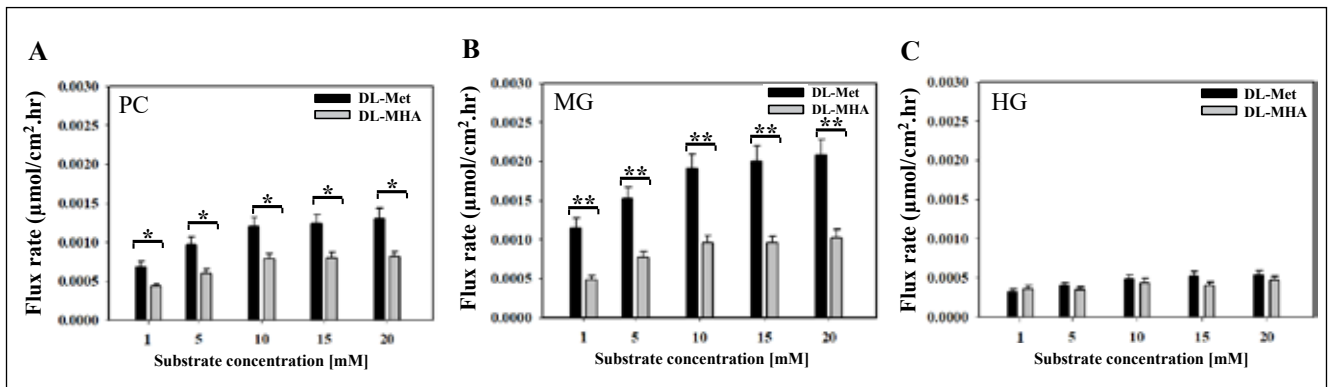
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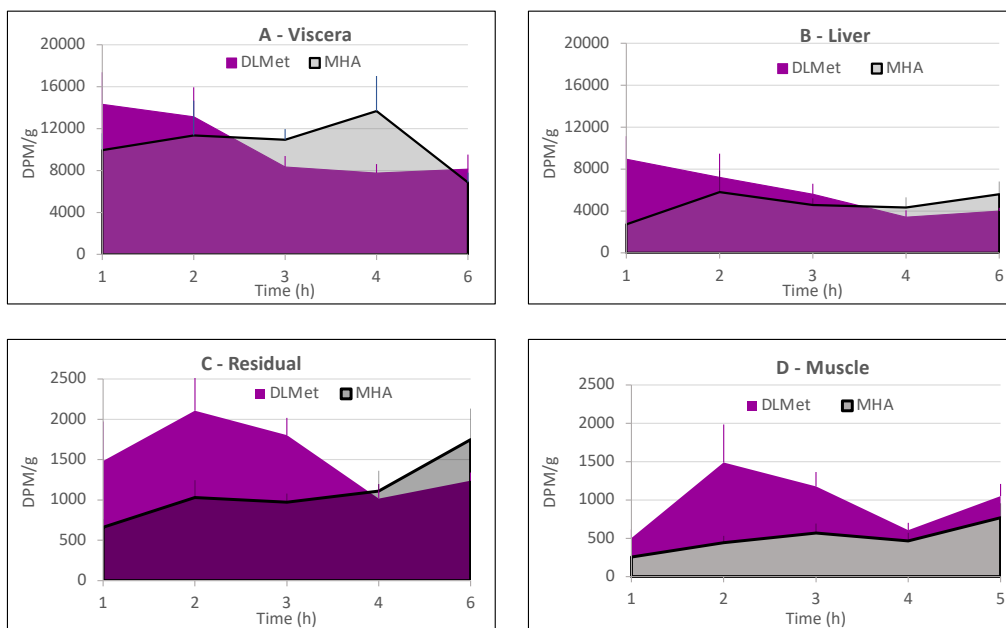


References	Species	RBV (%) of MHA-FA or MHA-Ca relative to DL Met		
		WG	FCR*/FE**	SGR
Zhou et al., 2021	Common carp	41.0	50.0*	43
Teodósio et al., 2021	Nile tilapia	58.0		
Powell, Chowdhury, & Bureau, 2017	Rainbow trout	69.0		60.0
Facts & Figures 1617, 2013	Common carp	46.0		48.0
Facts & Figures 1615, 2012	Nile tilapia			22.0
Li et al., 2009	Hybrid striped bass	86.0	76.0**	
Forster & Dominy, 2006	White leg shrimp	100	100*	
Goff & Gatlin, 2004	Red drum	62.0	69.0**	
Keembiyehetty & Gatlin, 1995	Sunshine bass	53.0	62.0**	
Poston, 1986	Rainbow trout	63.0	60.0**	
Robinson et al., 1978	Channel catfish	26.0		
<b>Average</b>		60.4	69.5	43.25
<b>Average RBV of all parameters</b>		57.72		

**Table 1.** The RBV of MHA-FA and/or MHA-Ca compared to DL-Met in aquaculture (weight-to-weight basis of active substances)



**Figure 1.** Flux rates of DL-[<sup>14</sup>C]Met and DL-[<sup>14</sup>C]MHA-FA at different intestinal segments, (A) Pyloric caeca (PC), (B) midgut (MG), and (C) hindgut (HG) of Atlantic salmon. Met substrate concentration was in millimolar concentration. Values were means ± SEM (N = 17–22). Asterisks represent significant difference in flux rates between Met sources (Student's t-test \*P < .05, \*\*P < .01, \*\*\*P < .001).



**Figure 2.** Activity expressed as disintegrations per minute (DPM) per gram of tissue of radiolabeled DL-Met and MHA-FA in Nile tilapia. Viscera (A), Liver (B), Residual (C) and Muscle (D) free fractions at 1, 2, 3, 4 and 6 hours after tube-feeding experiments. Values are presented as means ± standard deviation (n = 6–7 fish for each diet and incubation period). Different letters at the same time-point indicate significant differences (p < 0.05) between diets

## Absorption and retention

In addition to the difference in the chemical composition of HMB (65% monomer and 23% polymers in MHA-FA), lower RBV of HMB compared to DL-Met could be due to poorer absorption and transportation across the intestine. Pham et al. (2020) in an *in vitro* study looked at the transportation mechanism of HMB and DL-Met in the intestine of Atlantic salmon. The results from the study showed that the flux rates of liquid DL- $^{14}\text{C}$ MHA-FA were only about 42.2–66.0% in the pyloric caeca and midgut compared to that of DL-Met, suggesting that intestinal transport of MHA-FA to be lower than DL-Met (Figure 1).

In another *in vivo* trial with radio labelled DL-Met and MHA-Ca in Nile tilapia, Teodósio et al. (2021) revealed that  $^{14}\text{C}$ DL-Met has faster absorption and more retention than  $^{14}\text{C}$ -MHA-FA, resulting in greater availability of free Met in the tissues when fish is fed with DL-Met supplemented diet (Figure 2). When HMB stays longer in the intestinal tract it is more prone to bacterial degradation (Drew, Van Kessel & Maenz, 2003), that would lead to a further decrease in the intestinal absorption of HMB leading to higher excretion. Additionally, in rainbow trout, it has been demonstrated that MHA-FA presents a slower intestinal absorption rate than DL-Met (Pham et al., 2020).

In conclusion, application of dry DL-Met in aquaculture feed production delivers consistent results and better animal performance. Based on updated published data, it is confirmed that the average RBV of HMB to that of DL-Met is significantly lower for all performance parameters in aquaculture owing to differences in chemical composition and digestive physiology. Selection of the best Met source and application of correct RBV is important for precise nutrition and cost optimisation in aquaculture production.



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# Gut health: A focal point of Chinese aquaculture

The importance of gut health for fish and shrimp and measures to avoid gut enteritis

By Yufan Zhang



A fish farm in Zhejiang province, China

Aquaculture plays a significant role in supplying high-quality aquatic animal products to the global population, and its importance has grown in recent years, particularly in China. If we compare coastline length/national territory area, China ranks only 94<sup>th</sup> globally. Combined with the pressure to feed her population, it is not hard to understand why the biggest country in East Asia needs to rely heavily on aquaculture.

In 2019, the total aquaculture production in China was about 50 million tonnes. However, at the same time, the wastes from aquaculture processes and their consequences to the environment have become more prominent, resulting in frequent outbreaks of aquatic animal diseases.

## The physiological function of the gut

The gut is the main peptic and biggest immune organ in fish and shrimp. Damage to the gut can lead to decreased appetite, high incidence of disease, slow development, reduced ability to digest and absorb nutrients and many more.

Although the gut has many functions, digestion and absorption are among the most important. Fish and shrimp do not have intestinal glands like mammals. Still, as the most complex secretory organs, the gut of aquatic animals secretes the necessary digestive enzymes through goblet cells to aid in digestion and absorption. It is also a critical immune organ. The abundant folds of the intestines make



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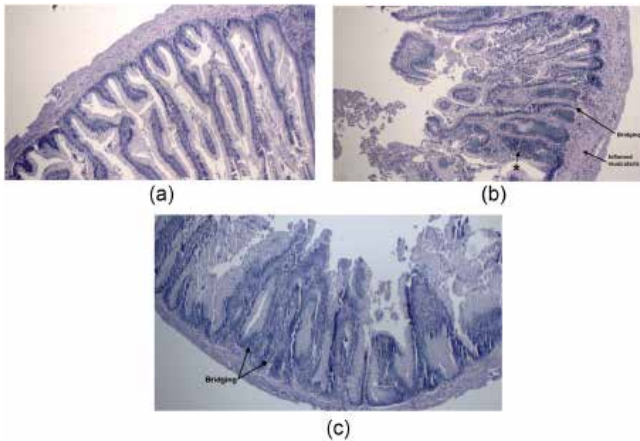


it the organ with the largest contact area with the external environment, giving it an essential role in resisting pathogenic infection and protecting the health of fish and shrimp.

The relationship between the gut and its microbes is fast becoming the focus of aquatic animal nutrition and immunity research. The intestinal microflora composition of aquatic animals is affected by various factors, and many studies show that some functions performed by the intestinal microflora are essential for maintaining normal physiological gut functions. In terms of immunity, beneficial intestinal flora interferes with and reduces the colonisation of harmful bacteria in the gut through isolation and competition. At the same time, by secreting extracellular enzymes and small molecule metabolites, aquatic animals can benefit from enhanced nutrition.

### Factors that affect gut health

Feed, the most critical input in aquaculture, significantly impacts gut health. Plant protein sources are rarely part of the natural diet of commercially farmed aquatic animals, perhaps apart from grass carp. Despite high temperature and high pressure pelleting, many plant protein sources still contain anti-nutritional factors that can damage the gut. Not only that, other low-value proteins, peroxide lipids, mycotoxins and other unsafe factors are also a threat. It is worth nothing that with the slow expansion in aquafeed demand and increased competition, price has become an important factor. A common phenomenon is the use of suboptimal and cheaper feeds with higher plant protein sources which have adverse effects on the gut.



**Figure 1.** From (a) to (c): rainbow trout (*Oncorhynchus mykiss*) fed feed with increasing levels of soybean meal show villi and lamina propria that are highly inflamed. (Kumar et al., 2020).

The farming environment also poses a threat to intestinal health. Aquaculture practices are diverse and vary from farm to farm, species to species, and dependent on the culture density. Aquatic animals are susceptible to hypoxic stress due to high stocking density. Aquaculture with lax biosecurity is often at risk from a variety of bacteria and viruses. These common problems in aquaculture will put the fish in a state of sub-health. This state will make aquatic animals particularly sensitive to opportunistic pathogens, resulting in intestinal diseases and abnormalities.

The abundance of microbes in the gut of fish and shrimp undoubtedly affects gut health. When beneficial microbes colonise the gut in large numbers, such as various anaerobic or facultative anaerobic bacteria (*Lactobacillus*, *Bifidobacterium*, *Clostridium butyricum*), they form a biological barrier that prevents harmful bacteria from colonising and multiplying. At the same time, some beneficial bacteria also secrete minor molecular nutrients, such as formic acid and butyric acid, that make it easier for the gut to recover from damage. Many factors, such as temperature, feed composition, the number of pathogens or the amount of antibiotics used, can alter the structure of gut microbes and thus affect gut health.

### Common gut problems in aquaculture

In recent years, largemouth bass farming is a booming industry in China, with production estimated to exceed 600,000 tonnes by 2021. With its rising popularity, high economic value and a continuous increase of unit yield, the problems related to its farming also increase. In 2021, bacterial enteritis is taking a toll on largemouth bass farming.

The causes of bacterial enteritis vary. Pursuing higher economic benefits with increased feeding rate lead to adverse effects on the fish. The use of trash fish is also a contributing factor. Improperly stored trash fish often contain a variety of pathogenic bacteria and toxins, damaging the fish gut health. In addition, in high stocking density fish farming, the water quality is often

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relatively poor. High ammonia nitrogen and nitrite impair fish immunity. With pathogenic bacteria in the water due to eutrophication, an outbreak of bacterial enteritis is significantly increased.

*Penaeus vannamei* is the most cultured crustacean in China. After several sluggish years, production is expected to exceed 1.1 million tonnes in 2021. In recent years, white faeces syndrome (WFS) in *P. vannamei* has plagued shrimp farmers in several producing countries. Under a microscope, we can see that the white strands floating in the water consist mainly of broken gut cells, diseased tissue, mucus and faeces. The causes of WFS vary, overfeeding in the pursuit of high yield, anti-nutritional factors and mycotoxins in feed, algal toxins or bacterial infections can all lead to this disease. In the first few days of the syndrome, shrimp are often seen swimming with long faecal strands trailing. Without timely intervention at this stage, the next phase of this syndrome can cause the sick shrimp to stop eating and gradually lead to higher mortality.

### Measures to maintain gut health


As the most crucial input in aquaculture, safe and nutritious feed is the first condition to ensure good gut health. The freshness of animal protein sources, peroxide values of lipids and the mycotoxin content of starch sources are critical in ensuring good gut health.




Checking the gut of a largemouth bass by a feed company technician



A farmer testing improvement in gut health of a farmed fish via its gut thickness and toughness; he hangs scissors over dissected intestines to verify the increase in gut toughness.




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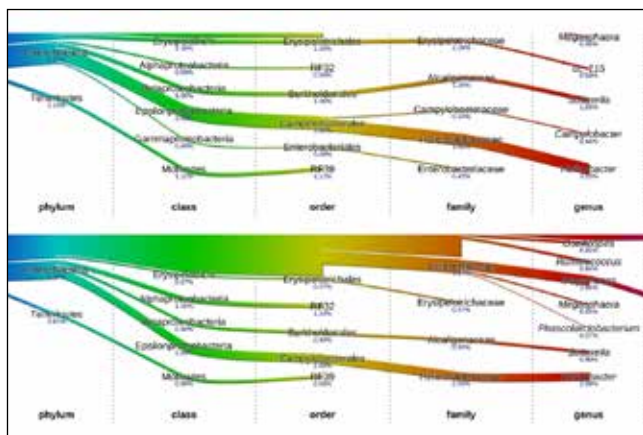
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The replacement of fishmeal is a common topic in the study of nutrition and the operation of feed enterprises. In replacement studies, the alternatives used are often only validated during the 8–10 weeks of growth experiments but some alternative ingredients may damage the gut over time. Overfeeding in aquaculture is a problem. However, if farmers avoid excessive feeding in pursuit of high yields, they can significantly reduce digestive stress in the gut.

