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AQUA CULTURE

Asia Pacific

Aqua Feeds in Asia: A varied growth in 2016

Optimising shrimp pond management

Living with pathogens

Extrusion: output & environment

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A milestone with snakeheads in India

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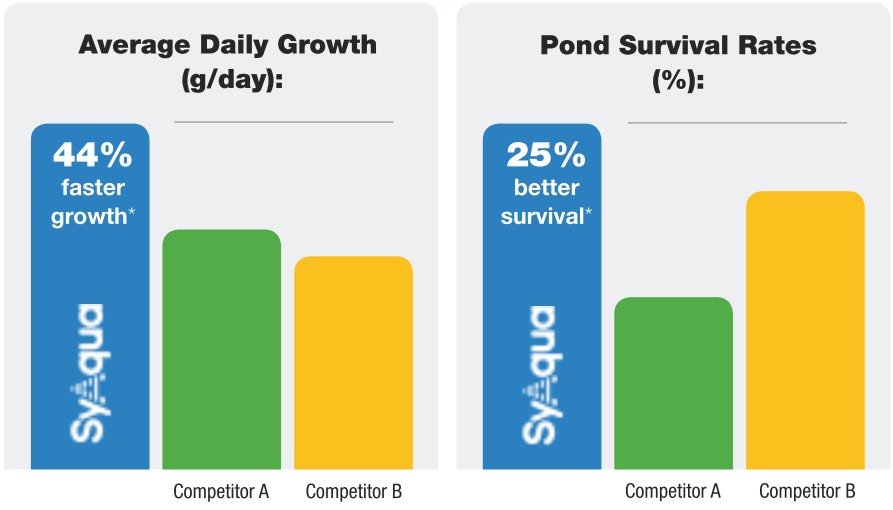

* Based on actual data from 2016 from 606 ponds in Southeast Asia.

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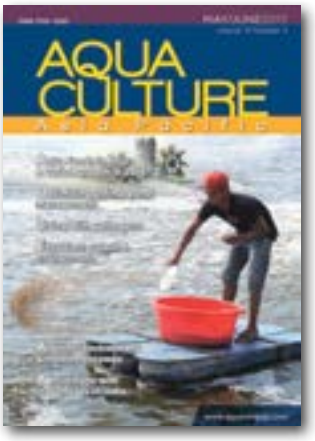

Feeding vannamei shrimp in Indonesia

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Complacency slows development

Zuridah Merican

The 1st quarter of the year for me always starts with finding the most relevant topics for the plenary session at The Aquaculture Roundtable Series (TARS). This year's meeting will focus on Finfish Aquaculture – Strategies for Growth. There is no fortunate stroke of serendipity in the chosen topics and my modus operandi is always to look at the weak links in the industry. The interview with Einar Wathne, Cargill's Aqua Nutrition President (see issue March/April 2017) raised an interesting issue of complacency in the salmon industry which was noted with surprise by Anton Immink of Sustainable Fisheries Partnership. Then came the thought, how is this relevant across aquaculture in Asia?

In shrimp farming, with EMS or AHPND nearly 8 years old, alongside WSSV and EHP, bacteria, viruses and microsporidian have become our weakest link. The limited supply of shrimp due to significant declines in survival rates have pushed prices up. Consequently, farmers continue business as usual in the same paradigm, waiting for a therapeutic solution to counter diseases. There has been a revival with old ponds as the high prices attract new farmers to the business. The mentality (others may call it a strategy) is to be prudent with costs to ensure margins and profitability. Greed has pushed stocking densities higher and the focus is on the production without concern for the pond carrying capacity or the total ecosystem. Clearly, without a revolution or dare I say disaster, nothing will change.

In the marine fish industry, the weakest link is the dependence on the high priced live fish market which favours the backyard farmer. Backyard farms have to culture numerous species because that is the demand of the well boat buyers. Backyard farms are profitable despite very low survival rates but just being good prevents them from doing greater things. Upscaling and industrialisation is the biggest challenge here because today the farmer can afford to be complacent with low survival rates. But is this the future we want for the next generation of farmers - the fear of dead fish in polluted coastal waters? This dependence on live fish markets does not encourage the industry to get out of its comfort zone.

What do we in Asia want to achieve? Governments want industrial farming in offshore cages. What happened in Turkey is a good example. This means a change - volume production of 1 or 2 species, standardisation and buyers who demand consistency. With industrialisation comes economies of scale for support segments such as feed and health management (vaccines) to invest and focus on this business. Volumes of a specific species will make it worthwhile for aquaculture health companies to focus on R&D in vaccines, etc. Economies of scale also bring increased volumes and price elasticity. Margins per kg of fish will fall but logically, the increased volume will compensate and surpass overall profitability.

In the freshwater fish industry, Regal Springs – the integrated tilapia company is a role model. Despite a low priced species, this company has been able to focus on tilapia, differentiate itself and provide quality, safety and sustainability. So how does the Vietnam pangasius segment fare? Admittedly, Vietnam's pangasius entered the market with a low price-high volume product but with unfair bad press, it has not been able to shed its image issue in the international market. This segment has a well-developed supply chain but it needs to consolidate and move the product up the white fish ladder. Generic marketing is critical to bring Vietnam's pangasius close to the promotion effort of Norwegian salmon. Easier said than done but perhaps a good start would be self-regulation in order to weed out the bad apples in the cart.

Modern aquaculture in Asia is at least 40 years old and for some species, we have seen several cycles of peaks and troughs. The bane of Asian aquaculture lies in human complacency. The industry will evolve very slowly if we are not proactive. It is interesting to note that bacteria mutate much faster than humans can change or react. Complacency Is bad for business.

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Reviving giant prawn farming in Asia

In Bangkok, scientists and industry reached out to each other on ways for a better future for the species at GIANT PRAWN 2017.

Two decades ago, the giant freshwater prawn (*Macrobrachium rosenbergii*) was a darling of aquaculture in Asia, alongside the monodon shrimp. Total production of freshwater prawns (*Macrobrachium* spp.) in 2014 was 217,000 tonnes (FAO, 2015), valued at USD 1.2 billion. China led in freshwater prawn production at 127,000 tonnes, but largely comprising the oriental prawn *Macrobrachium nipponense*. Next was Bangladesh at 45,000 tonnes, producing mainly the giant freshwater prawn. In general, aside from China and Bangladesh, other producing countries have seen their production volumes falling in the last decade, such as Thailand from a peak of 30,000 tonnes in 2005 to 18,000 tonnes in 2014.

Conference co-organisers, Michael New, Consultant, UK and Dr KR Salin, Assistant Professor at the Asian Institute of Technology (AIT) have dedicated their careers to this species. Together with Dr C. Mohanakumaran Nair, now with the Ananda Group, India, they also organised the Giant Prawn 2011 in Kochi which came along after the first Giant Prawn 1980, also in Bangkok. New is co-editor of the 2010 book on the Freshwater Prawns: Biology and Farming and author of the FAO technical manual on freshwater prawn farming whilst Nair is author of the Macrobrachium: The Culture of Freshwater Prawns.

Thailand was among the first countries to establish farming of the giant prawn back in the 1970s and with such a history, it was apt that this conference and workshop with the theme *"Emerging possibilities for sustainability"* was held in Bangkok again. New and Salin have achieved their goal of getting scientists involved in the breeding of the *Macrobrachium* with industry experts, hatchery and grow-out farmers to debate on what should be the future for the giant prawn and how to get farming back on its feet, particularly in those countries where production has been declining. Although the conference name could be taken to refer only to the Giant Malaysian prawn *M. rosenbergii*, presentations also touched on farming all species of *Macrobrachium*.

The 4-day conference, attended by 150 participants from 22 countries, was preceded by a 2-day workshop, attended by 25 participants from 15 countries. The workshop covered hatchery production and improving efficiency and survival. This was appropriate as during the conference, it was clear that the malaise in giant prawn farming starts with the genetics, hatchery and nursery stages. Asia's agro multinational Charoen Pokphand Public Foods Limited (CPF), the platinum sponsor, fully recognizes the potential in freshwater prawn farming in Asia. CPF is very active in the promotion of giant prawn farming in Asia and provides seed stock, feeds and technical assistance to farmers. Other sponsors included Thailand based Bio-Active Co Ltd and I&V Bio, NACA, China based Nutriera and India's Ananda Group.

GIANT PRAWN 2017 was held from March 20-24 at the Asian Institute of Technology, Bangkok, Thailand

Industry dilemma

Pinyo Kiatpinyo, representing national farmers in Thailand explained the dire straits of giant prawn farmers in Thailand. "There is a high demand for the giant prawn, locally for the Thai dish, tom yam goong, as well as for export. We have exported live giant prawn to Korea and China, but now we cannot meet the demand. For the last 10 years, we have been facing problems in its farming and do not have access to quality post larvae. The regional irony is that we used to buy large prawns from Myanmar and now Myanmar wants to buy from Thailand. There is demand for post larvae from Vietnam and we do not wish for the situation where we need to buy post larvae from Vietnam. The industry is asking academia and industry for help," he explained.