Methods aimed at regulating gut flora are becoming powerful tools to promote gut health. Research shows that adding probiotics and prebiotics to feed can improve the abundance and structure of gut flora. In Chinese aquaculture, probiotics such as *Bacillus* and *Clostridium butyricum* are often mixed with the diet before feeding. There is a lot of scientific evidence suggesting that this leads to the thickening and wrinkling of the gut mucosa, thus increasing the villi, and hence the digestive area. This is in line with what we have observed at farms, where some farmers hang scissors over dissected intestines to verify the increase in gut toughness.

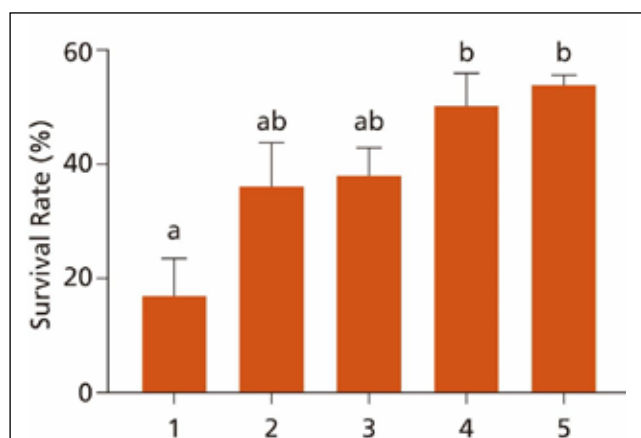
Actigen® (Alltech, USA) is a bioactive mannan rich fraction (MRF) product derived from *Saccharomyces cerevisiae*, to optimise gut health (Figure 2). It can help maintain the immune defense systems in shrimp. Farmers using Actigen in their feed have seen alleviation in WFS in *P. vannamei* farming in China's Guangdong province. These results have been gathered from on-farm observations in China. In the early stages of the syndrome, 1% to 3% Actigen was added to the daily feed ration to alleviate or even stop white faeces symptoms. In a study where Actigen was added, we found that the beneficial anaerobic bacteria in the gut, such as *Fusobacteria* and *Pseudoalteromonas*, formed an antagonistic effect with *Vibrio anguillarum*. The content of its metabolites, such as formic acid, propionic acid and isovalerate, also increased significantly.



**Figure 2 .** The supplementation of Alltech Actigen® reduced the relative abundance of pathogens consistently.

In another experiment conducted in China, we also observed that based on the regulation of gut flora, the resistance of *P. vannamei* to a *Vibrio parahaemolyticus* challenge was significantly enhanced. We conducted a 10-week growth experiment with different groups of *P. vannamei* fed diets containing Actigen from 0.2–1.6g/

tonne. After 10 weeks, *V. parahaemolyticus* was injected for a seven-day disease challenge. In Figure 3, we see significant differences in survival rates. This suggests that this prebiotic supports the health and integrity of the gut flora of *P. vannamei*.



Diet	1	2	3	4	5
Actigen® (%)	0	0.02	0.04	0.08	0.16

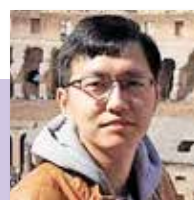
**Figure 3.** Effect of Actigen® on survival rate of shrimp after seven days of *Vibrio parahaemolyticus* challenge.) Unpublished data.

It is important to note that standardised farming and water quality management are essential in any farming model. As the organ with the largest contact area in the fish body, the gut is greatly affected by the water environment. The recommendations are to disinfect water before it is used for culture and to be replaced only with disinfected water; use formulated feed instead of trash fish, and regularly check water quality parameters to ensure that nitrogen wastes do not cause undue stress to fish and shrimp and provide adequate dissolved oxygen in the water.

These procedures are essential to maintain good gut health of fish and shrimp and for the safe development of aquaculture.

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# Functional feed additive strategies to optimise health in tilapia

Can Asian farmers learn from their counterparts in Brazil?

By Martin Guérin, Maria Mercè Isern-Subich and Waldo G. Nuez-Ortín.



Tilapia cage farming in São Paulo, Minas Gerais, Brazil (São Paulo, Minas Gerais, photo by N. Ishikawa)

In both Asia and Brazil, the tilapia's main market is domestic, usually with relatively low selling prices and there is a need to focus on cost efficiency at the feedmill as well as the farm. Therefore, the key challenge for tilapia farmers is to maximise profit, which explains the tireless efforts to improve feed conversion ratio (FCR), growth, survival, productivity and fillet yields among other indexes. On the other hand, diseases, whether parasitic, bacterial or viral, remain the main challenge faced by all tilapia farmers during all production stages and threaten the sustainability of many farming operations.

## Preventive strategies against fish diseases

Measuring the impact of disease outbreaks in fish farming is a complex task, since only a part of that impact is actually measured (e.g., apparent mortality and cost of drugs and chemicals). It is much harder for farmers to measure the hidden costs of diseases such as covert mortalities, loss of performance, under-utilised production facilities, lower fillet quality/yield, and opportunity costs from unavailability of fish during peak demand or market access limitations due to antibiotic use. In such situations, preventive strategies to manage disease problems not only improve profitability of the operation, but also help to reduce these hidden costs.

Recently, Brazilian tilapia integrators have managed to control the impact of bacterial disease threats such as streptococcosis and francisellosis on productivity through the optimisation of using specific additives in feed to promote fish health throughout specific challenging periods. The purpose of this article is to highlight opportunities for Asian farmers to improve their profitability and sustainability under challenging farming conditions.

## Tilapia farming in Brazil vs in Asia

While Asia dominates world production of farmed tilapia, Brazil, driven by a strong domestic demand quickly became the world's 4th largest producer of tilapia, reaching around 490,000 tonnes in 2020. This was +78% in 6 years, i.e. growing faster than other leading tilapia producers.

This expansion in the Brazilian tilapia industry was helped by the injection of Asian genetics including Chitralada and GIFT tilapia strains in the 1990s. The industry in Brazil differs from that in Asia by the fact that the preferred market size is for larger fish (600 to 1,200g/fish), mostly sold locally, whole or in fillets, fresh or frozen. This large fish farmed in cages or ponds, has helped the industry to move faster towards higher intensification, to use quality feeds and to implement sophisticated health management protocols.

By comparison, Asian tilapia farmers harvest fish produced from a large variety of farm types and sizes, and domestically market often smaller fish (200 to 700g/fish) that are rarely filleted. However, some large intensive cage farming operations target larger sizes (1kg/fish), aimed at fillet markets and often for exports to the USA or Europe. Such companies have much to gain from emulating disease prevention programs as practised in Brazil. However even smaller Asian tilapia farmers can also benefit as they face similar disease threats.

## Threats from *Streptococcus* and *Francisella*

The main threat for Brazilian tilapia farmers is the bacterial disease, streptococcosis during the warm months, caused by *Streptococcus* bacteria: *S. agalactiae*, *S. iniae*, and *S.*

*dysgalactiae*. These bacterial species are also found across Asia. *S. agalactiae* is the most common in key Brazilian production centres. Initially, it was observed mostly in summer (December to January) in 400–600g fish exhibiting clinical signs such as loss of appetite, bulging eyes, erratic swimming, accumulation of fluid in the abdominal cavity, and fillet damage. However, in recent years, the outbreaks started to affect also smaller fish, down to juveniles and during different months of the year, sometimes with the presence of asymptomatic animals.

During Brazil's colder winter months, *Francisella noatunensis* subs. *orientalis* is the leading bacterial threat to tilapia, causing severe damage to internal organs and fillets, often in the form of granulomas. *F. noatunensis* is globally distributed and has been reported in Asia, such as in China, Thailand, Taiwan and Indonesia (Nguyen et al., 2015). Its pathogenicity usually occurs at water temperatures <25°C (Huicab-Pech et al., 2016). The continuous threat from these bacterial diseases requires close surveillance and preventive strategy measures.



Exophthalmos in tilapia infected by *Streptococcus* bacteria

## Functional additives with antibacterial properties

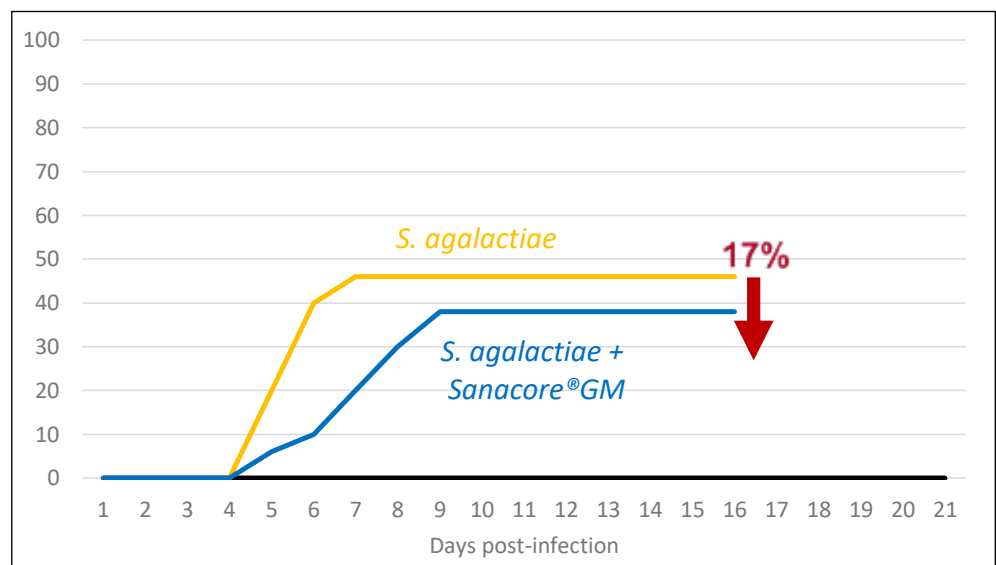
Functional additives are one of the disease prevention tools used by Brazil's leading tilapia farmers to ensure significant gains in productivity and controlling diseases, mainly in conjunction with proper nutrition and feeding, biosecurity, vaccination and good farm management practices.

The use of functional additives is recommended throughout the production cycle, mainly in highly challenging situations, such as during periods of intense manipulation (grading, vaccination and transfer), seasons of the year with high physiological stress (i.e. summer and winter) or according to demands specific to each fish farm.

Sanacore®GM and Bacti-Nil®Aqua are additives developed from Adisseo's Aquaculture Health Program and have a strong presence in the Brazilian market. They are added to the feeds both in feedmills and directly in fish farms. Sanacore GM is a blend of botanical extracts with broad-spectrum activity on fish immunity and microbial pathogens. This includes quorum sensing inhibition (i.e. interrupting the communication system between pathogenic bacteria), which promotes a positive modulation of the immune system, hence ensuring a more stable and robust intestinal microbial population. Bacti-Nil Aqua is a synergistic mixture of organic acids, with bacteriostatic and broad-spectrum bactericide activity against pathogenic bacteria, and it also acts as a growth promoter. Both additives have also demonstrated efficacy to reduce the severity of bacterial and parasitic infections.

A collaboration between Adisseo and the State University of Londrina (LABBEP, Brazil) assessed the minimum bactericidal concentration (MBC) or the lowest concentration of a product required to kill *S. agalactiae* and *F. noatunensis*. The results showed that both bacterial pathogens, Gram positive and Gram negative, respectively, are highly sensitive to both additives at the recommended doses (2 to 5g/kg of feed).

**Figure 1.** Effect of Sanacore®GM on cumulative mortality from intraperitoneal injection of *Streptococcus agalactiae*.



### Tilapia disease challenge by *Streptococcus*

The team from the State University of Londrina also conducted separate challenge trials to test the ability of both additives in minimising the effects of *S. agalactiae* infection in tilapia.

Tilapia juveniles (35 – 40g) were acclimated for 7 days after which they received either a control diet with no additive, or the same diet with either Sanacore GM (Experiment 01) or Bacti-Nil Aqua (Experiment 02) for 20 days during the pre- infection period.

During the pre-infection period in which the fish received the additives, there was a significant improvement in zootechnical performance for tilapia fed diets with Sanacore GM with 22% higher growth and 30% lower FCR compared to the control. The Bacti-Nil Aqua diet demonstrated a 10% reduction in FCR compared to the control. After 20 days, *S. agalactiae* were intraperitoneally injected with a concentration of 10<sup>6</sup> CFU/mL.

During the post-infection period, the group fed diets with the blend of botanical extracts achieved a mortality rate of 17% lower than the control group of infected fish fed no additive (Figure 1). However, the infection was more moderate. The group fed with Bacti- Nil Aqua showed a mortality rate of 6% lower than the control.

### Tilapia disease challenge by francisellosis

An *in vivo* experimental challenge in tilapia with *F. orientalis* was also conducted by infection via immersion at LABBEP. Groups previously fed (20 days) with the blend of botanical extracts added to a control diet showed 35% significantly lower mortality than the control without additive, with some fish infected. Groups fed the synergistic mixtures of organic acids showed 26% significantly lower mortality than the control group without the additives.

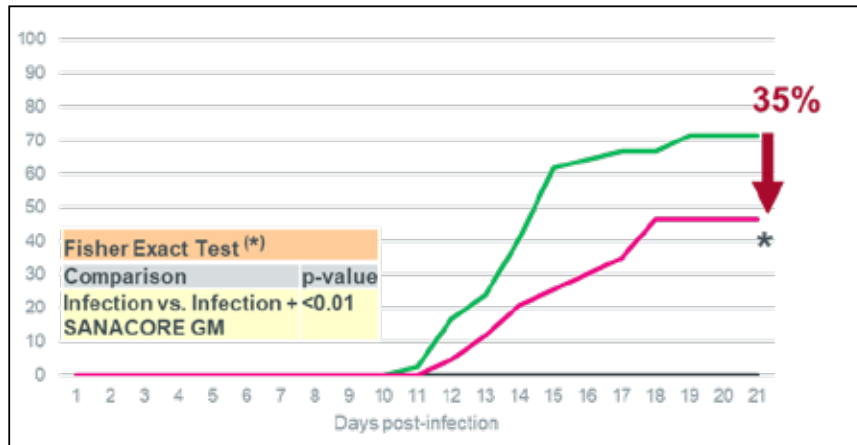


Figure 2. Effect of Sanacore®GM on cumulative mortality from *Francisella orientalis* infection by immersion.

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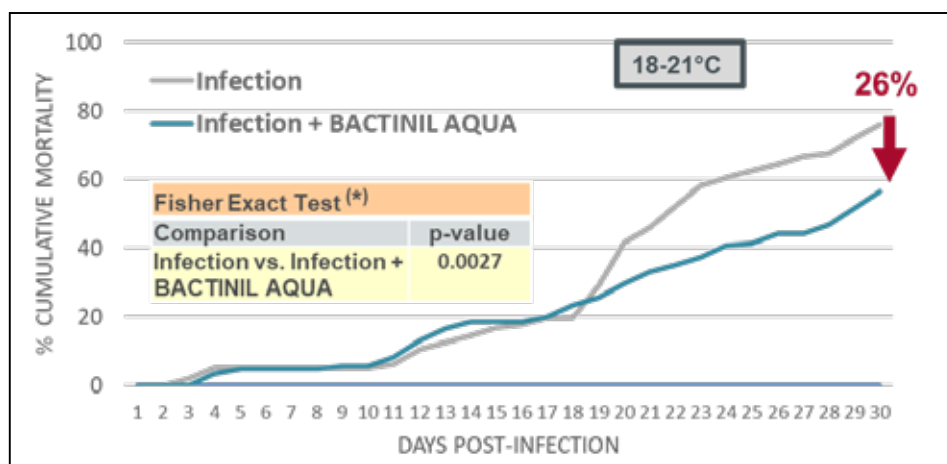
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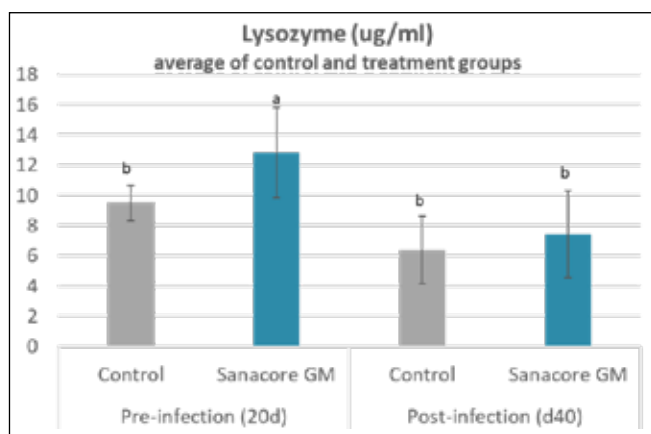
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**Figure 3.** Effect of Bacti-Nil®Aqua on cumulative mortality from *Francisella orientalis* infection by immersion.

Fish resistance to infection with Sanacore GM supplementation can be explained firstly by its antimicrobial properties, and secondly by the significant increase in lysozyme activity (Figure 4). The higher lysozyme activity means enhanced capability to break down the cell wall of pathogenic bacteria. An immunostimulant effect associated with increased diversity of the digestive microflora has also been found in fish supplemented with Sanacore GM (Robles et al., 2016). In the case of Bacti-Nil Aqua, the resistance to infection is mostly explained by its highly efficient antimicrobial effect.



**Figure 4.** Effect of Sanacore®GM supplementation on lysozyme activity in tilapia before and after bacterial infection

The more favourable improvement in survival obtained in the challenge with *Francisella*, compared to the *S. agalactiae* challenge may be due to the route of infection used for *Streptococcus*. Intraperitoneal infection (injection of bacteria inside the animal) is very different from natural infection and limits the ability of the additives to protect the fish from bacteria entering via the mucosa (gut, gills, skin), but it was the most reliable route to experimentally induce streptococcosis. Infection by immersion with *Francisella* is a more natural infection mode, where both additives offered a stronger protection as evidenced by the higher increase in survival.

The evaluations of these two additives in both *in vitro* and *in vivo* tests prove their effects against bacteria including *S. agalactiae* and *F. orientalis*. The use of Sanacore GM is recommended for fingerlings and juveniles of tilapia, to also boost immunity, while Bacti-Nil Aqua is recommended

for the fattening phases. During the periods of intense challenges, the synergistic combination of both additives is also advised.

### Major benefits: lower FCR and lower fillet rejections

This research has helped to convince leading Brazilian tilapia farms and feedmills to adopt Sanacore GM and Bacti-Nil Aqua in their disease prevention programs throughout the year, fighting *Streptococcus* during the warmer months and *Francisella* during the colder months. These pathogenic bacteria impact the efficiency of the whole production chain, especially growth, FCR and survival at the farm level, but also fillet quality and yield in the processing plants.

Farm trials using feeds supplemented with functional additives to prevent fish diseases, beyond the highly challenging periods (summer/winter) provided significant gains in survival and FCR in juveniles (-15% FCR and +10% survival) as well as positive results in the grow out phase (fast recovery in growth after challenge periods). Major benefits were also observed with reduced level of fillet rejections, which can reach up to 2% because of black spots and necrosis induced by the bacterial infections. At the processing plants, the impact of the preventive health programs showed up to 4-fold reductions in rejections compared to previous years. As a result, both the farmer as well as the processor benefited from the optimisation of the additive strategy.



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# Diving into palatability enhancers

Lessons learnt from European marine fish species to speed up innovation in Asian seabass

By Paul Seguin, Vincent Fournier and Mikael Herault

Aquaculture is in a continual state of improvement today. Focus has been directed on new methods and technologies, such as genetic selection, feed formulation, and water quality management in order to drive higher rates of production per unit area while decreasing the impacts on the environment. This endeavour for improvement is critical, because intensification in aquaculture technology will continue in the decades ahead.

In a November/December 2020 edition of Aqua Culture Asia Pacific magazine, we presented the “New generation of feed palatability enhancers designed for carnivorous fish species.” This innovative and formulated palatability enhancer (PE) called Extrapal has demonstrated its success with European feed manufacturers for Atlantic salmon, European seabass and gilthead seabream feeds.

Supporting more sustainable feed formulations, Diana Aqua keeps investing and innovating into its range of palatability enhancers while ensuring stable, reliable and environment friendly products. This second article on the PE concept aims to present the results of research performed in 2021 with the Asian seabass *Lates calcarifer*.

## A simple reminder on PE concepts

A PE formulated by Diana Aqua consists of a state-of-the-art proprietary hydrolysate rich in free amino acids and specific peptides combined to selected ingredients. The optimum effect of the PE is observed in carnivorous species when it is applied as top coating (1-2%) and during stressful events such as fish grading, feeds containing low level of marine protein, changes in feed formulation, transfer from nursery to sea cages, wintering, exposure to predation etc. The utilisation of PE will result in better growth rates over the whole cycle, with less incidences of reduced growth linked to stressful events which adversely impact on feeding behaviour (Figure 1).

Extrapal, was launched in 2020 in Europe, targeting the grower feed segments for carnivorous fish. The PE is sprayed onto extruded feed pellets at up to 2%, allowing a quick release of palatable compounds into the water that will stimulate fish to feed. At this low PE dosage, its inclusion cost is undeniably more competitive than the use of any other dry product form commonly used for the same purpose to achieve equal performance.



**Figure 1.** (Left) Modeling of a fish growth curve with and without the application of a palatability enhancer (PE). Right: PE is sprayed up to 2% on extruded feed pellets, allowing a quick release of palatable compounds in the water that will stimulate feeding.

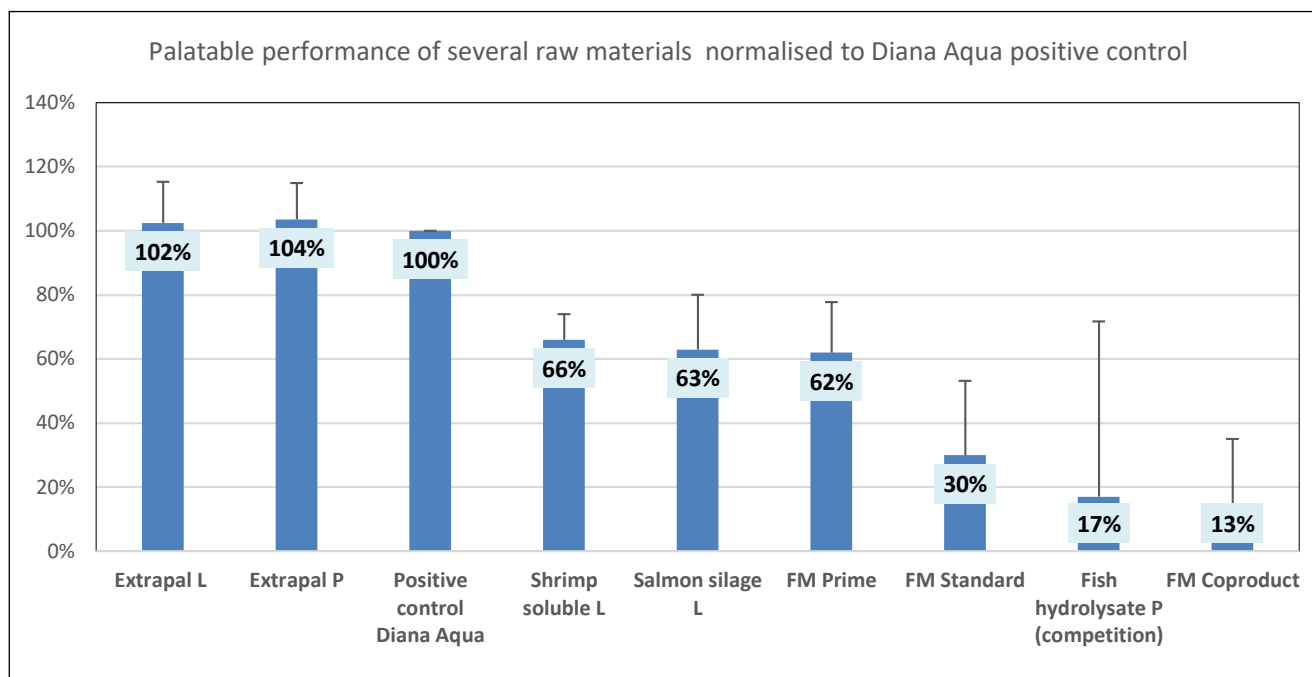
## Measuring feed palatability in fish

As indicated in the previous article, Diana Aqua has been developing and testing products for their palatability for over a decade at its Aqualis testing centres, initially in France, and since 2020, in Thailand. The method of palatability assessment is unique and enables the company to benchmark and rank the performance of its products, as well as raw materials and ingredients commonly found in the aquafeed market.

At Aqualis France, with the European seabass *Dicentrarchus labrax*, the protocol involves the utilisation of 5-10g fingerlings at a density of 40 individuals per 100L tank. To maximise expression of product palatability potential, fish are fed in slight excess using an automatic feeder for 15 days and every diet or ingredient is tested in triplicate. Feed wastes are collected. The diet is made of very standardised and nutritionally balanced plant-based feed formula (with no fishmeal) which is, naturally, not palatable to this

very carnivorous species. Diana Aqua's unique method for palatability measurement relies on a relative performance calculated from standardised negative and positive control diets.

After more than 300 palatability trials on the European seabass, it was clear that, during 15 days of feeding, fish fed the non-supplemented plant-based diet did not show an acceptable feeding behaviour. Trials demarcated two groups of fish: the first is where fish were accepting feed at low or medium rates and the second, where fish were becoming skinny because they systematically rejected fishmeal-free diets. This large heterogeneity leads to cannibalistic behaviour or a disease outbreak. In contrast, any PE added onto this plant-based diet during these 15-day trials triggered more positive fish feeding behaviour, since the very first day of the trial, and thus resulting in improvements in feed intake, growth and feed conversion ratios (FCR) compared to the group fed diets without the PE.



**Figure 2.** Palatability performance in European seabass *Dicentrarchus labrax* of Diana Aqua's palatability enhancer (Extrapal range) as compared to palatability of different grades of fishmeal, silages and fish hydrolysate. Performance was normalised to the positive control, which consists in a very standardised proprietary formulation of raw materials and ingredients guaranteeing specification and quality consistency over time.



Asian seabass *Lates calcarifer*



European seabass *Dicentrarchus labrax*

Figure 2 shows the performance of palatability enhancers compared to different grades of fishmeal and ingredients considered as highly palatable. It shows that the Extrapal range of PE outperformed these products.

### Replication of concept for tropical fish species in Asia

There are tremendous opportunities to develop the aquaculture of carnivorous fish species in Asia. If today, there are a lot of efforts on marketing and sustainability, one species in particular, the Asian seabass, is showing promising adaptations to new technologies, like recirculating system, and can contribute to a development of marine aquaculture in Southeast Asia. Since its feed formulations are still very dependent on fishmeal as the leading protein source (commonly 20 to 40% of the formula), and that the Asian seabass is very sensitive to changing environmental conditions, it makes this fish a perfect candidate to validate the PE concept developed for the European seabass. When feed palatability is ensured, a focus on feed nutrition will become possible to meet new farming requirements (improving digestibility, lowering feed wastes etc.), which will result in a lower environmental footprint while keeping fish healthy.

At Aqualis Thailand, Diana Aqua's testing centre in the Asia Pacific (APAC) area, the first palatability trial on Asian seabass was started at the end of 2020. Transposing our successful testing model from European to Asian seabass, we first developed related standardised control diets; a negative control with adequate nutritional composition, but not palatable, versus a positive control diet, widely accepted and reaching (current) maximum palatability performance. Besides the development of control diets, several factors were also considered, such as to adjust our testing protocol to this local species. This includes fish behaviour, fish genetics, feeding frequency and duration of trials, in order to standardise as much as possible our testing method and obtain very accurate responses, with low coefficient of variation, from trial to trial.

Once the protocol was defined, Diana Aqua benchmarked many ingredients and raw materials following the protocol described above. In this we created a database (Figure 3), which is helpful for a deeper understanding of palatability drivers in Asian seabass and more broadly, in carnivorous fish species.



Aqualis Thailand, Diana Aqua's testing facility in Samutsakhorn, Thailand is developing the methods to measure palatability in Asian seabass.

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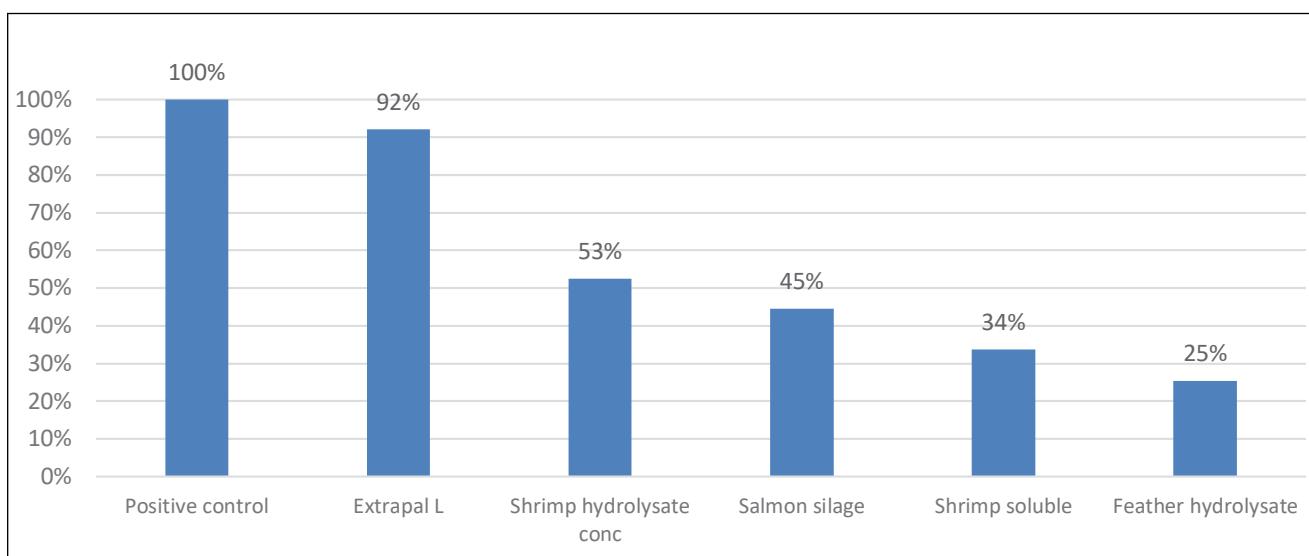
The Extrapal range is proven to enhance feed intake with flexibility for formulators. These natural ingredients ensure palatability consistency. Improving feeding behavior, feed intake is stable whatever the situation: variation in feed raw materials, stressful events... for happy fish!