Statements from producers and farmers during the meeting underlined that a major bottleneck is the use of wild broodstock by most hatcheries in Asia and inbreeding over the years. The uncertainty in achieving results in breeding in Malaysia was echoed by Thanabal who has been operating his 3 million post larvae/year hatchery in Lumut, Perak for the past 7 years. As he often experiences poor performances of wild broodstock, he said, "I cannot guarantee the demand of my clients and worry, in case I disappoint them with poor quality post larvae." Post larvae are sold at MYR70-80/1000 PL (USD 16-18/1000PL).

Several country reports mentioned the shift to production of vannamei shrimp post larvae, which reflects the rising demand for the shrimp with better prospects of high yields from higher stocking density. At this conference, several presenters reported on the decline in hatchery production of post larvae of the giant prawn. In Myanmar, the number of hatcheries dropped from 29 to 5 and in Bangladesh, from 81 to only 5-10. Myanmar has imported post larvae from Thailand at USD 7.4/1,000PL, whilst in Bangladesh post larvae were sold at USD 25.5/1,000 PL.

KR Salin (second right) with from left, U. K. V. Raju, Chairman, Ananda Group, India, Nyan Taw, Mohanakumaran Nair and Endhay K. Kontara

Pinyo Kiatpinyo (left) and Donghuo Jiang

Khoo Eng Wah (centre) with Liaw Boo Lai, Kg Chennah Agro Resort, Malaysia (left) and Dr U Win Latt, Aqua Global Environs, Myanmar. Liaw said that because of the lack of post larvae, he now alternates between prawns and tilapia culture.

Breeding and genetic selection

Recent progress in breeding and genetic selection studies include those by the team at CPF for specific pathogen free broodstock and the development of all male and all female progeny, led by Professor Amir Sagi, Ben Gurion University, Israel, (Jiang, 2016; Assaf, 2017; Sagi, 2013). In China, Dr Yang Guoliang, Huzhou University reported on the development of specific pathogen free technology and also on the farming of an improved strain "South Taihu No 2" since 2014. The strain was developed after seven generations targeting growth and survival. In Indonesia, two research institutes, in Sukabumi and Sukamandi have through selective breeding produced GI-Macro II and Siratu, which showed fast growth and brood stocks that are free of macrobrachium rosenbergii nodavirus (MrNV). "The two institutes are also working on the production of all male or sterile female *M. rosenbergii*," said Dr Endhay K. Kontara, Ministry of Marine Affairs and Fisheries, Indonesia.

"Since 2009, CPF has been working on SPF populations for the *Macrobrachium* following the example with the marine shrimp," said Dr Donghuo Jiang. The breeding goals were to improve body size, growth rate, survival and density tolerance. They have succeeded after five generations with consistent improvements in harvest weights and average daily growth. Post larvae are marketed in several countries. Jiang added that this works well in Thailand, where the farming model is for large sizes farmed at lower density. "However, CPF has only 20% of the post larvae market and this poor acceptance is related to the cost of post larvae which is much higher than regular post larvae," said Dr Uthairat Na-Nakorn, Faculty of Fisheries, Kasetsart University, Thailand in her presentation on the current situation in Thailand.

Monosex culture is aimed at production of large-sized prawn. The RNAi based technology developed in Israel at Ben Gurion led by Professor Amir Sagi is geared towards the culture production of large all male prawns. This technology has been introduced to China and Vietnam. In contrast, the proprietary all female technology presented by Assaf Shechter, Enzootic, Hong Kong is a novel alternative strategy for growers seeking an intensive culture model, closer to that common in marine shrimp farming.

Production situation

Uthairat Na-Nakorn said main obstacles in the farming of the prawn are: low yields and farmers' sensivities to high post larvae prices. "The situation is not good for the giant prawn in Thailand. The low yield/unit area and long culture period (8-12 months) are obstacles, giving giant prawn farming a low return on investment, compared to farming the marine shrimp *Penaeus vannamei* and Nile tilapia. Farmers either switch to other species or opt to co-culture.

Many in the audience were aware of the switch to the farming of vannamei and monodon shrimp in areas previously the domain of the freshwater prawn. In Thailand, the market price of the freshwater prawn is similar to that of the vannamei shrimp at THB 150-200/kg (USD 4.4-5.7/kg). In the monoculture of freshwater prawn, 250,000 to 375,000/ha of juveniles are stocked and partial harvesting starts from the 6th-8th months of culture. The yield is 2 tonnes/ha but with a large size variation. "Solitaire culture developed in Chainat where single prawns are reared in cells can yield 200-250 g prawns, after 4 months when fed high crude protein (40%) diets," said Uthairat Na-Nakorn.

"With a supply shortage, ex-farm harvest prices have been rising. It was MYR 58-65/kg (USD13.3-14.9/kg) for size 30-35/kg in March," said Khoo Eng Wah, who runs aquaculture courses in Malaysia. "Restaurants demand live prawns but at high prices, they sometimes settle for chilled or frozen imported prawns", added Khoo. Dr Mohd Fariduddin Othman, Department of Fisheries Malaysia, said that in 2016, only 1,500 ha were dedicated to the farming of the prawn and production was estimated at between 300-500 tonnes in 2016. He added that yield/ha was only 1-2 tonnes as survival was low at 20-30%.

In Myanmar, Dr Nyan Taw, Consultant said that the major challenge for the industry was white diseases affecting larval production. Since 2005, few hatcheries continue to operate. "The prawn is a potential for aquaculture in Vietnam but the issue is the shortage of post larvae, although there are 59 hatcheries operating in Vietnam," said Dr Tran Ngoc Hai, Can Tho University. The demand is 1-3 billion post larvae/year but supply is only 260,000 post larvae.

Revival with all male prawns

In India, Nair described the developments with neo females which helped to raise production. However, he added that although production during 2015-2016 rose to 10,152 tonnes, it was still below the peak in 2005-2006 at 45,780 tonnes. The issues were high feed, labour and certification costs, poor seed quality and issues related to water quality. "A recent revival in India is the grow-out of all male prawns. Orange claw prawns are fast growers and so farmers remove the slower growing blue claw prawns. This manual segregation in 8 hours separates 5,000 to 8,000 juveniles. Our expansion in production is due to monosex culture. We throw out females or if possible, farm males and females separately. All male culture gives us 60% increase in yields and

Dr Peter B Mather, Queensland University of Technology, Australia (left) and Uthairat Na-Nakorn

Tran Ngoc Hai

Mohd Fariduddin Othman

Five-years' stay for US anti-dumping duties on frozen shrimp

On May 2, the US International Trade Commission (USITC) has determined that revoking the existing anti-dumping duty orders on imports of frozen warmwater shrimp from China, India, Thailand, and Vietnam would likely lead to the continuation or recurrence of material injury within a reasonably foreseeable time. This came under the five-year (sunset) review process required by the Uruguay Round Agreements Act. The report will be available by June 15, 2017; when available, it may be accessed on the USITC website at: *http://pubapps.usitc.gov/applications/publogs/qry_publication_loglist.asp.*

The US is the largest market for Indian exporters. In 2016 (January-December) the US imported 153,984 tonnes of shrimp from India, which was 25.5% of the total shrimp imports at 603,591 tonnes (st.nmfs.noaa.gov). In January 2017, imports from India peaked at 13,566 tonnes. This is a setback for the USD 4.7 billion Indian seafood exports sector, reported the business.standard.com. The US anti-dumping duty was imposed on frozen shrimp from China, India, Thailand, and Vietnam, as well as the Indian frozen warm water shrimp since 2004-05. Tara Patnaik, chairman, Falcon Marine Exports Ltd, which is the country's largest exporter, said that exporters have to conduct business amidst uncertainty.

Vanami Shrimpapp

ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) has launched an android based mobile app called the "*Vanami shrimpapp*" for the dissemination of technical information among members of the shrimp farming sector. Presently this app provides information on best management practices of Pacific white shrimp *Penaeus vannamei* farming in the form of "Frequently Asked Questions". The target is shrimp farmers and field level extension workers of the coastal states. The user can view the content either topic-wise or through key word search. Further, the users can post their queries through 'post a query' option and it will be answered within two working days. *Penaeus vannamei* is being farmed from very low to oceanic salinities with different levels of technology adoption ranging from extensive, zero water exchange to biofloc based intensive systems and with formulated feeds at varying protein contents. Also *P. vannamei* shrimp is farmed in about 60,000 ha in nine coastal states, mostly by small scale farmers, with a production of 360,000 tonnes per annum. This app can be downloaded free from Google playstore (https://play.google.com/store/apps/details?id=com.vanami.shrimpapp&hl=en).

New aquaculture R&D centre in Vinh Long

In May, 2017 Royal De Heus opened its aquaculture R&D centre in Vinh Long, Vietnam. Supported by three organisations: Fresh Studio, Vietnam's Can Tho University and the Netherlands' Wageningen University, this state-of-the-art centre enables De Heus to test innovative feed formulas and new aquaculture farming techniques. The 6-ha facility has 111 indoor tanks and 25 outdoor ponds, as well as 2 pumping stations, 2 water treatment ponds, bio-filter tanks, laboratory, storage buildings, offices and facilities for the employees.

"The facility will be used by De Heus to conduct aquaculture R&D and will also be used by other public and private organisations for their (contract) research activities. This means our facility will contribute to the further professionalisation of the total aquaculture sector," said Gabor Fluit, Business Group Director of De Heus Asia. "The R&D centre situated in the Mekong Delta, is equipped with facilities for testing the nutritional value of ingredients, and for deriving innovative feed formulas and farming techniques. We will also use the centre to train farmers in farm management and best practices."

continued from p5.

larger size harvests. We have production of jumbo prawns (up to 760 g each) such as in Malampuzha, Kerala. However, we still need genetic studies to have fast growers only or at least some homogeneity in sizes."