*Diana Aqua is a key player in aqua ingredients supporting human's nutrition and health through the development of a sustainable aquaculture. Thanks to our dedicated team of experts and through our partnerships, we guarantee a reliable and steady supply of high quality ingredients to your business.*

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**Figure 3.** Palatability performances in Asian seabass *Lates calcarifer* for Diana Aqua's palatability enhancer (Extrapal range), and products in the aquaculture market. The performance was normalised to Diana Aqua positive control, which is currently Extrapal P in our Asian seabass model.

validated in several different carnivorous fish species. The Asian seabass is the latest species; taking advantage of the years of research carried out with European marine fish, Diana Aqua is proud to propose a new solution for the industry in Asia.

We also showed that the European and Asian seabass share the same preferences regarding palatable compounds. A good way of illustrating this is the high correlation rate we found between the relative palatability performance of both species—more than 90%. Such findings resulted in the development of a performing range of new palatability enhancers for Asian seabass. These performance gains are demonstrated in controlled laboratory conditions, with best husbandry practices besides basal diet palatability, meaning that they could be much higher during or after stressful rearing conditions (wintering, predator attacks, fish grading etc.).

## Conclusion

Feed palatability is a key driver of feed performance in carnivorous fish species. It can help the standardisation and improvement of feed and fish performance in many different challenging conditions: from fish fed diets with a low level of marine protein to those farmed under sub-optimal environmental conditions. Palatability enhancers by Diana Aqua are unique solutions developed and



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# Essential oils and their aromatic compounds

With multiple bacteriostatic and bactericidal effects, these are key to sustainable performances of fish

By Jean Peignon

Essential oils and their aromatic compounds have been studied extensively and showed many beneficial effects on fish health. However, they remain a group of diverse molecules and a complex topic which requires knowledge and expertise to ensure benefits.

Essential oils are well-recognised compounds to support the health of fish and reduce the deleterious effects of pathogenic bacteria. Recent publications (Suttili et al., 2017; Reverter et al., 2014; Mittal et al., 2018; Zeng et al., 2015) reviewed the multiple benefits of essential oils and their potential to provide sustainable alternatives to chemical treatments and antibiotics.

Essential oils is a generic term that refers to mixtures of various compounds, mainly terpenes and their derivatives, which are synthesised by plants and concentrated in hydrophobic liquids containing volatile aromatic compounds (Zeng et al., 2015). Typically, essential oils are characterised by two or three aromatic compounds in relatively high concentrations (Suttili et al., 2017): in thyme (*Thymus vulgaris*), the essential oil's main aromatic compound is thymol (20–50%), while the essential oil in clove (*Syzygium aromaticum*) is mainly composed of eugenol (70–90%). Their efficacy to reduce development of bacteria is not a coincidence, as they are an active part of the plants' defences against microbial threats.

One of the several advantages of essential oils is their multiple bacteriostatic and bactericidal effects, depending on the quantity and quality of the aromatic compounds present in them. The array of action is vast and includes the alteration of membrane lipid layer, inhibition of cell division, inhibition of ATP synthesis enzymes, inhibition of quorum sensing and biofilm formation etc. (Mittal et al., 2018). These multiple actions prevent the risk of resistance by the bacteria, which represent a major concern regarding the use of antibiotics. Besides the bacteriostatic and bactericidal effects, essential oils also exert positive effects on gut bacterial communities and digestive functions, as well as anti-oxidative effects (Suttili et al., 2017).

## Years of expertise in precision nutrition

In the late 90s, Techna Nutrition saw the potential of essential oils and their aromatic compounds to improve gastrointestinal health and nutrient absorption. More than 20 years of expertise and trials allowed for the designing of a new range of products based on essential oils and their aromatic compounds to address specific problems such as the replacement of antibiotic growth promoters, and overcome weaning stress, digestive disorders and anorexia. These products are used every day by feedmills and farmers all around the world.

Conscious that the aquaculture industry pays a heavy toll on bacterial disease outbreaks, Aquaneo, the aquaculture brand of Techna developed a dedicated solution by using the group knowledge on essential oils and their aromatic compounds. The objective was to support gut health by promoting a balanced microbiota for improved nutrient absorption and reduced impact of pathogens. Subclinical infection can lead to decreased performances, especially in aquatic environments which are prone to variations.

Aquaneo's product, called Aquaviance, is a special blend designed to tackle challenges specific to aquaculture. It uses the benefits of essential oils and their compounds on the microbiota to guarantee a better resilience of the fish in stressful environments, and improve the overall digestive functions and feed efficacy. Thanks to its mode of action, based on a strengthened gut microbiota, this blend helps fish growth and feed efficiency in farming and during challenging conditions, thus contributing to a more sustainable aquaculture.

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## The genesis of an aquaculture dedicated solution

We developed Aquaviance by combining the following:

- Digestive function support: Techna's blend for maximum effects on the gut bacterial community.
- Pathogen inhibition: A special mixture, designed to reduce the impact of most common pathogens in aquaculture and the impact of subclinical infections.
- Encapsulation: The prerequisite of technological constraints in the aquaculture industry. Aromatic compounds are sensitive and volatile, which make them difficult to use as such under commercial conditions, especially when the feed is extruded. To guarantee the lasting effect of the product after extrusion and inside the digestive tract, the product is encapsulated using a special process.

### In vitro efficacy against pathogens

A minimum inhibitory concentration (MIC)/minimum bactericidal concentration (MBC) test was performed to assess the efficacy of the Aquaviance blend on the most impacting pathogens to guarantee a vast operating range of action at constant concentrations. The trial was done to test this blend on eight types of pathogenic bacteria and challenged with a different blend on three strains of *Vibrios* (see Figure 1).

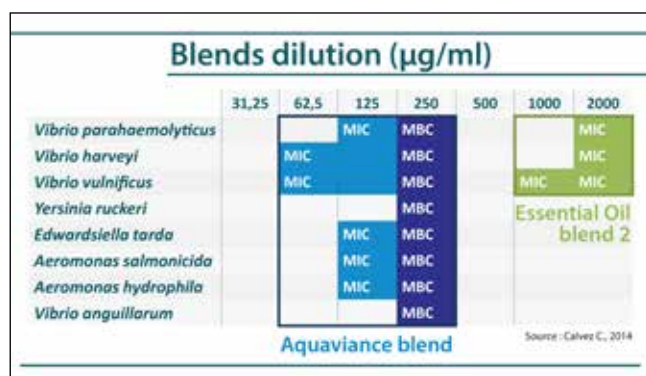


Figure 1. Aquaviance *in vitro* efficacy against pathogens.

The results showed a constant minimum bactericidal concentration *in vitro* located around 250µg/mL for this blend and a four to eight times higher efficacy when compared with the second essential oil blend. Showing that all essential oils and their constituents do not have the same efficacy and knowing the correct ingredient at the right dosage is a prerequisite to guarantee the effect.

### In vivo trials

#### Improved feed efficiency

To validate the *in vivo* efficacy of Aquaviance on digestive health and performances, several trials were performed on different species and various environments. The following

	Control	Aquaviance 0.1%	Aquaviance 0.2%
Initial body weight (g)	27.4±0.27	27.6±0.04	27.7±0.16
Initial body weight (g)	132±8.86	140±3.00	144±6.74
Weight gain (%)	381±34.6	406±10.2	418±24.3
Feed conversion ratio (FCR)	1.28±0.05 <sup>a</sup>	1.19±0.02 <sup>ab</sup>	1.13±0.07 <sup>b</sup>
Specific growth rate (SGR - (%))	2.18±0.10	2.25±0.03	2.28±0.06
Apparent digestibility coefficient (ADC - Dry matter)	66.8±1.6 <sup>a</sup>	76.9±0.9 <sup>b</sup>	77.9±3.9 <sup>b</sup>
Apparent digestibility coefficient (ADC - Protein)	86.8±0.6 <sup>a</sup>	91.4±0.3 <sup>b</sup>	92.0±1.4 <sup>b</sup>
Protein efficiency ratio	1.66±0.07 <sup>a</sup>	1.78±0.03 <sup>ab</sup>	1.88±0.12 <sup>b</sup>

Table 1. Growth performance and apparent digestibility of olive flounder *Paralichthys olivaceus* after 75 days of feeding on experimental diets supplemented with Aquaviance. Data with same superscript letters within rows are not significantly different at P<0.05.

results, from the Marine Science Institute, Jeju National University show details on its benefits on the olive flounder *Paralichthys olivaceus* (Table 1).

The nutritional trial was performed using three diets: A commercial diet as control and the same diet with 0.1% and 0.2% of Aquaviance. The fish (initial body weight 27.4g) were fed for 75 days; zootechnical parameters were recorded, as well as apparent digestibility. The results showed improved growth, feed efficacy, protein digestion and protein efficiency ratio. Survival remained high, without significant differences among the groups.

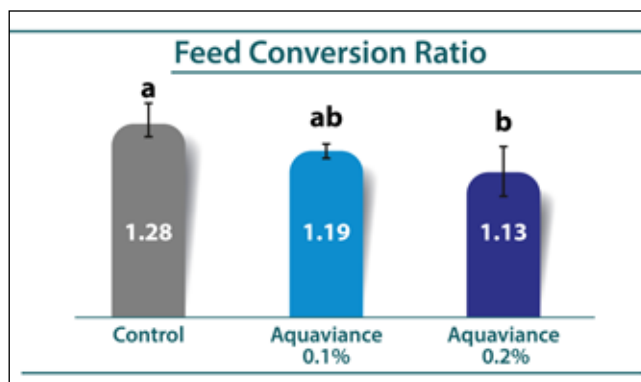
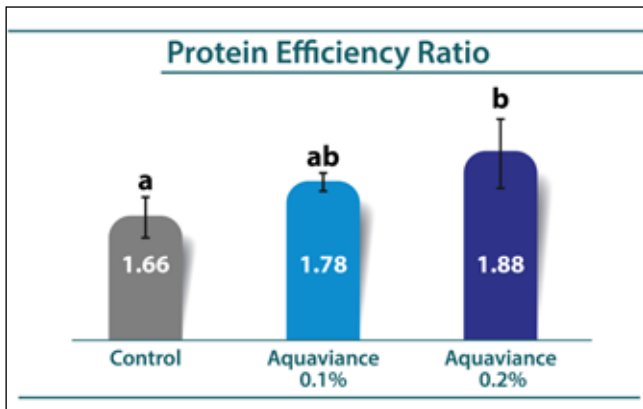
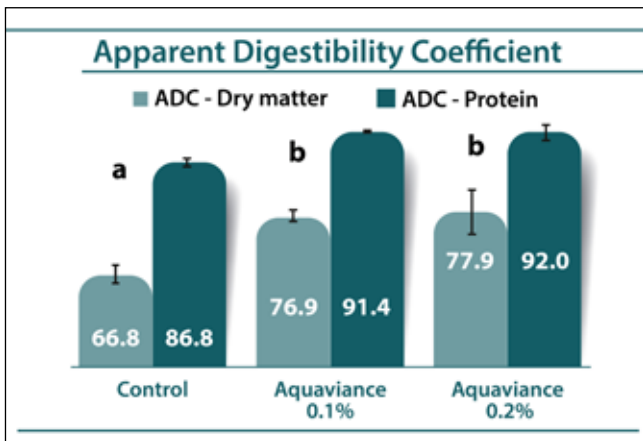


Figure 2. Feed conversion ratio (FCR) of olive flounder *Paralichthys olivaceus* fed experimental diets supplemented with Aquaviance at 0.1% and 0.2%.



**Figure 3.** Protein efficiency ratio of olive flounder *Paralichthys olivaceus* fed experimental diets supplemented with Aquaviance at 0.1% and 0.2%.



**Figure 4.** Apparent digestibility (dry matter and protein) of olive flounder *Paralichthys olivaceus* fed experimental diets supplemented with Aquaviance at 0.1% and 0.2%.

Statistical differences appeared between control and the treatment groups, Aquaviance at 0.1% for dry matter and protein apparent digestibility and at 0.2% for the feed conversion ratio (FCR) and protein efficiency ratio (Figures 2-4). These results are in line with a better valorisation of the feed, even though the diet contains a high level of fishmeal (46%).

### On farm benefits

If the effects of this blend can be measured precisely during laboratory trials, its benefits are fully seen in farm environments. Several trials were conducted under various farms conditions all around the world; one of them was performed in Vietnam with 280g catfish *Pangasius hypophthalmus* raised in earthen ponds. The use of Aquaviance at 0.1% improved the growth by 14.7%, survival by 10.4% and reduced the FCR by 9.4%. The overall outcome is a secured biomass for the farmer and a better feed efficiency which leads to substantial profits for the farmers.

As often proven, when well selected and dosed, essential oils and their compounds are useful elements in ensuring sustainable fish health and performance as well as farm profitability. Aquaviance has been developed following these principles and has proven its effectiveness in a variety of environments and species in the aquaculture industry.

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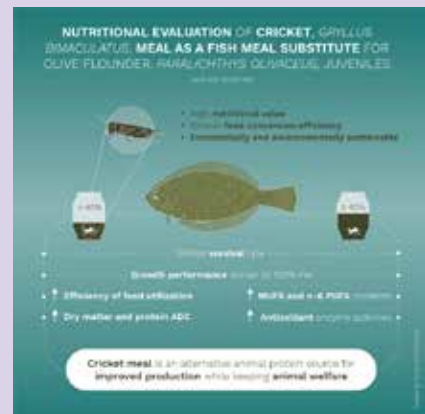
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### JWAS Editor's Choice Awards 52(4)

#### Nutritional evaluation of cricket, *Gryllus bimaculatus*, meal as fish meal substitute for olive flounder, *Paralichthys olivaceus*, juveniles

Jeong, S-M, Khosravi, S, Mauliasari, IR, Lee, B-J, You, S-G, Lee, S-M.

Olive Flounder, *Paralichthys olivaceus*, is one of the most successfully cultured flatfish species worldwide. This marine species demands high levels of easily digested protein and current production methods still rely on large amounts of fishmeal or trash fish inclusion in formulated and freshly mixed diets respectively. In the latest featured article, authors investigated increasing inclusion of meal from cricket, *Gryllus bimaculatus*, to replace fishmeal in olive flounder diets. Results showed up to 40% fishmeal replacement without any growth reduction. Antioxidant enzyme activity increased with cricket meal inclusion up to 60% but fatty acid profiles were impacted by high inclusion levels. Results indicate cricket meal is a readily available and viable protein source for partial fishmeal replacement for this valuable finfish species. <https://doi.org/10.1111/jwas.12790>



Source: [www.was.org](http://www.was.org)

# Insect meal improves the survival rate and boosts growth performance when partially replacing fishmeal in whiteleg shrimp diets

By Rafael Hermes, Martin Zorrilla and Nicholas Piggott

Approximately a third of global shrimp production is in Southeast Asia, but the vast majority of the feed raw materials needs to be imported at a high cost from all over the world. Imagine the carbon footprint to support the growing production.

The insect meal industry is one of the most viable alternatives to tackle the growing demand for sustainable protein sources. It represents a natural feed ingredient for aqua species, it is naturally sustainable and can deliver essential nutrients that allow farmers to produce high quality fish in a more feasible way.

The objective of this trial was to identify the best inclusion rate of black soldier fly (*Hermetia illucens*) or BSF meal (Hi. Protein®, Nutrition Technologies, Singapore) to partially replace fishmeal (FM) in whiteleg shrimp *Penaeus vannamei* diets. The economic feasibility was also assessed. The trial was carried out by ShrimpVet Laboratory in Ho Chi Minh City, Vietnam.

Our results indicate that BSF meal is not only a cost effective and highly digestible animal protein, but also that the protein meal is a functional ingredient that can improve animal disease resistance via for example an antimicrobial effect on pathogenic bacteria.

## Trial design and statistical analysis

A total of 1,400 healthy juveniles (initial weight 1.8g) were divided into five treatments. There were seven replicate tanks for each treatment with 40 shrimp/tank. In addition to the control with 0% inclusion of BSF meal in 26.5% fishmeal (FM 67% CP) diet, there were four treatment diets where the BSF meal was partially substituted for fishmeal. The inclusion rates of the treatments containing Hi.Protein were: 1.3% replacing 5% FM; 3.9% replacing 15% FM; 6.6% replacing 25% FM and 9.3% replacing 35% FM (Figure 1).

Each tank contained 350L of water treated in accordance with ShrimpVet's protocol. The aeration system comprised two air stones and a biofilter bucket. Tanks were covered with a plastic film to reduce the risk of cross contamination. Modified experimental tank set-up followed the methods described by White et al. (2007).

The trial lasted 44 days, including 2 days of acclimation. Parameters measured were growth performance, survival rate, feed intake and feed conversion ratio (FCR) as well as water quality. An economic analysis was also included.

Data were analysed using SPSS (version 25) software; one-way analysis of variance (ANOVA) was applied, followed by the Duncan's multiple range test to determine differences among treatments. All significant tests were at  $P < 0.05$  levels. Results were presented as mean  $\pm$  standard deviation.

## Experimental diets

All diets (Table 1) were isonitrogenous and isocaloric (moisture 10%, crude protein 39% and crude lipid 7%) formulated to meet the nutritional requirements for the whiteleg shrimp. In terms of essential amino acids, they contained: lysine 2.59%, methionine 0.93%, and threonine 1.73%. Cholesterol was 1,100mg/kg, phospholipids, 2.00, calcium 1.26% and phosphorus, 1.20%.



Experimental Feed

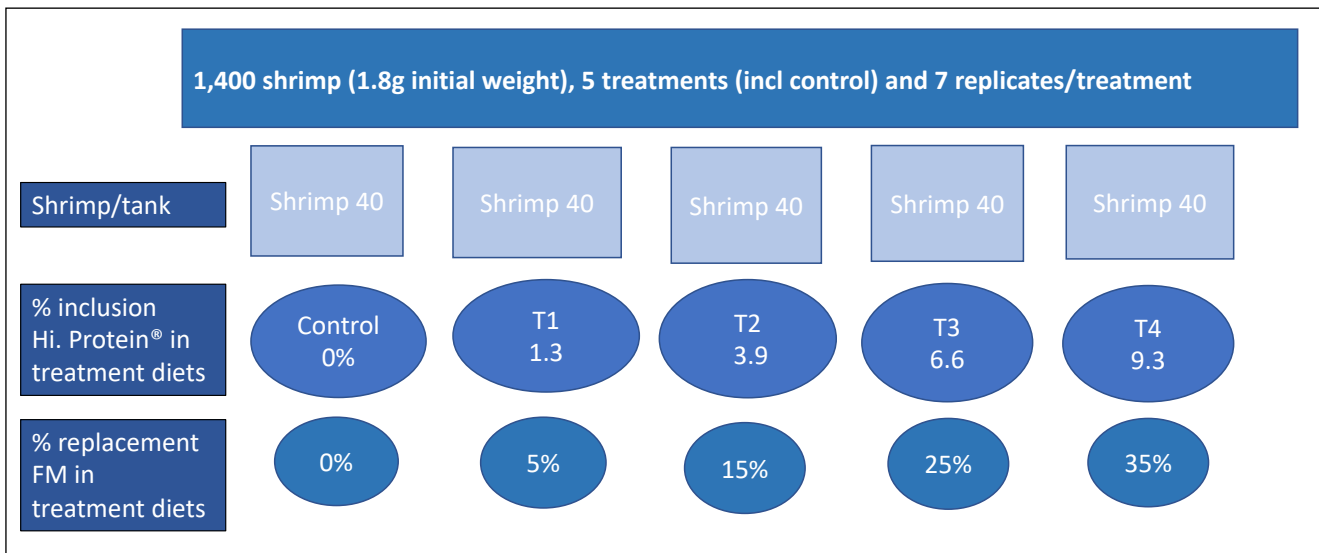


Figure 1. Experimental set up.

INGREDIENTS (g)	Control	FM replacement levels			
	(Basal diet)	5% FM Replacement	15% FM Replacement	25% FM Replacement	35% FM Replacement
Anchovy fishmeal 67%	265	251.8	225.2	198.8	172.2
Soybean meal, 45%	322	328	338	349	350
Hi. Protein® 50%	0	13.2	39.8	66.2	92.8
Tuna oil	20	17.9	16	13	12
Wheat flour	285	283	283	275	273
Feed grade cholesterol	0	0.05	0.15	0.2	0.3
Soy lecithin	15	16	17	18	19
Others: wheat flour, feed additives and lecithin.	86	83	73	71	71
Total	1000	1000	1000	1000	1000

Table 1. Composition(g) of the experimental diets (% as fed basis)

### Results and discussion

Performance data at the end of the trial are summarised in Table 2. The highest shrimp biomass per tank was observed in the treatment where shrimp were fed the diet with 6.6% and 9.3% BSF meal (replacing 25% and 35% of fishmeal, respectively). Means for both treatments were significantly different from the control diet. The performance was most likely due to a higher survival rate, when compared to the other treatments. As the feed intake was similar for all treatments, the best feed conversion ratio (FCR) was observed with the 25% FM replacement group.

There are several likely explanations as to why a 25% FM replacement diet (6.6% inclusion of BSF meal) presented the best performance. It may be due to a more adequate amino acid profile for whiteleg shrimp, or to the presence of chitin, known for having immune-modulating effects (Rahimejad et al., 2018) and better gut histology parameters. Also, the lauric acid present in the insect meal has been reported to have an antimicrobial effect (Matsue et al., 2019). These functional benefits of insect meal led to stronger animals that can better survive under challenging field conditions.



Size of shrimp at the end of the trial.

Treatments	Individual initial weight (g)	Individual final weight (g)	Survival rate (%)	Feed intake/ tank (g)	Biomass/ tank (g)	FCR (g/g) *
Control (basal)	1.79 ± 0.5	12.72 ± 0.9	84.6 ± 7.7 <sup>c</sup>	509.1 ± 8.9	429.6 ± 37.1 <sup>b</sup>	1.43 ± 0.11 <sup>a</sup>
5% FM replacement	1.80 ± 0.5	12.64 ± 1.1	87.9 ± 6.4 <sup>bc</sup>	513.3 ± 19.1	444.5 ± 51.5 <sup>ab</sup>	1.34 ± 0.05 <sup>ab</sup>
15% FM replacement	1.78 ± 0.5	13.14 ± 0.8	87.5 ± 6.3 <sup>bc</sup>	525.0 ± 26.7	460.6 ± 52.3 <sup>ab</sup>	1.31 ± 0.10 <sup>b<sup>c</sup></sup>
25% FM replacement	1.79 ± 0.5	12.96 ± 1.1	96.8 ± 2.8 <sup>a</sup>	519.6 ± 25.4	502.2 ± 47.0 <sup>a</sup>	1.19 ± 0.07 <sup>d</sup>
35% FM replacement	1.80 ± 0.5	13.13 ± 1.1	93.6 ± 5.8 <sup>ab</sup>	516.5 ± 19.6	492.0 ± 56.4 <sup>a</sup>	1.22 ± 0.10 <sup>c<sup>d</sup></sup>
P-values	0.990	0.808	0.030	0.675	0.047	0.001

<sup>abc</sup> Data with different letters are significantly different (P < 0.05) by Duncan's multiple range test. N=7 per treatment. \*It needs to discount the initial biomass of 72g per tank.

**Table 2.** Results as mean ± standard deviation for final weight and biomass, survival, feed intake and FCR of shrimp fed the treatment diets with varying inclusion rates of BSF meal, Hi.Protein®

Parameters	Control	5% FM Replacement	15% FM Replacement	25% FM Replacement	35% FM Replacement
Inclusion level (%)	0.0%	1.3%	4.0%	6.6%	9.3%
Feed cost (USD/tonne)	800	805	818	826	836
Feed investment (USD)	0	5	18	26	36
Feed intake (g/tank)	509	513	525	520	517.0
Biomass (g/tank)	430	445	461	502	492
Yield difference (% to Control)	0	3.47%	7.22%	16.90%	14.53%
Feed efficiency (discounting initial weight)	0.70	0.72	0.74	0.83	0.81
Revenue* from 1 tonne feed	3,513	3,621	3,701	4,137	4,062
Revenue difference	0	108	188	624	549
ROI (USD per additional USD invested)	0	22	11	24	15

\*Based on a selling price of fresh shrimp is USD5.00/kg.

**Table 3.** Economic analysis of shrimp fed the treatment diets with varying inclusion rates of BSF meal Hi.Protein®

Analysing the different treatment results and the feed efficiency showed that the most cost efficient treatment diet had 6.6% inclusion of BSF meal, replacing 25% fishmeal (Table 3). Compared to the control, by investing only an additional USD26/tonne of feed to replace one quarter of the fishmeal, the farmer can gain back this amount with a revenue difference of USD624.

## Conclusions

In this trial, we demonstrated a successful replacement of a part of fishmeal from the whiteleg shrimp diets, with a more sustainable, price-stable and locally produced source of nutrients. The BSF industry is growing fast due to its scientifically proven performance and the multiple benefits it can bring to animal production.



**Rafael Hermes** is Animal Nutrition Director

**Martin Zorrilla** is Chief Technology Officer

**Nicholas Piggott** is Founder and Co-CEO.

All authors are with Nutrition Technologies, Singapore.

# NEXT ISSUES

## January/February 2022

Issue focus: Hatchery & Nursery

Industry review: Marine Shrimp

Feed Technology: Larval and Nursery Feeds

Deadlines: Articles – November 16/ Adverts November 23, 2021

## March/April 2022

Issue focus: Health & Disease Management

Industry review: Marine Fish

Feed Technology: Fishmeal/Fish Oil Replacements

Deadlines: Articles – January 18/ Adverts January 25

Email: [zuridah@aquasiapac.com](mailto:zuridah@aquasiapac.com); [enquiries@aquasiapac.com](mailto:enquiries@aquasiapac.com) for details

# Blockages causing limited exports of Asian shrimp to high-end HOSO shrimp markets

Why do Latin American HOSO shrimp often have better reputation than those from Asia?

By Hervé Lucien Brun



Asia is by far the leading producer of farmed shrimp. We can find Asian origin shrimp in all consumer countries (Figure 1). Nevertheless, they are still shrimp that can be qualified as a commodity, defined as widely available products with little difference in their added value, from one supplier to another. However, in the most demanding markets in terms of quality, especially for the head on shell on (HOSO) product, such as in cooking markets in France and Spain and also in China, most of the imported shrimp are from Latin America, mainly from Ecuador (Figure 2). These markets often represent more than a third of global shrimp imports (Figure 3).

The aim of this article is to explain why Latin American HOSO shrimp often have the reputation of better quality than those from Asia.

## The HOSO shrimp market

Initially, the most important shrimp market was the US logistical, which imported mainly headless shell on (HLSO) blocks. At that time, in most Asian countries, farmed shrimp were sold to middlemen who brought them to the big city markets to auction to processors. However, currently in Europe and Asia, there is a high demand for HOSO shrimp, making it a higher value product.

Today, to obtain better quality shrimp from their Asian suppliers, the Chinese importers give a better price for the "live frozen" head on shrimp. There is no easy nor cheap technique to achieve good quality head on shrimp. However, since shrimp heads degrade immediately with death until frozen, bringing live shrimp to the factory will drastically reduce the degradation process.

Therefore, why is there this situation in Asia where quality HOSO shrimp is so difficult to achieve in farms and processing plants and so little product end up in the high-end HOSO shrimp markets? Analysing the situation, the reasons could be because of the following factors:

- History and culture
- Structural differences in the aquaculture sector
- Technical and logistical differences

## History and culture

Europeans began to be interested in farmed shrimp in the second half of the 1980s. With the linguistic and historical proximity between Spain and Latin America, Spanish buyers, the biggest European consumers, turned first to Latin American producers who produce white shrimp which are favoured in their market.

Latin American processors marketed 2kg boxes in semi-IQF blocks that were sold in supermarkets. Later, the French buyers followed them. But in this case, it is for the cooking industry (called "cookers") in consumption areas where frozen shrimp are cooked and sold refrigerated to customers.

Importers have higher quality requirements so that the cooked shrimp will not suffer any damage or loss of quality. In the 1990s, Ecuador was the first supplier of farmed shrimp to Spain and France. Ecuador also established close relationships with these European countries, such that an important Ecuadorian group became the main shareholder of a French cooker.

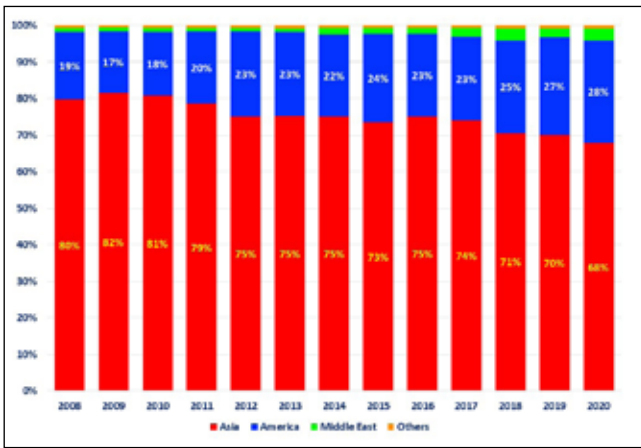


Figure 1. Origin of the global farmed shrimp production (Source: Shrimp Panel – 2020)

This is how the Ecuadorians understood what their European customers meant by quality shrimp. It is also for this reason that Latin American producers and exporters have certifications which meet the specific demand of their customers such as Best Aquaculture Practices (BAP) for the American and North European markets and Aquaculture Stewardship Council (ASC) for the European markets.

**The quality criteria**

It is important to understand that quality is a subjective term. It is therefore essential that the various actors are on the same page. Of course, there are objective criteria such as weight or size, but most of the others - hardness, drooping heads, colour, etc. are subjective criteria. This is where the cultural similarities between Latin America and Europe and/or the US play a large role. Unfortunately, this is less so in the case of Asian suppliers, who often have a different cultural perspective.