Optimism ahead

There is hope for the revival in the production of the giant prawn with the breeding technology presented at this meeting, and with the co-culture with fish or shrimp or all male culture. With increasing demand from local and export markets and rising prices, the giant freshwater prawn will always have a niche market. In his welcome speech to participants, AIT President, Professor Worsak Kanot-Nukulchai, said that it is obvious that the giant prawn when free of major diseases and farmed in low density, is a sustainable form of aquaculture. Now it is up to the industry to bring its farming to the next level.

Participants and speakers, from left, Tang Qiong Ying and Cui Aibing from China, Zurong Wang, Biorigin, Singapore, Huang Xuxiong, Shanghai Ocean University and Professor Yang Guoliang, Huzhou College, China, Dr Yang Derun, NACA, Thailand and Dong Qiufeng,Guangzhou Nutriera Biotechnology Co., Ltd, China

At the CPF booth, the team displayed products and technology for prawn farming. The 6 feed types contain 40-38% crude protein, 5-4% fat and 10-12% fibre. They also promoted the genetically improved SPF freshwater prawn

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More innovations in shrimp farming

By Poh Yong Thong

Three innovations are described, including an ingenious automatic dead algal removal tool developed at a farm in East Java and a check valve to keep the outlet channel dry.

Commercial shrimp farming has a relatively short history, having originated some 35 years ago in the early 1980's, in Taiwan. In comparison, poultry farming, started more than 150 years ago! The husbandry in shrimp farming is thus still in its infancy stage and it is not a wonder that it is still plagued with husbandry and disease problems. Many techniques and innovations are continuously being perfected to make shrimp farming efficient and productive

In an article in 2014, I reported on some innovative ideas developed by farmers in Southeast Asia. These were auto-on paddlewheel switches, paddlewheel arrangement in long ponds to create two sludge areas, water sampling bottles, partial harvesting from the bund area, a central sludge removal system and water mover airlift. Another innovation reported was the dispensing of chemicals/probiotics directly to the sludge area, via a 30- or 50-L tank (containing a mixture of probiotics and water), with a 2.5 cm pipe or hose controlled by a valve. (Aqua Culture Asia Pacific, January/February 2014, pp13-16).

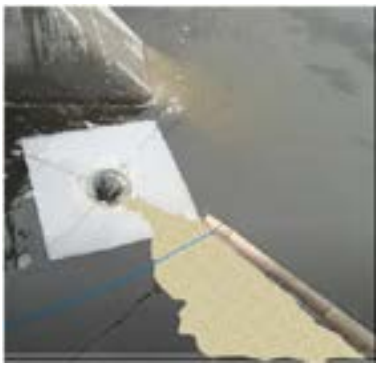
In general, innovations described earlier and in this article are the results of many trials by innovative farmers and technicians. They are the real heroes in shrimp farming; thinking out of the box, they make shrimp farming easier and more productive. I am very grateful that they are willing to share and explain these innovations for the benefit of the wider shrimp farming community.

Automatic dead algae removal device

The water quality in a pond is constantly changing, sometimes resulting in massive algae die-off. These dead algae float to the surface and may sink and accumulate in certain dead zones in the pond bottom, resulting in the formation of sludge and hydrogen sulphide. The dead algae, if not removed will decompose, emit a foul smell and is highly toxic. Conventionally, removal of dead algae employing manual labourer is time consuming and tedious. A farm in East Java has devised an ingenious automatic dead algae removal tool.

Floating dead algae

Drain pipe with the PVC sheet to divert shrimp away from the drain pipe.



Floating dead algae are guided into the drain pipe by a floating bamboo pole

The floating dead algae are guided by the ingenious arrangement of a floating bamboo pole positioned above a drain pipe placed about 0.5 cm below the water surface. In order to prevent shrimp from climbing up the drain pipe and escaping, a 40 cm x 40 cm (16" x 16") PVC sheet diverts the shrimp away.

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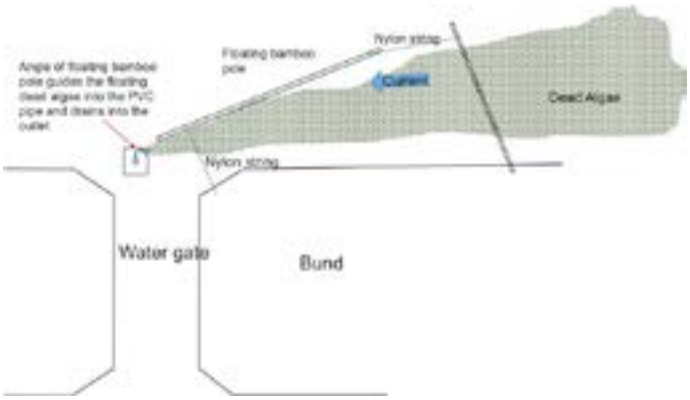
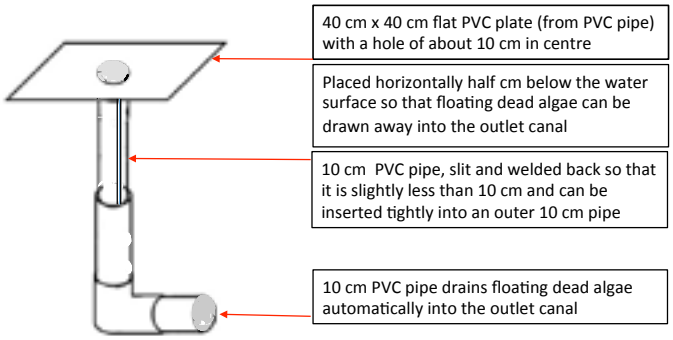
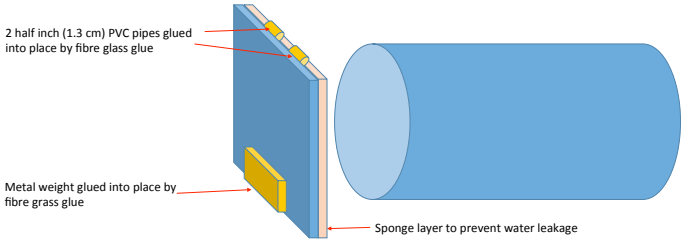


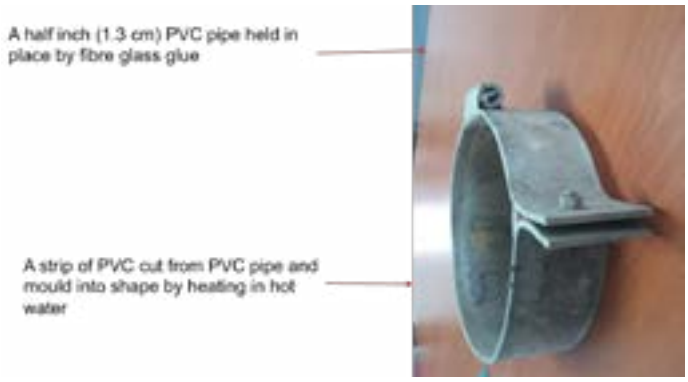
Schematic drawing demonstrating how the dead algae removal tool works



Different parts of drain pipe



Schematic drawing to show various parts of homemade back flow valve



Homemade PVC collar

Homemade check valve

Many farms are located in very low lying areas and the outlet canal is constantly filled with water both from the pond effluents and from the incoming tide. For economic and security reasons, the outlet water is discharged to the outside by drain pipes. The discharge is slow and back fills quickly during high tides. These farms have to resort to pumping to remove water in the outlet canal during harvests and incur high operating costs. In addition, the constantly water logged outlet canal harbours wild crustaceans as well as bacteria and present a high biosecurity risk.

In Gold Coin's R&D farm in Perak, Malaysia, the farm manager devised an automatic check valve that discharges outlet water during low tide but closes automatically when the tide rises and the water flow is reversed. In this way, tide water is prevented from entering back into the outlet canals. With this device, the outlet can be kept relatively dry, thus saving on pumping costs. More importantly, it helps to dry out the outlet canal and greatly reduces biosecurity risks.

Series of automatic check valve to discharge outlet water during low tide but closes automatically when the tide rises.

High salinity mitigation through adding fresh water to feed

Farmer adding freshwater to feed

During the dry season, pond water salinity can increase to 45 ppt or higher, resulting in slower shrimp growth. A farm in West Java has found a way to overcome this problem. The farmer adds clean freshwater to the feed before feeding to shrimp. Water at 10% of the weight of the feed is added uniformly using a watering can and is thoroughly mixed with the feed. The feed is left to stand for 30 min to allow the feed to completely absorb the water. The feed pellet will still remain hard and can be handled as usual. The farmer has thus found a novel way to make the feed "less salty" by allowing the feed to first absorb some freshwater.

Poh Yong Thong is Assistant Director Technical Services in Gold Coin Aquaculture. He is based in Malaysia. Email: yongthong.poh@gcaqua.com or poyoto2002@yahoo.com

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Optimising shrimp pond management with bioremediation

By Stephane Ralite, Eric Leclercq, Slyvie Roquefeuil and Mathieu Castex

Selecting the best microbial candidates contributes to the degradation of organic matter for a healthier pond bottom. The enhancement of soil and water quality leads to an improvement in shrimp growth.