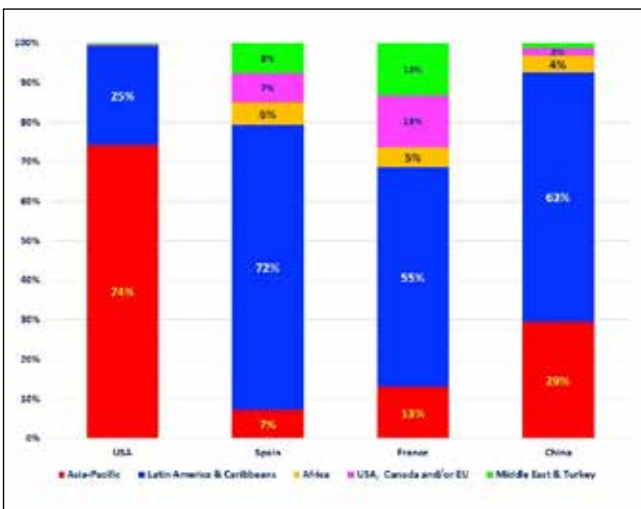


Figure 2. Shrimp imports by the main importing countries

Today, in Asia, which is a very dynamic continent and knows how to adapt to situations quickly, producers are beginning to assimilate better to the quality criteria of the different markets they supply to and soon, this should no longer be a problem.

**Structural differences in the aquaculture sector**

Often, we hear that the main reason for this imbalance is that the sector in Asia is much more fragmented than in Latin America. This is not as true as it seems (Figure 4).

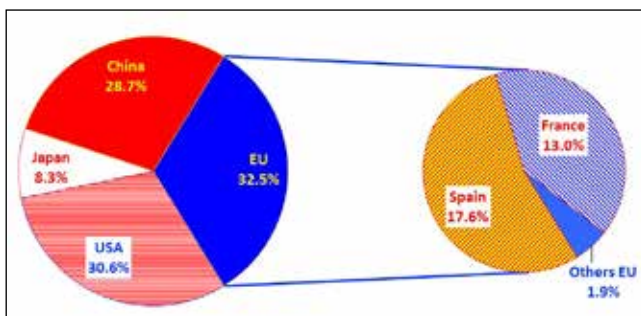


Figure 3. Main shrimp markets in 2020

Until the early 2000s, Ecuador had a large proportion of small independent farmers. Large families with a few hectares of farms initially owned the factories that freeze shrimp, and later hatcheries as these require large investments. At that time, most of the feed producers were also independent.

During the post Taura syndrome virus (TSV) epidemic and then with the white spot syndrome virus (WSSV) outbreaks, in 1992 and 1999, respectively, many small farms were bought by big groups. This led to a greater integration of the sector. Today, we find large groups integrating: broodstock production and genetic selection facilities, hatcheries and grow-out farms, and the packaging and exporting plants. These groups or partners within the group may also own grow-out farms. Often, these groups are also shareholders of feedmills which in turn are associated with large international feed producers. Most of the independent feed millers have disappeared.



Shrimp ponds in the delta of Guayas

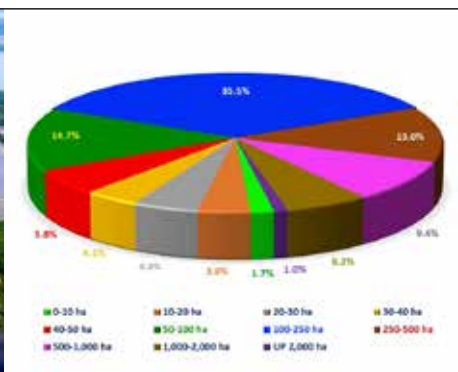


Figure 4. Water surface area of Ecuadorian shrimp farms. Production technology is low density semi-intensive farming in large ponds (from 4 to 30ha) per pond. Almost 50% of the Ecuadorian on-growing ponds are still owned by independent farmers.

Compared with Asia, there are more integrated groups in Latin America, but there are still many independent farmers. Today, almost 50% of the Ecuadorian grow-out ponds are still owned by independent farmers. Nevertheless, these farms are still much larger than those in Asia. The production technology is low density semi-intensive farming in large ponds (from 4 to 30ha/pond). This culture system causes less stress to the shrimp as compared to the very intensive culture systems practised in Asia. In addition, there are very few intermediaries between the farms and other parts of the chain, such as hatcheries, feed millers and/or packers in Latin America. Farmers normally deal directly with their suppliers, with whom they can sometimes negotiate credit terms.

### Quality assurance at source to plants

When a farmer decides to harvest, which means that shrimp have the optimum average body weight to give the best margin and the percentage of moulted shrimp is lower than 2%, they take the following steps:

1. Ask the packers for their price list. An example is given in Table 1;
2. They then choose to whom they will sell their shrimp;
3. The packer will provide to the farmer the needed ice for the harvest, the insulated bins and the transportation from the farm to the plant (this could be by road or by boat according to the location of the farm);
4. The harvest will then be paid to the farmer according to pre-agreed conditions such as the net weight by type, size and quality.

### Role of farmer's representative

However, to ensure that everything runs smoothly and without dispute, the bins will be sealed with numbered seals by the harvester at the farm. These seals will only be broken at the factory by the farmer's representative who will stay in the workshop during the whole process to control the number of boxes produced by type and size. The representative will also control the good practices of the packers and that the products of the harvest follow strict procedures and are not subjected to a long waiting time at an incorrect temperature, leading to their degradation and their downgrade in classification.

At the end of the process, the farmer's remuneration will be calculated from the price list provided beforehand based on the actual production certified by his representative. To avoid any dispute, an agreement is signed by both parties, defining among other things:

- The price list and the terms of payment;
- The net weight in the boxes, specifying the method and duration of draining, for example: 2,020g per 2kg box after draining for 3 minutes; and
- The number of pieces per size, for example: size 30/40 should carry between 34 and 36 shrimp per kg packed.

With such conditions, the farmer is directly affected financially by the quality of shrimp he will harvest and supply to the packer. In general, if the quality control department of the packer, through its analysis upon receipt of the shrimp at the plant, and in the presence of the representative of the farmer, considers that more than 25% of the shrimp are not in compliance with a HOSO process, the entire batch is downgraded and will be treated as "HLSO Rechazo". In this case, the farmer can still withdraw the sale of his shrimp and go to another packer but in general, this will be a financial disaster for the farmer.

Therefore, this system ensures that farmers harvest their shrimp at the optimum moment during the intermoult cycle to avoid having a high percentage of soft-shell shrimp. Shrimp temperature is lowered as fast as possible in ice water and transported immediately to the plant to avoid any degradation before arriving. The farmers understand that the shorter the time between harvesting and freezing, the better will be the product quality.

There are no practices such as draining shrimp at the edge of the ponds to achieve a net weight and sorting the shrimp according to size at the farm site to send them to different packing plants, according to the offer price of each plant. In the latter, the gain from this operation is lost because of the downgrading of shrimp quality. The unethical practice of soaking shrimp for several hours in freshwater or chemical solutions to artificially gain weight is banned by packers.

With the above practices, shrimp when sold to cookers will have a disastrous effect. Indeed, the water absorbed by soaking will be lost during the cooking process. Yields are devastating and the cookers will quickly blacklist this supplier.

The only case, where this practice can be accepted, would be in the case of shrimp with off flavour due to an excess of cyanobacteria in the tanks. In this case, the shrimp are sometimes sold at the edge of the tank to unscrupulous intermediaries who will market the mediocre quality shrimp to dubious processors.

There is a double advantage with this system:

- The shrimp arrive as quickly as possible at the packing plant;
- Soaking operations which invariably result in a significant decrease in the quality of the products are avoided.

It is true that in Asia, middlemen play an important role for farmers, particularly in terms of financing and assistance. In Ecuador, packers, who are usually part of an integrated group, may sometimes participate in financing by offering

Empacadora XXXXX Lista de Precios del 15 de oct		
HOSO	HLSO Rechazo	HLSO Directa
20 \$/k 5.40	16 \$/lb 2.40	16 \$/lb 3.65
30 \$/k 4.40	21 \$/lb 1.70	21 \$/lb 2.55
40 \$/k 4.20	26 \$/lb 1.65	26 \$/lb 2.25
50 \$/k 3.55	31 \$/lb 1.40	31 \$/lb 2.00
60 \$/k 3.00	36 \$/lb 1.4	36 \$/lb 1.95
70\$/k 2.60	41 \$/lb 1.10	41 \$/lb 1.80
	51 \$/lb 1.00	
	61 \$/lb 1.00	
	71 \$/lb 0.90	
	91 \$/lb 0.80	
	91 \$/lb 0.80	Saludos. Xxxx. Xxxx
HLSO Rechazo: Tail from HOSO rejection with SMBS treatment		
HLSO Directo: Tail from shrimp harvested for HLSO process without SMBS treatment		

**Table 1.** An example is of prices by a packer

to provide larvae and/or feed; in return the packers will secure the harvested crop. Since the major epidemics of TSV and WSSV, this is now less common.

There are also several universities and research centres focusing on aquaculture in Ecuador. CENAIM ([www.cenaim.espol.edu.ec/](http://www.cenaim.espol.edu.ec/)) works to advance technology and ensure the transfer of results to professionals. In addition, there is a professional aquaculture group in Ecuador (Camara Nacional de Acuicultura (CNA), [www.cna-ecuador.com](http://www.cna-ecuador.com)) organising regional and national seminars annually to transfer the technical advances to producers.

### Technical and logistical differences

Before deciding when to harvest a pond, the farmer will check the condition of the interbreeding cycle and the quality of the shrimp, in particular the taste of the shrimp and the absence of necrosis. If the shrimp do not conform, the operation is postponed.

In terms of moulting, it has been observed for many years that the vast majority of shrimp have a hard shell during spring tides (full and new moon). This means that harvests are often better during these periods. This is such an important phenomenon that packing plants do not receive a harvest during the neap tide periods. A forecast calendar of the best harvesting periods is published every year by CNA and several packers (Figure 5).

Harvesting is usually at night during the coolest hours. They are always done by emptying the pond and the shrimp harvested at the outlet manually with a pocket net but more often with a harvesting pump. The Ecuadorians do not practice partial harvest.

For this, the water level is gently lowered by about 20 to 30% during the 24 to 36 hours preceding the harvest. Then the outlet gate is opened and the shrimp are harvested completely.

On the other hand, in New Caledonia, where the harvesting system is very similar to that in Ecuador and where the quality of the shrimp is renowned, there are several systematic partial harvests before the final one. For a partial harvest, the farmer will reduce the pond water by around 30% and collect shrimp at the outlet gate.

When the required quantity is reached, in New Caledonia this would be 4 tonnes to fill one truck or at most 8 tonnes to fill 2 trucks; the gate is then closed and the pond is refilled. However, in general, at the end of the partial harvest, the pond water is almost at half level.

In Asia, partial harvesting is done by concentrating the shrimp by operators walking in the pond handling a seine net. This technique causes a lot of stress to the shrimp. This will result in a higher percentage of moulting shrimp and a deterioration of the hepatopancreas tissue which will decline more rapidly during the process. Therefore, harvesting with a cast net is not recommended because it damages the shrimp enormously. A cast net is only used for sampling or to collect the few shrimp remaining in puddles at the end of the harvest.

After harvest, the shrimp are immediately cooled by immersion in ice-cold saltwater and then treated with sodium metabisulfite (SMBS). For this treatment, the shrimp are most often immersed in an ice solution of



Figure 5. Seasonal calendar of spring tides and harvesting periods

SMBS (5 to 10% depending on the farm) for about 10 minutes. Shrimp cooled to a temperature lower than 2°C are either transferred in transport boxes and covered with ice (in general for the transport by boats), or more often, especially for transport by road, shrimp are put in insulated bins in alternating layers of shrimp and ice.



Harvest by pumping in an Ecuadorian shrimp farm.



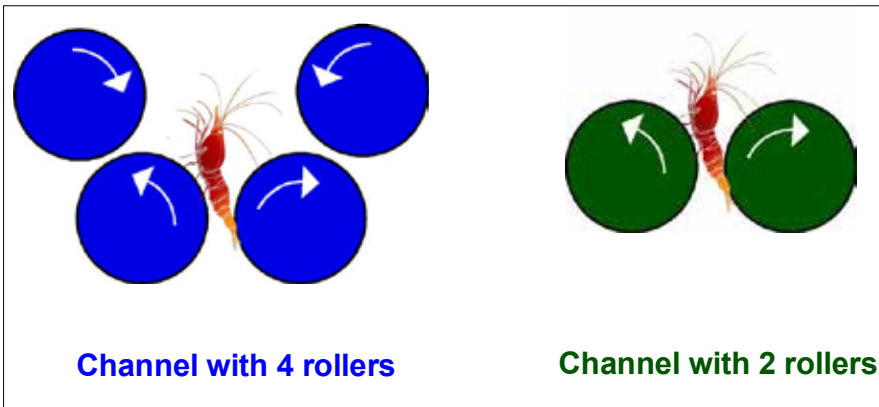
Partial harvest with pescalator in a New Caledonia shrimp farm.



Treatment by immersion in an ice-chilled solution of SMBS



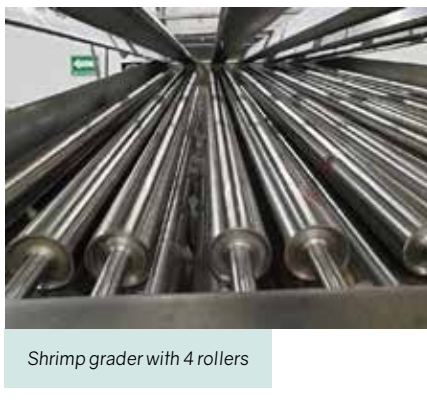
Transport of shrimp in insulated bins from farms to packing plant



**Figure 6.** The shrimp graders used in Latin America are mostly roller graders with spaces between 4 rollers instead of 2 rollers. This is to ensure the uniformity of size ratio which in general lower than 1.3. A standard method to measure uniformity is to weigh the 10 largest shrimp and then separately weigh 10 of the smallest shrimp in any given 5lb package. The weight of the smaller shrimp is divided by the weight of the larger shrimp.



Emptying the transport bin into the ice separator of the grading line.



Shrimp grader with 4 rollers



Direct boxing and weight adjustment at the exits of the shrimp grader

At the plant, shrimp are immediately processed respecting the first in-first out (FIFO) rule. If the plant is already in production, the bins are stored in a cold storage room (<math><4^{\circ}\text{C}</math>) while waiting to be processed.

During processing the bins are emptied directly into the ice separator of the grading lines. The shrimp are directly boxed at each chute of the graders and the net weight adjusted. The shrimp graders used in Latin America are mostly roller graders with spaces between four rollers. This is to ensure the uniformity of the size ratio which in general is lower than 1.3.

Then the boxes are directly transferred to the freezing unit, which can be a blast or plate freezer, and now more often it is a brine freezer. This is a very fast process during which the temperature of the shrimp stays low. The manipulation of the animals is also minimised.

It is critical to understand what the importer means by quality. However, it is also necessary to ensure that the farmer produces high quality shrimp. To summarise, the three most important basic principles to obtain a good quality HOSO product are:

- A temperature as close as possible to  $0^{\circ}\text{C}$  from the moment the shrimp is out of the water to the time they are frozen.
- The shortest possible time between the shrimp exit from the tanks to the freezing process.
- The least possible handling of the shrimp from the tank to the freezing process.



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# Korean aquaculture industry projects to boost high-tech farming systems

The Korean Ministry of Oceans and Fisheries (MOF) is developing policies to build up high-tech and scale-up foundations for smart aquaculture technology. Government and commercial projects related to high-tech aquaculture in Korea since 2014 are given in Table 1 and described below.

## Government projects

### Aquafarm 4.0

Three Korean government departments (MOF, Ministry of Science, and ICT & Ministry of Trade, Industry, and Energy) are cooperating on preliminary feasibility studies of Aquafarm 4.0's potential as a government research and development (R&D) project. The goal of the Aquafarm 4.0 project is implementation of artificial intelligence

through all stages of the aquaculture production cycle. Implementation will be in phases - beginning with digitalisation, proceeding to smartification, and then artificial intelligence. The mission of this project is to improve the aquaculture business ecosystem economically and sustainably for the whole value chain (production to consumption). Currently re-evaluation of the total plan is in progress with planning of the revised budget and project range as a priority.

### Smart Aquaculture Cluster Project

This is planned by MOF with the goal of building up production test beds and developing main cluster business in the local area, by implementing automation and artificial intelligence based on testbed results.

	Project Title	Target Species/ Project Area	Project Budget (draft)
Government Projects Division	Smart Aquaculture Cluster Project	Salmon/ Busan	Total budget: KRW40 billion (USD40 million) Test bed: KRW30 billion (USD30 million) Developing main cluster businesses in local area based on test bed results: KRW10 billion (USD10 million)
		Grouper/ Goseong	
		Shrimp, sea cucumber/ Shinan	
		Salmon/ Pohang	
		Salmon/ Gangwon-do	
	Smart Freshwater Farm Demonstration Complex	Catfish etc./ Hwasun	KRW7 billion (USD 7 million)
		Loach/ Namwon	KRW7 billion (USD 7 million)
	Smart Sea-Cage Demonstration Complex	Redlip mullet/ Hadong	KRW3 billion (USD3 million)
	Developing Eco-Friendly Aquaculture	Shrimp/ Namhae	KRW 3.7 billion (USD3.7 million)
		Shrimp/ Hwaseong	KRW10 billion (USD10 million)
Aquafarm 4.0	Government departments are cooperating on preliminary feasibility studies since 2019	Draft budget and planning are in progress	
Aquaculture Specialist Human Resource Development	Chonnam National University Smart Aquaculture Research Center	KRW9.9 billion (USD9.9 million)	
Commercial Projects	Sustainable Land-Based Salmon Farm Complex	Salmon /Yangyang (Managed by Dongwon Industries)	KRW200 billion (USD200 million)

\*1 USD = 1,000 KRW

**Table 1.** The main government and commercial projects for high-tech aquaculture.



Busan smart aquaculture cluster. Source: Busan City



Image of Goseong smart aquaculture cluster. Source: Goseong-gun

Recently, a total of 5 local projects (Busan, Goseong, Shinan, Pohang and Gangwon-do) were confirmed as test beds. Busan city and GS Engineering & Construction (GS E&C) have an agreement to cooperate on this project since July 2020.

### **Smart Sea Cage Demonstration Complex**

This was established with automatic feeding, farm environmental monitoring and growth measurement systems for 10 farms in Hadong-gun in 2020.

### **Developing Eco-Friendly Aquaculture**

Chowon Environment Company, which was selected as "2020 Developing Eco-Friendly Aquaculture Project", is constructing a land-based closed system marine shrimp farm in Namhae-gun with a budget of KRW 3.7 billion (USD3.7 million).

### **Shrimp RAS Farming - Gyeonggi-nambu Suhyup (Fisheries Cooperatives)**

Hwaseong in Gyeonggi-do, selected as "2020 Developing Eco-Friendly Aquaculture Project", will carry out the shrimp land-based RAS project for vannamei shrimp with a government budget of KRW10 billion (USD10 million) from 2021 to 2022.

## **Commercial projects**

### **Salmon RAS Farming plan-Dongwon Industries**

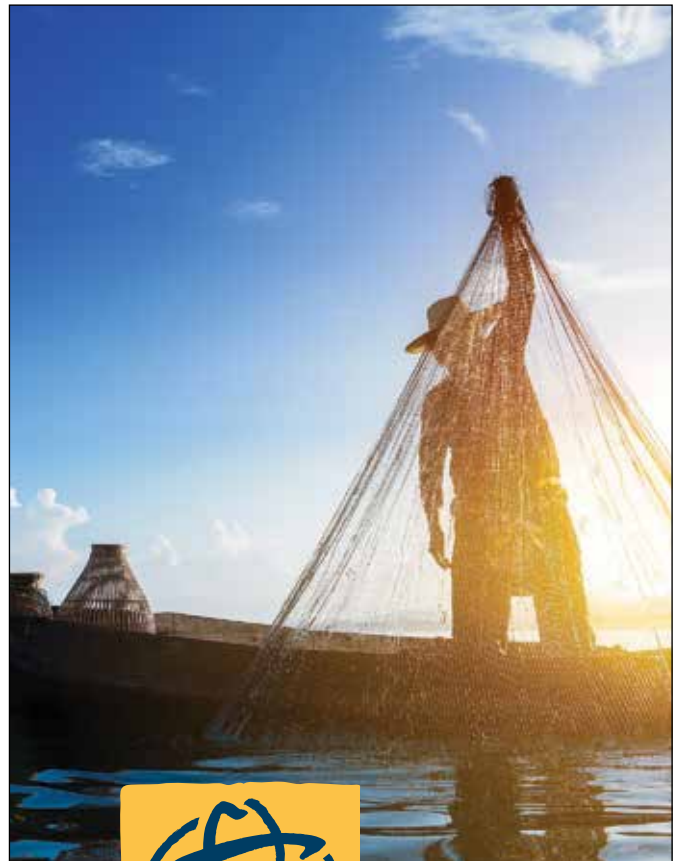
A revision of the law allowing major companies to participate in aquaculture (named the 'Aquaculture Industry Development Act) was enacted in August of last year. Consequently, major companies (GSE&C, Dongwon Industries, etc.) have joined or are very interested in entering the aquaculture industry. It is expected that the entrance by major companies with strong capital will rapidly accelerate the development of smart aquaculture technology.

On September 1, 2020, Dongwon Industries held a ceremony to celebrate the investment agreement with Yangyang-gun and Gangwon-do for the project to establish the 'Sustainable Land-based Salmon Farm Complex at Yangyang-gun'. The target production is 20,000 tonnes salmon per year. Dongwon will invest KRW200 billion (USD200 million) for a land-based salmon farming complex from 2020 to 2023.

In addition, Dongwon Industries invested in 'Norway's Salmon Evolution' last July and intends to adopt the technology provided by this company to establish the 'Sustainable Land-based Salmon Farm Complex at Yangyang-gun'.



Dongwon sustainable land-based salmon farm complex. Source: Dongwon group



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## TFM to grow overseas through direct exports and cooperation with strategic partners



Bunluesak Sorajjakit

With over 20 years of experience and expertise in feed production, **Thai Union Feedmill PCL** or TFM has become a leader in the production and distribution of aquaculture and commercial animal feeds in Thailand, offering quality and widely known branded products. It has accumulated know-how leading to new innovations in production processes.

Following its listing on the Stock Exchange of Thailand (SET) under the symbol "TFM" on October 29, the company is prepared for sustainable growth and is determined to take the leadership role in the aquaculture and commercial animal feed business sector.

Bunluesak Sorajjakit, Chief Executive Officer is confident that TFM's IPO shares will attract widespread interest among investors. Between 2021 and 2023, TFM aims to grow in overseas markets through cooperative agreements, joint ventures with trading partners and direct exports to support food security for Asia's future. TFM expects to spend the proceeds of THB 1,177.4 million (USD40 million) from the sale of shares in the following activities:

- Expand production and distribution of aquaculture feeds through Indonesia-based subsidiary TUKL by adding two lines of production, which will increase capacity by 36,000 tonnes per year, requiring an investment of no more than THB 250 million (USD 7.6 million) by 2023;
- Repay loans of between THB 250-350 million (USD 7.6-10.7 million) by March 2022 to reduce the debt-to-equity (D/E) ratio to less than 1 time (x), after the IPO; and
- Use the remainder as working capital.

Moreover, as a policy, TFM intends to pay dividends twice a year, amounting to no less than 50% of the net profit per the consolidated financial statements after reduction of all categories of reserves according to company rules and legal requirements.

The TFM CEO adds that TFM is determined to expand its operations to overseas markets with appropriate business models deemed beneficial. These are:

- Technical support to the Indian partner. An agreement of technical cooperation with Avanti Feeds Limited (AVANTI), India's major shrimp feed producer, allows it to use TFM's trade name and feed formulations to produce and sell shrimp feed in India;
- Overseas joint ventures with partners. TFM joined strategic partners to form PT Thai Union Karisma Lestari Co., Ltd. (TUKL), a subsidiary to produce and distribute aquafeeds in Indonesia. The two strategic partners are PT MSK, a major producer of frozen seafood in Indonesia and Avanti. TFM, PT MSK and Avanti hold 65%, 25% and 10% TUKL's paid-up capital respectively.
- TFM formed a joint venture AMG-Thai Union Feedmill (Private) Limited (AMG-TFM) with a strategic partner in Pakistan. The Pakistani partner AMG is the country's major producer of aquafeed. AMG holds 49% of shares in the new company while TFM holds 51% as of June 30, 2021. AMG-TFM produces 7,000 tonnes of fish feed per year and plans to increase capacity to 15,000 tonnes per year within 2021. The joint venture has started commercial operations and has recognised revenues with net profit since the second quarter of 2021;
- Direct exports to various countries, including Malaysia, Maldives, Myanmar, Pakistan and Sri Lanka.

On domestic market expansion, TFM plans to develop new business and continues efforts in maintaining its competitiveness as an industry leader. The company is the first in Thailand to produce and distribute pelleted feeds for sea bass to replace the use of trash fish. Recently, the company has also launched products under its "fighting" (high protein) feed brand through a marketing campaign to expand its customer base to more diverse segments as the demand for fish feed is on the rise.

Furthermore, the company has set its sights on promoting feeds for other fish species and has R&D on feeds for other aquatic species, such as crab and gourami. TFM also envisions a growth opportunity in the commercial animal feed sector that should help support food security in Asia. [www.thaiunion.com/](http://www.thaiunion.com/) [www.thaiunionfeedmill.com](http://www.thaiunionfeedmill.com)



## Nine contestants off to the races



Nine companies from across the globe have officially joined the **F3 Challenge - Carnivore Edition**—the aquaculture industry’s premier race to replace fishmeal and fish oil in feeds for farm-raised carnivorous species. They will vie for a total of USD300,000 in prizes for most “fish-free feed” sales.

The sales competition, designed to accelerate the development and adoption of fishmeal and fish oil substitutes in feeds, will award USD100,000 in each of three categories—salmonid, shrimp and other carnivorous species—to the contestants that produce and sell the most “fish-free feed” within their designated category.

Company/Team	Category	Location
Star Milling Co/Scoular US	Salmonid	United States
Jiangsu Fuhai Biotech Co	Salmonid	China
Chapul Farms	Salmonid	United States
F4F Food for the Future	Salmonid	Chile
	Category	Location
Empagram/Veramaris	Shrimp	Ecuador
Jiangsu Fuhai Biotech Co.	Shrimp	China
Remediate	Shrimp	United Kingdom
De Heus LLC	Shrimp	Vietnam
	Other carnivorous species	Location
BGreen Technologies	Asian seabass	India
Jiangsu Fuhai Biotech Co	Largemouth bass	China
Dainichi Corporation	Red seabream	Japan



Kevin Fitzsimmons

“We are thrilled by the global participation we have for this challenge, definitely our most challenging contest to date,” said Kevin Fitzsimmons, F3 Challenge chair and professor at the University of Arizona. “Unlike omnivores, carnivores are choosier eaters and present a greater challenge.”

Four contestants have registered in the salmonid category — Chapul Farms, F4F Food for the Future, Jiangsu Fuhai Biotech Co. Ltd and Star Milling Co. in partnership with The Scoular Company.

In the shrimp category, four contestants registered — Empagram in partnership with Veramaris, Jiangsu Fuhai Biotech Co. Ltd, Remediate and De Heus LLC.

In the other carnivorous species category - BGreen Technologies is competing with Asian seabass feed, Jiangsu Fuhai Biotech Co. Ltd with largemouth bass feed and Dainichi Corporation with red seabream feed.

Contestants have until November 30, to submit feed samples and add partners. The winners will be announced in Fall of 2022.

Each year, an estimated 16 million tonnes of wild fish are caught exclusively for use as fishmeal and fish oil in global feed production. Salmon aquaculture, one of the fastest growing food production systems in the world, supplies roughly 70% or 2.5 million tonnes of all salmon produced and uses over 20% of the fishmeal and 60% of the fish oil consumed by the aquaculture sector globally.

Today, over half of the global shrimp supply is farmed. Global shrimp farming production, which reached nearly four million tonnes in 2018 according to FAO, is also one of the dominant consumers of the global fishmeal supply. A recent study found that if ‘business as usual’ continues, forage fisheries will reach ecological limits by 2037.

The qualifying feeds for all prize categories must not contain any ingredients consisting of or derived from marine animals, including but not limited to fish, squid, shrimp, or krill.

The goal of the F3 Challenge contest series is to eliminate the use of wild-caught fish and other marine animals in aquaculture feeds to assure greater food security in the future from both wild and farmed sources. Supporting organisations of the F3 Challenge include the University of Arizona, The Campbell Foundation, Synbiobeta, The Nature Conservancy, University of Massachusetts-Boston, Anthropocene Institute, Dawson Family Fund, Sustainable Ocean Alliance, Tides Foundation, Cuna Del Mar, the National Renderers Association and Shanghai Jiao Tong University.

The Future of Fish Feed (F3) is a collaborative effort between NGOs, academic institutions and private partnerships to accelerate the commercialisation of innovative, substitute aquaculture feed ingredients to replace wild-caught fish. Official contest rules are available at <https://f3challenge.org/>

## Commercial success challenged by raw materials and logistics

The quarterly release from **BioMar** reveals as expected a solid growth across markets with a significant increase in volumes and revenue. However, the bottom-line results are affected by global increases in raw material prices, logistic costs, and energy prices.

During the pandemic, BioMar has managed to grow commercial relationships across the divisions through strong collaboration with customers to build new feed concepts and commercial opportunities. The commercial success is being emphasised by the quarterly results for Q3 2021, where the volume sales grew by 11% year-on-year and reported revenue was up by 17%.

“Looking at the world around us, we are now in the middle of a situation, that is completely changing factors of our industry’s cost structure in a way and at a speed that we have not seen before. Through the pandemic, it has been difficult to conduct business, but our business model is founded upon a belief in local agility and empowerment of our business units which has enabled us to find strong commercial paths together with our customers. Now that the game is changing completely, we need, as an industry to find solutions on how to overcome this volatility”, explains Carlos Diaz CEO BioMar Group.