Management of water quality is key in shrimp farming, in particular in intensive systems under high stocking density. Poor water quality is detrimental to both shrimp growth and survival. A shrimp pond is essentially a closed ecosystem, where shrimp as well as various microorganisms, plankton and algae interact with one another. They are involved in organic matter degradation and nutrient recycling or removal, especially nitrogen, which can rapidly accumulate from left-over feed and shrimp faecal wastes.

Bacteria play an important role in this rich and complex ecosystem. An approach based on adding selected bacteria to help orientate and manage these ecosystems has been used for decades in aquaculture. This approach, called bioremediation, is defined as *"the treatment of pollutants or wastes by the use of microorganisms (such as bacteria) that break down undesirable substances"*.

In this article, we report on the rational development of a novel bioremediation solution aimed at facilitating the management of organic matter and nitrogen compounds in shrimp ponds, from selecting the right microorganisms in the laboratory to farm efficacy trials.

Importance of microbial balance

As Lavoisier wrote in the 18th century, *"in nature, nothing is lost nothing is created everything is transformed"*. This is perfectly true when it comes to shrimp ponds. Ponds are essentially closed environments which can be described as complex ecosystems, with bacteria, plankton, algae and finally shrimp, all involved in organic matter degradation and nutrient recycling or removal. A well-functioning ecosystem also has a major impact on sanitary conditions. Together with phytoplankton, bacteria populations dominate this ecosystem. The pond microbial communities play four major roles:

- They form part of the food chain (sources of nutrients for the zooplankton and shrimp)
- They contribute to biological processes (organic matter degradation, nitrogen cycle etc)
- They can be a source of undesirable bacteria or pathogens
- They can be a source of positive microflora that helps keep pathogens under control through competitive exclusion and direct antagonisms

Ultimately, all of the above is a balance between the positive and negative microflora. Changes, in nutrients, water environment (temperature, pH, oxygen etc.) can represent a sudden challenge for these ecosystems and tilt the balance. A shift in this balance can affect the nitrogen cycle and organic matter removal, or lead to the over-development of undesired microorganisms or potential pathogens, with possible impact on shrimp health and performance.

In addition to controlling sludge accumulation, the three major elements of concern for pond bioremediation are: organic carbon, nitrogen and phosphorus. In practice the farmer will focus on the control of nitrogen compounds as it can have direct toxic effect on shrimp (un-ionized ammonia and nitrite) and will have an important impact on pond water equilibrium (for example, through algal developments).

By manipulating the microbial establishment and managing the bacteria communities in the pond as early as possible, a bioremediation approach can help farmers reach these objectives for a balanced and healthy pond system. The aims of such an approach would be:

- To promote an early establishment of heterotrophic bacteria which are crucial for the pond equilibrium and its recycling capacity.
- To support the establishment of nitrification and denitrification bacterial populations.

The ammonia and nitrogen cycle

The main parameters which determine water quality include pH, alkalinity, oxygen, temperature, salinity and the level of nitrogen compounds which is a key parameter and a limiting factor to shrimp growth. Nitrogen in the pond exists under different forms, with different degrees of toxicity. Figure 1 summarizes the nitrogen cycle. Ammonia (NH_3/NH_4+) is a water soluble nitrogenous waste originating from the degradation of proteins. It is continuously excreted by shrimp as a result of their normal metabolic activity and is also released from the decomposition of organic matter within the pond. Major sources of organic wastes are feed and faecal waste, in addition to dead shrimp and dead plankton.

There are two distinct forms of ammonia in equilibrium in the water: unionized-ammonia (NH_3), which is toxic to shrimp, and ionized-ammonium (NH_4^+), the non-toxic form. Together they constitute the total ammonia nitrogen (TAN) level of a water sample. The effects of NH_3 include gill damage, metabolic stress, reduced feed intake and growth performance, increased susceptibility to disease, lethargy and death.

TAN= NH_4^+ +NH_3

The proportion of the different forms of TAN is directly dependent on the water pH, temperature and to a lesser extent salinity. For a given level of TAN, the concentration of toxic NH_3 increases with increasing water pH (particularly above pH 8.0), temperature and salinity. Thus, a meaningful interpretation of the ammonia level with regard to direct toxicity must be based on the unionized form (NH_3) which can be measured directly or calculated from the total ammonia level, water pH and temperature.

Dissolved ammonia present in the water can be incorporated in the tissues of heterotrophic bacteria and algae as they multiply; if bacteria are insufficiently present or active, algae can thrive on available ammonia leading to an uncontrolled algal bloom and plankton crash. This creates a major imbalance in the pond ecosystem which is detrimental to the shrimp stock.

Ammonia can also be transformed through the nitrification pathway into nitrite (NO_2^-) and then nitrate (NO_3^-) by the action of slow-growing autotrophic bacteria. Nitrate can in turn be used by denitrifying bacteria present at the pond bottom; gaseous nitrogen is ultimately released into the atmosphere, therefore, removing nitrogen out of the pond ecosystem.

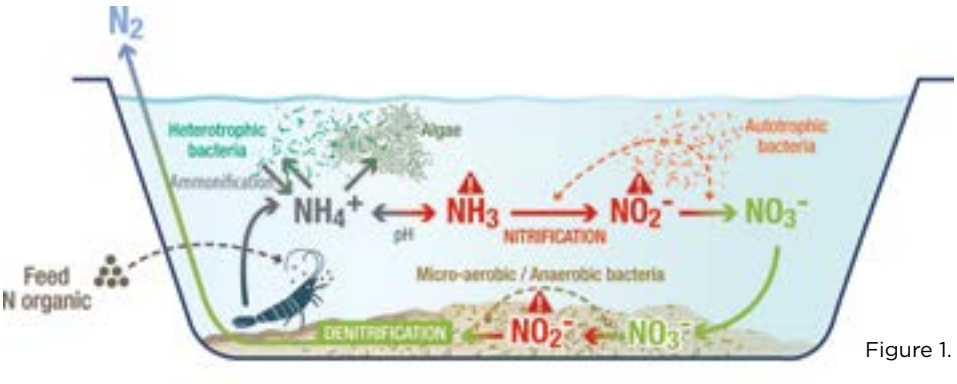

Figure 1. Simplified nitrogen cycle in a shrimp pond.

Selecting best microbial candidates for bioremediation

With the objectives of establishing a healthy and balanced pond system, microbiologists at Lallemand Animal Nutrition went "fishing" for the best microbial candidates among a huge library of microorganisms (10,000 marine microorganisms, with over 5,000 already sequenced at the Lallemand Aquapharm cell bank). Using an advanced microbial screening platform, "SeaRch" technology, they have selected several complementary microbial strains based on different criteria.

First of all, bacteria were selected for their capacity to survive and be active in various water environments. These include the ability to grow in anaerobic and low oxygen conditions, followed by the tolerance to saline conditions, from freshwater up to hyper-saline conditions. The selected bacteria are thus bioactive in a variety of salinity and oxygen conditions and can be applied in various pond environments.

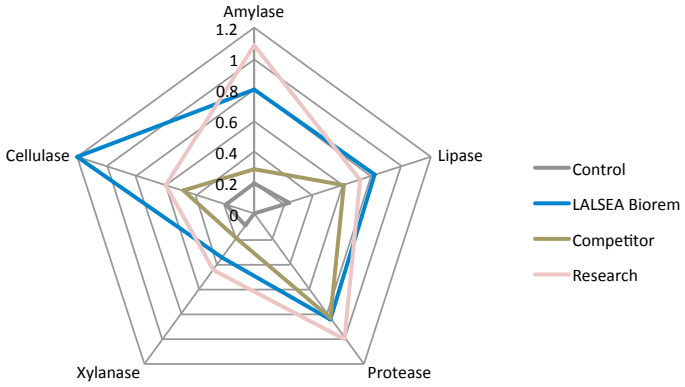

Figure 2. Enzymatic profiling of various bacteria combination. Lalsea Biorem is the combination that was selected for shrimp ponds applications.

The second round of selection concerned the ability of the bacteria to help degrade organic matter. The researchers performed enzyme activity screening and selected organisms with interesting and complementary enzymatic activities on the digestion of lipids, proteins, sugars and fibre.

These tests involved working on different formulations in order to select the best one with complementary and optimal degradation activities (Figure 2). Lalsea Biorem, a combination of several bacteria strains (six strains from three different *Bacillus species* and one specific *Pediococcus acidilactici* strain), was then selected and further tested in shrimp ponds to validate its benefits on pond bottom quality, water quality and shrimp performance at the commercial level.

Contribution to nitrogen detoxification

In order to further investigate and validate the effect of Lalsea Biorem applied at commercial doses in shrimp ponds, a trial was performed within a tank system mimicking real farm conditions. The tanks were prepared with a layer of organic soil rich in organic matter collected from a nearby shrimp farm, and Lalsea Biorem was applied at the commercially recommended dose. This approach allowed full control over rearing parameters and experimental replication for an accurate evaluation of the effects of Lalsea Biorem in close-to-real farm conditions.

The trial was conducted in Peru in 2015 on juvenile white leg shrimp (*Litopenaeus vannamei*; 3.6 ± 0.3 g). Six tanks of 1m^3 each were used, under similar conditions, with half of the tanks receiving the bioremediation solution once weekly at a dose equivalent to a commercial dose, for 9 weeks.