	Q3 2021	Q32020
VOLUME (1.000 T)	453	408
REVENUE (MIO DKK)	4,127	3,528
EBITDA (MIO DKK)	282	326

“The current situation of high prices of raw materials, freight and energy is unfortunately not expected to improve over the next few months and the general supply situation is expected to remain challenging. While it will affect our earnings in the short term, we will make it a priority to be able to ship goods continually to customers worldwide as we play an important role in the supply chain”, added Diaz



The EBITDA for the quarter fell from DKK 326 million (USD 50.2 million) in Q3 2020 to DKK 282 million (USD 43.4 million) in Q3 2021 for the consolidated companies, while the non-consolidated joint ventures and associates are recognised in the Q3 2021 consolidated financial statements at a DKK 36 million (USD 5.54 million) share of profit after tax, compared with a DKK 44 million (USD 6.8 million) share of loss in the

Q3 2020 period. The significant improvement was generally attributable to Salmones Austral in Chile, as settlement prices on farmed salmon are now improving strongly in that market from a low point caused by the coronavirus pandemic.

Against this background, BioMar has lowered its 2021 EBITDA guidance to the DKK 890–920 million (USD 137–142 million) from the previous estimate of DKK 940–985 million (USD 145–152 million).

BioMar are innovators in high performance aquaculture feed dedicated to doing our part in creating a healthy and sustainable global aquaculture industry. BioMar operates 17 feed factories across the globe in Norway, Chile, Denmark, Scotland, Spain, France, Greece, Turkey, China, Vietnam, Costa Rica, Ecuador, and Australia. Worldwide, we supply feed to around 90 countries and for more than 45 different species. BioMar is wholly owned by the Danish industrial group Schouw & Co, which is listed on the NASDAQ, Copenhagen. [www.biomar.com](http://www.biomar.com)

## First in Sri Lanka with 3-star BAP shrimp

**Taprobane Seafood Group**, Sri Lanka’s first company is qualified to offer three-star Best Aquaculture Practices (BAP) shrimp, said the Global Seafood Alliance, which owns the industry-leading BAP certification program. The Colombo-based company recently attained BAP certification for its Taprobane Sea Food (Pvt.) Ltd. seafood processing plant, Taprobane Frozen Food (Pvt.) Ltd. shrimp farm and Taprobane Frozen Food (Pvt.) Ltd. shrimp hatchery. As such, Taprobane is now eligible to offer three-star BAP shrimp, and it is the first Sri Lankan company to attain BAP certification for shrimp.

“As the pioneer of vannamei shrimp in Sri Lanka and one of the largest and most fully integrated seafood companies, we are delighted to have finalised our BAP certification,” said Tim O’Reilly, managing director and owner of Taprobane.

“SPF vannamei was only approved throughout Sri Lanka in June 2020, so the industry is still in its infancy. So, we



felt it was important to move our organisation and hopefully the industry toward BAP certification,” he explained. “Taprobane works with some of the leading US customers for our pasteurised crab meat, so we knew that until we had BAP certification it was difficult to enter into the US market.” [www.taprobaneseafoods.com](http://www.taprobaneseafoods.com)

# Second Marine Aquaculture Technology Forum

**Time: 13:30-17:45, December 2, 2021, (hybrid), Taipei, Taiwan**

On December 2-4, the **Taiwan International Fisheries and Seafood Show (TIFSS)** will be held in Taipei in a hybrid format. On December 2, there will be the **Second Marine Aquaculture Forum** with the theme: *Towards profitability during pandemic*.

This year, organisers have condensed this forum into a half day forum, from 1 to 6 pm. This hybrid event is to enhance the interaction between the international and Taiwanese industry and academia. Seven well-known experts will present their innovative technologies in pond environment management, feed and nutrition, health management, etc.



The forum agenda is given below.

Topics	Speakers
Opening remarks	Yew-Hu Chien, Professor, National Taiwan Ocean University
	Kuo Ping Lin, Deputy Director-General, Taiwan Fisheries Agency, Council of Agriculture
The new aquaculture development upon pandemic: Enhancing productivity by smart technologies	Krishna R. Salin, Chair, Aquaculture Program, Asian Institute of Technology (AIT), Thailand
Molecular-assisted selection and breeding of salinity tolerant strain in seawater Taiwan tilapia	Chang-Wen Huang, Associate Professor, Department of Aquaculture, National Taiwan Ocean University
Bio-Floc System-blue revolution	Nyan Taw, Shrimp Aquaculture Consultant (Former Chief Technical Advisor), FAO, Myanmar
Introducing a new book: Mullet and its aquaculture (Editors: I Chiu Liao & Eduardo M. Leaña)	Yew-Hu Chien, Professor, National Taiwan Ocean University, Taiwan
Mealworm meal: A premium sustainable animal protein resource for aquafeed	Guillaume Daoulas, Business Development Director, Ynsect, France
Antibiotic abuse in aquaculture and recent progress in antibiotic alternatives	Han-Jia Lin, Founder, Giant Bio Technology Inc., Taiwan
Functional nutrition for sustainable marine aquaculture	Waldo Nuez-Ortin, Lead Scientist Aquaculture, ADISSEO, Spain
Resilient value chain/ supply chain of the barramundi in Taiwan	Peter Chiang, Founder, HANAQUA Tech Inc., Taiwan
Closing Remarks	Yew-Hu Chien, Professor, National Taiwan Ocean University, Taiwan

## 2nd Marine Aquaculture Technology Forum

### Toward profitability during pandemic



**Time:**  
13:30-17:45, December 2, 2021  
**Hybrid Event**  
**Fee:** NTD 2800

**Registration**





### December 11-14 2021, Alexandria, Egypt

The theme for this inaugural event, to be held from December 11-14 will be "Sustainable Aquaculture - Feeding Africa". **AFRAQ2021** is the first Annual International Conference & Exposition of the African Chapter of the World Aquaculture Society.

The technical program aims to cover developmental issues including latest research on aquaculture in Africa. AFRAQ2021 will feature an international trade exhibition, industry forums, student sessions and activities, satellite workshops (and training sessions) and various meetings/forums on aquaculture development in Egypt and Africa.

The conference offers a great opportunity for aquaculture researchers, practitioners, decision makers and other stake holders to meet, network and discuss all aspects of aquaculture in Africa. Exhibitors from all over the globe are expected to exhibit their products in the amazing exhibition Centre - Bibliotheca Alexandrina, Alexandria, Egypt. Egypt is the biggest aquaculture producer in the continent. Both local and international aquaculture delegates will converge for the event at the beautiful City of Alexandria, the Pride of the Mediterranean Sea.

The plenary speaker will be Prof. Abdel-Fattah M. El-Sayed from the Oceanography Department, Faculty of Science, Alexandria University, Egypt. He will present on Egyptian Aquaculture. Read his article on "The Success Story of Aquaculture in Egypt: The Real Motivation for Hosting the First Aquaculture Africa Conference (AFRAQ21) on the web (<https://bit.ly/3kARlYy>)



For general information about Egypt travellers and COVID visit: Egypt Online Visa <https://www.egyptonlinevisa.com/travel-restrictions/#egypt-travel-advice>

More information: [www.was.org](http://www.was.org); Contact: [mario@marevent.com](mailto:mario@marevent.com), Mario Stael for commercial stands.

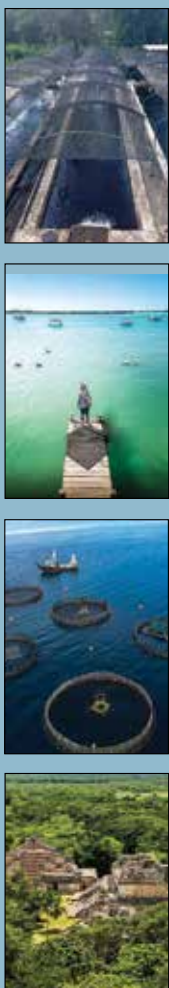


## EDITORIAL CALENDAR 2022

Look out for AAP's annual report on trends in Asia's production of marine shrimp and aquafeeds

Volume 18	Jan/Feb	Mar/Apr	May/Jun	Jul/Aug	Sep/Oct	Nov/Dec
Deadlines - Technical articles	Nov 16, 2021	Jan 18	Mar 15	May 17	Jul 12	Sep 13
Deadlines - Advert Bookings	Nov 23, 2021	Jan 25	Mar 22	May 24	Jul 19	Sep 20
Innovations/ Startups	Experiences and opinions covering role models; clear and present needs of industry; innovations and digitalisation in aquaculture					
Interviews with industry leaders	Focus in 2022 will be leaders pushing for sustainable aquaculture					
Issue focus Emerging trends and challenges	Nursery & Hatchery	Health & Disease Management	Sustainable & Responsible Aquaculture	Demand & Supply Equilibrium	Aquaculture Innovations	Health & Disease Management
Industry Review Developments, outlook, demand & supply	Marine Shrimp	Marine Fish	Aquafeed Production	Tilapia	Marine Shrimp	Caffish & Freshwater Fish
Feeds & Processing Technology Technical contributions from industry	Larval & Nursery Feeds	Fish meal/oil Replacements	Sustainable Feeds	Functional Feeds/ Additives	Novel Ingredients	Feed Enzymes/ Post Pellet Applications
Production Technology Technical information along the value chain	Controlled Systems (hybrid/ RAS)	Offshore and Industrialisation	Hatchery Technology	Real Time Monitoring/ Big Data	Feed management	Post-Harvest Processing
Marketing activities	Market and product developments, generic marketing, certifications, branding, food safety etc					
Company/Product News	News on activities at international, regional and local conferences and trade shows					
Events Distribution at these events as well as local and regional meetings *Show preview	<b>AquaIndia 2022</b> Chennai-India January 27-29	<b>RAStech 2022</b> South Carolina, USA March 30 - 31	<b>*World Aquaculture</b> Merida, Mexico, May 24-27	<b>*TARS 2022:</b> August 16-18  <b>DAA11 Kuching, Malaysia</b> Aug 23 - 26	<b>Aquatika Asia</b> Jakarta, Indonesia November 9-11	<b>*World Aquaculture Singapore</b> November 29 - December 2
For advertising/article contributions, and guidelines contact: <a href="mailto:zuridah@aquaaasiapac.com">zuridah@aquaaasiapac.com</a>		<b>Seafood Expo Global</b> Barcelona Spain Apr 26 - 28	<b>13 Asian Fisheries Aquaculture Forum</b> Tainan, Taiwan May 31- June 02	<b>Vietfish 2022</b> (TBA) Ho Chi Minh City, Vietnam  <b>*Nutrition and Health Asia/ Vietnam 2022</b> Bangkok, Thailand September 7-9	<b>Aquaculture Europe 2022</b> Rimini, Italy, September 27-30  <b>Taiwan International Fisheries and Seafood Show (TIFSS 2022)</b> (TBA)	

**NEW DATES**



# WA '21

## World Aquaculture 2021

#AquacultureNow

**May 24-27, 2022**

**Mérida, Mexico**

Centro Internacional de Congresos de Yucatán, CIC

Annual global meeting of the World Aquaculture Society

**WORLD AQUACULTURE Society**



# World Aquaculture Singapore 2022

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# Aquaculture 2022

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Latin America & Caribbean Chapter WA  
US Trout Farmers Association  
World Aquatic Veterinary Medical Association  
Zebrafish Husbandry Association



## Sustainable Aquaculture – Feeding Africa

AQUACULTURE AFRICA 2021

Alexandria Egypt • December 11-14, 2021

The 1st Annual International Conference & Exposition of the African Chapter of the World Aquaculture Society (AFRAQ2021)

Egypt is the biggest aquaculture producer in the continent. Both local and international aquaculture delegates will converge for the event at the beautiful City of Alexandria, the Pride of the Mediterranean Sea.

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**Trade Show Contact: [mario@marevent.com](mailto:mario@marevent.com)**

# 31st Annual Practical Short Course on Feeds & Pet Food Extrusion



## January 31–February 4, 2022

As several events continue to be postponed, moved online, or cancelled altogether because of Covid-19 concerns in the United States, Texas A&M University (TAMU) has announced its 31st **Annual Practical Short Course on Feeds & Pet Food Extrusion**, will be held in *hybrid format* for those who like to attend face to face and for those who still cannot travel because of the pandemic.

This one-week course will be presented on January 31– February 4, 2022 at Texas A&M University by staff, industry representatives, and consultants.

The program will cover information on different extrusion systems such as dry extruder, expander, single and

twin-screw extruder, designing new feed mills and selecting conveying, drying, grinding, conditioning and feed mixing equipment. Current practices for production of pet foods, preparing full-fat soy meal; recycling by-products and secondary resources; spraying and coating fats, digests and preservatives; use of encapsulated ingredients and preparation of premixes are reviewed. Participants can register online at <https://cvent.me/44O2ae?RefId=TEES+Edge+Website>

Reservations are accepted on a first-come basis. For more information, programs and application forms, contact: Mian N. Riaz, Dept. Director, Extrusion Technology Program, Texas A&M University, College Station, TX 77843-2256. Email: [mnriaz@tamu.edu](mailto:mnriaz@tamu.edu); <https://foodscience.tamu.edu> or <https://teesedge.tamu.edu/online/extrusion>

# 2021

# 2022

**January 27–29**

**AquaIndia 2022**

[www.aquaprofessional.org](http://www.aquaprofessional.org)

**February 28–March 4**

**Aquaculture 2022**

**San Diego, USA**

[www.was.org](http://www.was.org)

**March 30–31**

**RAStech 2022**

**South Carolina, USA**

[www.ras-tec.com](http://www.ras-tec.com)

**April 25–28**

**World Aquaculture 2022**

**Qingdao, PR China**

[www.was.org](http://www.was.org)

**December 2–4**

**Taiwan International Fisheries and Seafood Show (Hybrid)**

**Taipei**

[www.taiwanfishery.com](http://www.taiwanfishery.com)

**April 26–28**

**Seafood Expo Global**

**Barcelona, Spain**

[www.seafoodexpo.com/global/](http://www.seafoodexpo.com/global/)

**May 24–27**

**World Aquaculture**

**Merida, Mexico**

[www.was.org](http://www.was.org)

**May 31–June 2**

**13 AFAP – Asian Fisheries**

**Aquaculture Forum**

**Tainan, Taiwan**

<https://13afaf.tw/index.php>

**August 23–26**

**DAA11**

**Kuching, Malaysia**

[www.daa11.org](http://www.daa11.org)

**December 11–14**

**African Aquaculture 2021 (in person)**

**Alexandria, Egypt**

[www.was.org](http://www.was.org)

**September 7–9**

**Nutrition and Health Asia/**

**Victam 2022**

**Bangkok, Thailand**

<https://victamasiam.com/>

**September 13–15**

**SPACE**

**Rennes, France**

[www.space.fr](http://www.space.fr)

**September 27–30**

**Aquaculture Europe 2022**

**Rimini- Italy**

[www.aquaeas.eu](http://www.aquaeas.eu)

**November 9–11**

**Aquatica Asia**

**Jakarta- Indonesia**

<https://aquaticaasia.com/>

**November 29–December 2**

**World Aquaculture Singapore**

[www.was.org](http://www.was.org)

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