The levels of nitrogen compounds in the water (Figure 3) indicated that Lalsea Biorem had an effect on the nitrogen cycle :

First, bioremediation treatment reduces the level of total ammonia in the tanks. This could be attributed to the increased assimilation of ammonia into the cellular tissue of heterotrophic bacteria. A lower ammonia level reduces the risk of direct toxicity to shrimp, uncontrolled algal blooms and pond eutrophication.

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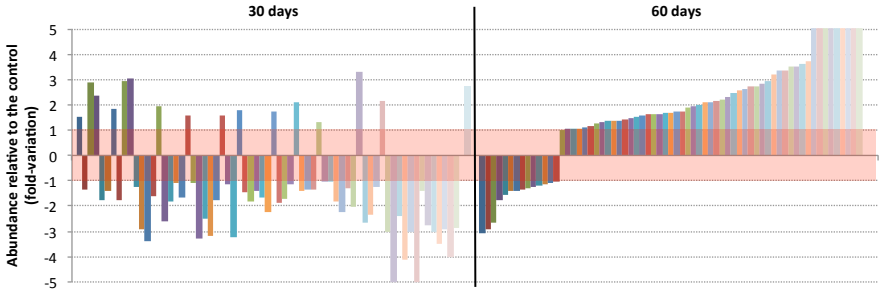

Figure 5. Abundance of the main bacterial genus in the soil layer of tanks treated with Lalsea Biorem relative to the non-treated control soil.

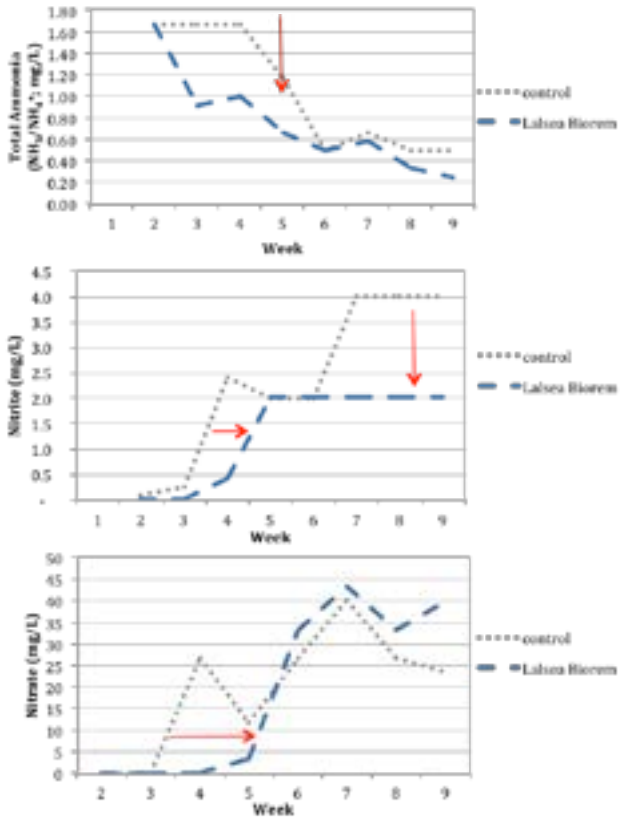

Figure 3. Effect of specific bioremediation treatment on nitrogen compound levels in shrimp ponds (Peru, 2015).

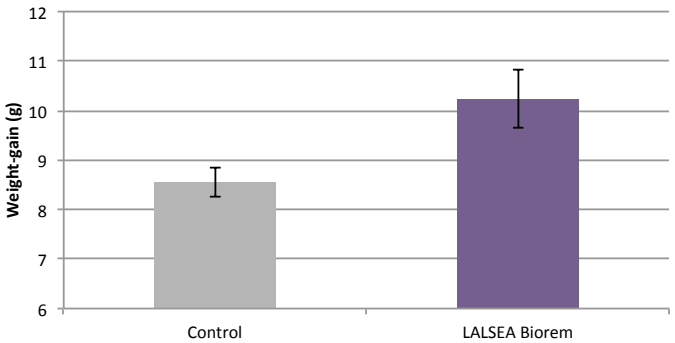

Figure 4. Effect of specific bioremediation treatment in ponds on shrimp growth (initial body-weight 3.6 ± 0.3g, initial density 27 shrimp/m²).

Second, bioremediation delays the build-up of nitrite as the level of ammonia dissolved in the water is reduced.

Third, bioremediation results in a lower pressure on the two-step nitrification pathway (see box) by slowly growing autotrophic bacteria which therefore have more time to establish themselves. By facilitating full coupling of the two-step nitrification, ammonia is efficiently converted into nitrate with a lower risk of accumulation of the toxic intermediary nitrite.

At the end of the trial, the bottom layer of the organic sludge improved visibly with a lighter colour and there was an absence of sulphide smell in all the tanks where Lalsea Biorem was applied.

Altogether, these results showed that the bioremediation treatment contributed to the degradation of organic matter for a healthier pond bottom, to ammonia removal by heterotrophic bacterial assimilation and finally to a more efficient nitrification.

As a result, shrimp zootechnical performances improved. In the same trial, the enhancement of soil and water quality is associated with a 20% shrimp growth improvement (Figure 4).

We went a step further in demonstrating the bioremediation concept. We looked closely at the microbial populations of the pond sediment layer using the state of the art microbial identification by metagenomics. The results showed that Lalsea Biorem had a significant effect on the relative abundance of many bacterial genus within 30 days of application (Figure 5). At the end of the trial (60 days), the abundance of 45% of the bacterial genus varied more than two-fold in the treated ponds as compared to the untreated ponds. Thus, added bioremediation bacteria had a significant effect on the overall make-up of the pond microbial populations. Positive modulation of the pond natural microbiota is a promising study area and undoubtedly a key mechanism on how Lalsea Biorem supports a balanced and healthy pond environment.

Conclusion

The bioremediation approach, based on manipulating and improving the pond microbial communities, appears helpful in controlling waste accumulation and improving water quality in shrimp pond, with positive consequences on farm yield. In addition, we should keep in mind that, during periods of high risks such as the onset of monsoons, cold or hot seasons or pathogenic outbreaks, water quality management is even more critical. Shrimp farming relies heavily on the judicious management of the pond ecosystem based on the farmer's practical experience.

Bioremediation is a useful tool to support a balanced and healthy pond environment, and to optimize farm yields.


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Is 100% replacement of *Artemia* possible?

By Craig Browdy, Peter Van Wyk, Chris Stock, M.S. Diego Flores and Murthy Chennamsett

Part 2: Commercial results of using synthetic *Artemia* in hatcheries and ponds

Global aquaculture growth will require additional *Artemia* supplies, with no obvious additional production sources in sight. The alternative is formulated, synthetic products that provide the same nutrients as live *Artemia* and can also offer a more consistent enhanced nutrient profile, stable quality and supply, biosecurity and also act as a delivery mechanism for immunostimulants, enzymes and other beneficial compounds.

Artemia is a key feed for larval stages of many commercially farmed shrimp and fish species throughout the world. As the aquaculture industry grows, increasing demand for Artemia could make its supply and availability a bottleneck for the future growth of the aquaculture industry.

In part one of this article, we discussed the relevance of *Artemia* to the growing aquaculture industry around the world, the global status of *Artemia* resources and the potential bottleneck its limited supplies could represent. The possibility and advantages of replacing *Artemia* with innovative manufactured synthetic products was presented. Here in part two, we discuss results of some of the field trials at the hatchery and pond stages in commercial facilities as well as some perspectives on the future of *Artemia* replacement.

Performance of synthetic *Artemia*

Our synthetic *Artemia* has over a decade of proven commercial application in hatcheries and nurseries in several countries all over the world.

Commercial hatchery tests – Western Hemisphere

In an earlier test, we compared two feeding protocols using 100% synthetic *Artemia* (not from hatched cysts), and evaluated the dietary impact of the two protocols on growth and survival of larval shrimp using commercial mass production systems. Two feeding protocols (treatments) for *Litopenaeus vannamei* were tested in two types of rectangular 20 m^3 fiberglass tanks taking into consideration the main types of tanks commonly used in shrimp larviculture. In one, flat bottom Asian style tanks were used, coupled with the use of easily suspended liquid larval feeds and synthetic *Artemia*. In the other, parabolic American style tanks were used, together with low-cost, dry diets and synthetic *Artemia*. Each treatment had three replicates.

Tanks were stocked with nauplii (N) at 160/L, and the test ran for 21 days, from stages N5 to PL15 (post larvae 15). From N5 to PL4, the microalgae *Thalassiosira pseudonana* were added and maintained at a density of 60,000 - 100,000 cell/mL. Water temperature was maintained at 30.8 - 31.8 °C and dissolved oxygen at 4.5 - 5.0 mg/L; pH was stable at 8.2 for the duration of the test.

Table 1 shows the results in growth and survival of N3 to PL15 in each treatment. The experimental results indicate that regardless of the format of the supporting diets (liquid versus dry) and the type of production tanks (flat versus parabolic), excellent results were achieved in the commercial hatchery trials using no *Artemia* in the feeding protocols.

Table 1. Results of commercial hatchery trials comparing two feeding protocols eliminating 100% of *Artemia* from cysts.

Treatment	Stocking density	Survival (%)	Size (cm)
Protocol 1 (liquid diet tanks)	163 ± 6.76	66.8 ± 5	0.89 ± 0.03
Protocol 2 (dry diet tanks)	161 ± 4.43	62.9 ± 1	1.18 ± 0.11

This test was carried out at a hatchery that had eliminated hatched *Artemia* use and had already adopted a protocol that exclusively used synthetic *Artemia*. The facility noted increased survival, sustained improvements in water quality and increased hatchery productivity, leading to decreased production costs and higher profitability.

Subsequently, between 2014 and 2016, we carried out several additional tests at various commercial hatcheries in five countries in Latin America, where we evaluated our artificial *Artemia* at 100% replacement levels versus controls fed standard diets. Table 2 summarizes test conditions and results; % survival and animal weight at PL4 were comparable or better than those of controls, demonstrating that 100% replacement was possible depending on the hatchery setup and equipment, operators and other conditions.

At these innovative hatcheries in Latin America, management protocols have been developed which enabled the complete replacement of *Artemia*. Benefits reported include reduced *Vibrio* counts and improved biosecurity which enhanced production efficiencies and consistency. The trials were conducted with synthetic *Artemia* at stocking densities ranging from 85 to 300 nauplii/L). Successful results have been achieved in several countries, using different management and feeding protocols; survivals from 50 to 92% in the best cases were obtained.

Table 2 also shows that the growth of the shrimp and larval development rates were similar to those obtained in normal cultures fed with *Artemia* ranging from 0.7 mg in 10 days for PL4, up to 5.5 mg for PL13 in 20 days of culture.

Doing away with traditional protocols

One of the strategies employed by the most successful hatcheries with *Artemia* replacement involves the splitting of daily rations into larger numbers of feedings. The traditional feeding of live *Artemia* 2, 4 or 6 times/day has been replaced by innovative managers who feed dry and liquid manufactured feeds of all kinds up to 12 times/day, providing the developing larvae with access to fresh feeds on a frequent, semi-continuous basis.

The results achieved by innovative hatchery managers who have adopted *Artemia* replacement is being shared among producers. More and more hatcheries are gaining confidence in the safe, simple use of liquid synthetic *Artemia* by gradually increasing the replacement rates over time.

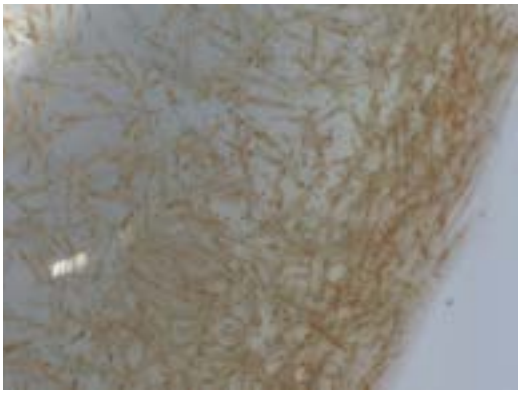
An additional application for synthetic *Artemia* beyond its use in the first and second phase of the larval culture system is its growing commercial use in Latin America for the transport of post larvae from hatcheries to nursery systems or grow-out ponds. Synthetic *Artemia* is easily maintained at the farm to reduce cannibalism during acclimation prior to stocking in the culture ponds. In plastic bags, tanks or tubs, water quality is one of the primary concerns of producers, especially in long transport. The stability of synthetic *Artemia* offers an effective and economical option for reducing handling stress and cannibalism while maintaining needed water quality.

Commercial hatchery tests – India

Over the past 12 months, a series of *Artemia* replacement trials were run at six commercial shrimp hatcheries in Andhra Pradesh, India. Each hatchery dedicated three tanks to testing replacement

Table 2. Results of trials with 100% replacement of hatched *Artemia* with a commercial synthetic *Artemia* product, in five major shrimp farming countries in Latin America. The test hatchery in Country 3 had a 2-year experience in replacing *Artemia*, Country 4 had carried out a 8-month protocol, and for Country 5, a first-cycle protocol.

Parameters	Country 1 2014	Country 2 2015	Country 1 2015	Country 3 2015	Country 4 2016	Country 5 2016
Artemia used	100 % replacement	100 % replacement	100 % replacement	100 % replacement	100 % replacement	100 % replacement
Nauplii/L	185	200	85	300	190	117
Feed(kg)/million	2.75	1.66	4.5	4	2.02	1.68
Culture cycle	10 days Z1-PL4	11 days Z1-PL4	12 days Z1-PL4	15 days Z1-PL8	20 days Z1-PL13	12 days Z1-PL6
Survival %	85%	69%	70%	50%	70%	92%
Weight at PL4 (mg)	0.87 mg	0.72 mg	---	1 mg	5.5 mg	1.1-1.2 mg



Shrimp postlarvae fed synthetic Artemia from one of the tests at an Indian shrimp hatchery. Note full gut and colouration. Credit: Chris Stock.

by reducing by 50% the amount of *Artemia* fed and substituting with synthetic *Artemia*. These three tanks were compared with three control tanks. To minimize the influence of genetic variation the trial and control tanks were stocked concurrently, two at time from the same batches of nauplii. As shown in Figure 1, the survival rates varied between hatcheries but were generally typical for Indian hatcheries, varying according to the season when the tests were run. Standard deviation bars in the graph indicated that *Artemia* was successfully replaced with no significant changes in survival rates. At the hatchery with the best culture conditions, as indicated by high survivals achieved during the cooler season, performance results for tanks where *Artemia* was replaced equalled or exceeded the results achieved for the *Artemia* fed tanks in survival, growth and post larvae quality measures (Table 3).

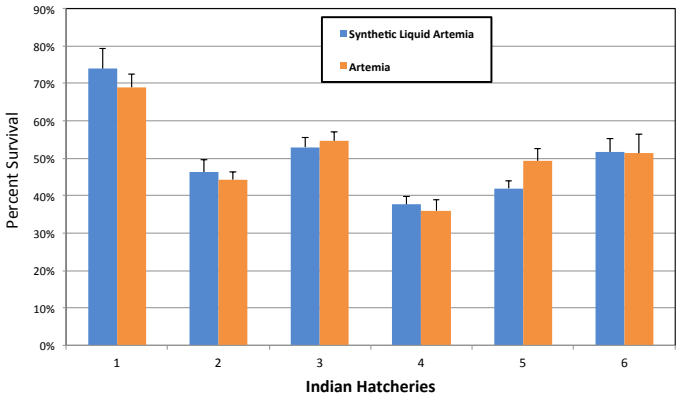


Figure 1. Replacement vs 100% live *Artemia* controls. Tests were conducted at six different shrimp hatcheries in India. N=3 tanks per treatment.

Table 3. At the hatchery with the best culture conditions, performance results for tanks where *Artemia* was replaced, equaled or exceeded the results achieved for the Artemia fed tanks in survival, and post larvae quality measures

Synthetic *Artemia*		Live *Artemia*	
Average Survivals	Std dev	Average Survivals	Std dev
74%	5%	69%	4%
46%	3%	44%	2%
53%	3%	55%	3%
38%	2%	36%	3%
42%	2%	49%	3%
52% Average Lipid Index (1-5 scale): 5 Average Muscle Gut Ratio: 4:1	4%	51% Average Lipid Index (1-5 scale): 5 Average Muscle Gut Ratio: 4:1	5%

Blue Star Marine Hatchery

With the kind collaboration of a customer, Blue Star Marine Hatchery in Ramatheertham, Nellore, India and the efficient support of Dr Ravikumar, we recently conducted a controlled trial to prove that our synthetic *Artemia* could replace hatched *Artemia* and improve post larvae quality and survival. The control treatment included several commercial, shrimp larval feeds and a commercial probiotic. The experimental treatments included the same commercial feeds and probiotic as in the control group, plus our synthetic *Artemia* product.

The 10-tonne larviculture tanks used in the trial were rectangular with flat bottoms, filled with dechlorinated water treated with EDTA. Each tank was stocked with two million nauplii (N5) produced from the hatchery's broodstock (from a commercial US supplier). Tanks had grid aeration, and water was exchanged at 40% daily from PL 6 until harvest. A commercial probiotic was added at 20 g daily, and also sugar at 250 g starting at the mysis (M3) stage. EDTA was also added and NH_4-N, alkalinity and pH were monitored, and the larval shrimp were fed six times/day.

Post larvae fed with our synthetic *Artemia* scored 100% survival in stress tests, and microscopic observations of the animals showed high numbers of fat globules and muscle: gut ratios of 4:1.

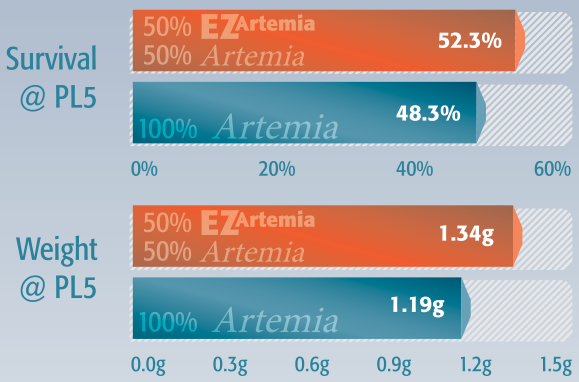
Our conclusion for this trial at Blue Star Marine Hatchery is that *Artemia* replacement with our synthetic *Artemia* liquid diet demonstrated similar performance when compared with hatched *Artemia* and was cost-effective.

Use of synthetic *Artemia* as part of a prevention protocol in hatcheries

Many shrimp hatcheries experience unusual mortalities during larviculture, likely due to bacterial and other pathogens. These mortalities typically involve an increase in the concentrations of *Vibrio* sp. (*V. parahaemolyticus, V. vulnificus, V. alginolyticus*), in the culture tank environment which affects various shrimp larval stages. Recently, virulent strains have emerged causing gross symptoms which include a reduction in appetite, progressive atrophy of the hepatopancreas and a reduction in overall activity. A small percentage (2-4%) of the population in a tank is initially affected, with exponential contagion of the rest and total mortalities in 12-14 hrs. Synthetic *Artemia* can be an important component in a prevention protocol, as shown in Table 4 that presents data on bacterial counts for a commercial hatchery in the Western Hemisphere which used *Artemia* nauplii versus synthetic *Artemia*.

Table 4. Comparison of bacterial counts (in colony forming units, CFU) in culture water and larvae for larval tanks fed synthetic *Artemia* or *Artemia* nauplii. The consumption of synthetic *Artemia* was 3.8 kg/mm PL; and 0.22 kg/mm PL.

Diet	*Total bacteria (CFU)*		*Vibrio alginolyticus (CFU)*		*Vibrio parahaemolyticus (CFU)*	
	Culture water	Larvae	Culture water	Larvae	Culture water	Larvae
Synthetic *Artemia*	2×10^5	1×10^5	5×10^4	1.8×10^3	2×10^3	4×10^2
Artemia Nauplii	2.8×10^5	1.5×10^5	2.1×10^5	3.2×10^3	4.2×10^3	2.6×10^3



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Some of the practical measures undertaken that have reportedly helped, according to one major hatchery in the Western Hemisphere, include:

- Bacteriological control: reduction of *Vibrio* sp loads in the environment and larvae; determine loads in algae and reservoir water; and evaluate efficiency of all treatments, including probiotics use, chlorination and addition of organic acids.
- Establishment of microbial health indices: identification of the levels, areas and foci of bacterial contamination in hatchery systems through periodic ongoing bacterial analyses and evaluations of animal behaviour.
- Intensive control of algae quality: externally procured certified microalgae, and use it during its optimum growth phase.
- Control of larvae quality: rate of development of larval stages, growth rate, water quality management, stress tests, size variation and bacterial load evaluations.
- Replacement of *Artemia* nauplii with synthetic *Artemia*: a very useful tool in larval production, beneficial for reducing bacterial loads in the system without affecting larval quality during the larviculture phase.

Commercial pond testing

To address the question of whether post larvae produced with synthetic *Artemia* have the same quality as those produced with live *Artemia*, tests were conducted comparing pond results at a Latin American shrimp farm using post larvae produced with hatched *Artemia* cysts and with synthetic *Artemia*. Two hatcheries produced 6 million post larvae for the test: 3 million post larvae with a larviculture protocol using synthetic *Artemia* and 3 million post larvae following the larviculture protocol using *Artemia* hatched from cysts. The post larvae were kept in nursery tanks for 7-12 days prior to stocking into the grow-out ponds. A total of 72 ha of ponds were stocked at a large commercial shrimp farm with animals from the nursery tanks: seven ponds (36 ha) of the area were stocked with the post larvae produced with synthetic *Artemia* and six ponds (36 ha) with the post larvae produced with live *Artemia* from cysts. Figure 2 shows the results of the test in commercial ponds, showing equal pond performance from post larvae produced using artificial *Artemia* versus post larvae fed hatched *Artemia*.

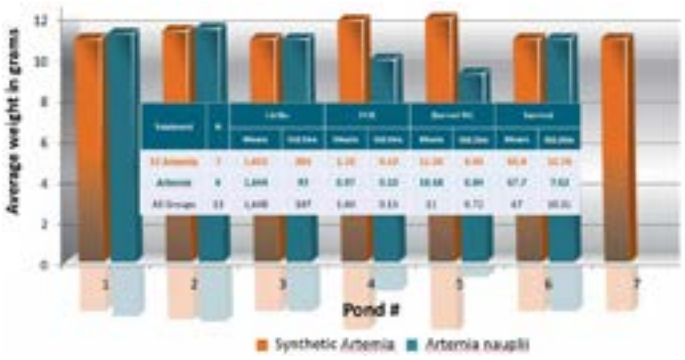

Figure 2. Statistical analysis of the commercial pond results demonstrates equal performance from post larvae produced using synthetic *Artemia* versus hatched *Artemia*

Perspectives

When considering the projected growth of global aquaculture production to feed a growing human population, the continued increase in global demand for *Artemia* cysts could make its supply, availability and price a potential bottleneck for the growth of the aquaculture industry. These supply pressures become particularly acute when environmental conditions deteriorate in water bodies like the Great Salt Lake which currently provide the highest quality cysts.

A global industry as important as shrimp farming cannot completely depend on *Artemia* as an indispensable natural resource. *Artemia*, has historically demonstrated ups/downs in availability and prices. The expected growth of the aquaculture industry will demand more and more *Artemia* – where is it going to come from? One alternative is to culture *Artemia* on land, but to date large-scale culture efforts have not succeeded.

In the evolution of the aquaculture industry, the development of advanced hatchery diets designed to reduce dependency on live feeds remains an ongoing process. Many hatcheries have successfully decreased their overall reliance on *Artemia*, but very often *Artemia* remains a key component of most larval feeding regimes. Nevertheless, some pioneering shrimp innovative hatcheries have completely eliminated *Artemia* from their feeding protocols while improving overall results.

Artemia has undoubtedly played a valuable role in advancing the global hatchery business and the aquaculture industry. Yet it is critical that the industry comes to terms with the limitations of *Artemia* and continue to work with academic and industry partners to implement gradual replacement, thereby reducing the risks and costs of excessive reliance on this resource. As the supply of *Artemia* cysts is a potential bottleneck to aquaculture industry growth, developing practical and cost-effective alternatives to *Artemia* will surely help aquaculture be a more significant and sustainable provider of food for our growing human population.

Significantly expanding production of farmed shrimp will require considerable increases in supply of shrimp postlarvae numbers from hatcheries, substantially raising demand for additional Artemia.

Complete replacement of *Artemia* is possible, thanks to the availability of a complete, artificial *Artemia* replacement that has a consistent nutritional profile. Synthetic *Artemia* is pathogen-free and has no biosecurity issues. The product has constant availability and quality, with no storage or hatch-out concerns. Synthetic *Artemia* can be used for delivery of higher levels of nutrients, immunostimulants, enzymes and probiotics to enhance digestion and improve water quality and animal health.

Shrimp larvae do not need *Artemia* as they exist in their natural habitats which are devoid of *Artemia*. The key is to effectively provide the nutrients in live *Artemia* in the synthetic replacement. Years ago, many shrimp producers assessed the quality of aqua feeds solely on the fish meal and crude protein content percentage in the feeds. Today shrimp feeds are utilizing nutritional strategies aimed at meeting amino acid, fatty acid, micronutrient and other specific nutrient requirements. The reality is that cultured animals need specific nutrients in their feeds, and the same strategy can and is being applied during the larval phase of penaeid culture with the use of synthetic *Artemia*.

Can all hatcheries replace 100% of the *Artemia* cysts they use? No, it depends on the particular hatchery, its infrastructure, resources and technical personnel capabilities. An initial goal of 50% replacement level could certainly be achieved by most shrimp hatcheries, and increasingly higher levels of replacement can be achieved with experience and training. Artificial *Artemia* is another important tool for hatchery producers to reduce their dependence on a limited resource.

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The polychaete solution: the new gold standard

By OddGeir Oddsen

Using worms as the protein base in aquaculture feeds is smart and sustainable for the industry.

The future of marine nutrition

In a time when the global population turns to aquaculture for healthy, nutritious food, there are excellent opportunities ahead. We can start by developing smart, new and sustainable feed solutions. Using polychaetes as a nutritious protein base for marine feed will benefit both the industry and seafood lovers around the world. Sourcing nutritious feed ingredients today is a challenging task, but with the right attitude and an open mind towards new solutions, our industry can look forward to a bright future.

Fish meal

The aquaculture feed industry is being challenged by seafood buyers when it comes to environmental sustainability. A lot of the attention is being directed towards the use of fish meal. From an environmental sustainability standpoint, the problem is the lack of proper regulations declaring what can and cannot be harvested. We need a functioning quota system that ensures sustainable harvests. In addition, some NGOs are calling for pelagic fish to be directly and exclusively sourced for human consumption. If, let us say, the Peruvian anchovy were to be consumed only as food fish, fish farms around the world would have protein problems right away.

Good retail standards

Many of the large mid- to high-range grocery retailers have turned their eyes toward ensuring, for instance, that there is an upper limit of marine ingredients in the aquaculture feed used by their suppliers.

However, as we know, marine animals benefit from marine nutrients. So, whatever we feed our fish or shrimp, it should include some marine fatty acids and other nutrients coming from marine raw materials. With new (and better) regulations, the global production of fish meal is going down. The total global annual production today lies somewhere between five and six million tonnes. The annual global production of fish oil is 800,000 tonnes. That is the upper sustainable limit for production of fish oil; if we go over, we start depleting our resources.

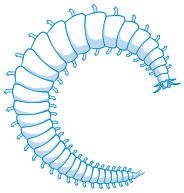
So with aquaculture, we have to start looking for smart alternatives.

What are the options?

Years ago, we had too much fish oil, people burned fish oil like bio-diesel. More than 20 years ago when fish oil was introduced in the aquaculture industry, the oil used in salmon feed consisted of 100% fish oil. Today, the same pellets contain 25% fish oil and 75% rapeseed oil. So why not switch entirely to rapeseed oil? The answer is simple: lack of marine nutrients and specific fatty acids.

There are other oils we can substitute for fish oil, but none of them are perfect. Palm oil contains some of the right nutrients for salmon and would together with rapeseed oil make a good blend, but the production of palm oil has the unfortunate effect of deforesting nature reserves and possibly eradicating species of animals including the orangutan. Hence, the use of palm oil is seen as off-putting and often a deal breaker among some of the larger grocery retailers of the (at least western) world.

So, the question is still what protein and oil sources we are going to use instead of fish meal and fish oil. Fish meal needs a protein replacement where fish oil needs a fatty acid replacement, but there are also a wide range of other nutrients that go into the feed equation. Possible replacement options could be insects, grain, different types of fermentation products, or oil beans such as soy, which has become increasingly popular. However, with soy, there are deforestation issues in South America and anti-nutrition factors within the soy. What we do have, though, are worms.



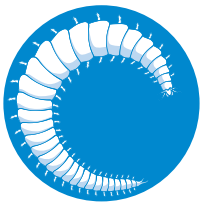


Illustration credit: Fredrik Kleppe
Agency: Holt & Paulsen

The polychaete solution

Worms, more specifically polychaetes, have all the necessary nutrients to form the basis of an exceptional aquaculture feed. This is well known and documented, but until recently the use of worms in aquaculture required harvesting worms in the wild, a practice that can both be dangerous for the workers and environmentally unfriendly, as well as spread diseases in fish and shrimp farms.

What we need to do, is to start farming polychaetes effectively. They represent a protein that is as good as – if not better than – fish meal, and they can be farmed sustainably. Worms utilise bi-products from other industrial processes – and could also be farmed by cultivating algae in the worms' own environment.

Polychaetes are tasty. There is a reason why we use worms as bait when we go fishing: Fish and shrimp love it, and the worms contain many of the nutrients that a marine species needs.

At ProChaete we are determined to find ways to utilise the farmed polychaete's immense potential in aquaculture. Our mission is to find smart, sustainable ways to produce protein. Producing nutrient-dense aquaculture feed sustainably will also speed up the farming process, and the higher performing feed with higher protein retention makes the industry less wasteful and more environmentally friendly.

The future of food

By 2050, nine billion people will populate this earth. If we don't start acting in a sustainable manner, we are going to deplete our own food supply. It is as simple as that. What our industry can do, is to rethink the way we feed our aquacultures, so future generations can enjoy even more delicious seafood than we do today.

OddGeir Oddsen is CEO of Sea Farms Nutrition. The ProChaete brand was set up in 2013 in order to create innovative feed formulations without the dependency of fish ingredients for marine farming.

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The future of hatchery feed is PRO

For a more productive future in the aquaculture industry, we have to raise feed standards. There are two key factors to making exceptional aquaculture feed: The right ingredients, and the optimal combination and handling of the ingredients. We start with the very best ingredients, analysing every potential component of our feed, and finding out how to preserve its nutrients as effectively as possible and then treating them as gently as possible.
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The future of hatchery feed is only for the pros
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Pathogen control in aquaculture

By Alain Michel

A shift from the old concept of trying to exterminate the pathogens to the new paradigm of welcoming and maintaining them in the culture system.

In aquaculture, there is a common perception on the importance of diseases and how their control is a major problem which needs to be addressed. This problem persists in spite of the strong focus on biosecurity. It is even more true for tropical marine fish where the basic knowledge on fish diseases is scarce. It does not mean that farmers should forgo the biosecurity concept but they should also realize that biosecurity alone is just not sufficient to keep diseases in check.

The progress can come only from team work between scientists and the farmers at the grow-out and hatchery stages. Farmers often require immediate answers to their problems while scientists need time to validate their hypothesis through well designed experiments and critical analyses of the results. To overcome disease problems, it has to be a constant interaction between the two parties.

Science and farming

When we started culturing marine fish, mainly barramundi, in an Indonesian farm in 1998, we were immediately confronted with mass mortalities from diseases with unidentified causal agents such as the big belly disease and more recently the mass mortality syndrome. The ones already known and identified, such as the viral nervous necrosis (VNN), iridovirus, *Streptococcus iniae* or *Tenecibaculum maritimum* (or *T. mar*) were also not known to have any effective preventive measures or curative treatments.

Our first priority was to develop a strong cooperation with the Intervet scientific team (now MSD), which had just established a new laboratory in Singapore. They were able to identify the causal agent of the big belly disease, which is an unknown intracellular *Vibrio* bacteria. Intervet also went on to develop a vaccine against *Streptococcus iniae*. It was a win-win cooperation, with the farm bringing its experience on the field trials following the initial laboratory trials.

The Asian sea bass is always schooling which promotes spread of pathogens

High losses from environment and culture system

For high fecundity species, a female fish can produce hundreds of thousands and even millions of eggs. In aquaculture, admittedly, we lose a large proportion of each batch, from eggs to the late juvenile stages during the culture process. We also lose more as we grow them to commercial size. These losses are partially the results of the purge of all the unviable gene recombination linked with the meiosis process but also largely the result of the selection pressure coming both from environmental and culture conditions. In a broad sense, we can say that losses are from how we culture the fish in a given environment

In any open environment culture system, it is necessary to take into consideration all the pathogens, including those originating mainly from wild populations which are often healthy carriers, and those within the culture system. In the latter, conditions are conducive for pathogens to bloom leading to outbreaks and high mortalities. However, up till today, the general strategy in the flow-through systems has been to try to eradicate all the pathogens by:

- conditioning pathogen free brooodstocks to produce pathogen-free juveniles or seedlings.

In a tank with seabass infected with iridovirus; dark black fish on the bottom

- fully controlling water quality through several steps of filtration and treatments such as UV and ozone treatment, and chlorination.

The moto is to "kill all the pathogens" and unknowingly, we allow a supposedly non-pathogenic flora to establish again in the water. This is the usual practice although it may be more sensible to always start culturing in waters where the conditions are as close as possible to where the fish comes from. However, it is not so simple to achieve.

When trying to increase the level of production, the farm was rapidly confronted with high mortalities: the first one was due to the VNN and the second one to an iridovirus. These two viruses were known and have been encountered in many species. At that time, PCR (polymerase chain reaction) diagnostic tools were still under development and the Intervet team was working in Japan on a vaccine against the iridovirus for *Seriola* spp.

During the same period, tilapia production was also confronted with emergent diseases similar to *Streptococcus agalactiae* which our farm was facing. But, we also faced an iridovirus infection. This also justified the existence of the Intervet laboratory as the barramundi market for vaccine alone was too small a market for animal health companies to set aside the necessary financial resources.

Meanwhile, we had to look for preventive and curative treatments for big belly disease, VNN and iridovirus. Immuno stimulants were used extensively against big belly and the iridovirus experimental vaccine gave negative results. On the contrary, these sometimes even aggravated the problem. For VNN, the advice was very simple, destroy infected batches.

This was an early indication that existing science was not ready to control these diseases. The repeated message was biosecurity, biosecurity, biosecurity! This was a necessity but also is a message to tell farmers to 'bury their heads in the sand'! Very soon, it was realized that this strategy alone was not sufficient as outbreaks of pathogens continued. Shrimp culture which regularly faces new emergent pathogens is the best evidence that biosecurity alone is not the answer to disease control. It was clear that the natural variations existing in the flora were allowing the organisms to select, progressively, the most harmful strains, thanks to a rebounding effect. This phenomenum highlights evolution on a short term scale.

Gradually, we have learnt that in fact, it is the fish themselves which are the vectors , selecting and transmitting the pathogens.

Once in the open culture system, it becomes obvious that the importance of controlling the water become secondary. Pathogens that enter the fish via water are negligible, in comparison to the number of pathogens already associated with the fish.

It is important to introduce the time notion and the role this plays in balancing the culture system. One parallel is that the fish can tolerate, for example, a quite high level of ammonia if it increases gradually but fish will die if ammonia increases abruptly since the organisms do not have time to reach a new state of equilibrium. It is the same for pathogens. If the pathogen is in high concentration the outbreak is fast and there is not enough time for the immune system to react.

The "Jukung Way"

While waiting for the development of a full set of vaccines (as it is the case for the mature salmon industry), we went back to the old method of trial and errors on pathogen control. Fortunately, this was often positive, but required time and is a hard way of learning.

First we found that very high doses of florfenicol in the feed, which was far above the normal range, was positive against the big belly disease. However, there was a secondary effect of a *T. mar* outbreak some days later. This situation helped but was not fully satisfactory. Then a serendipity effect happened. There was a fault with the temperature regulation of one larval tank which was affected by the beginning of an outbreak of VNN. As a result, there was a high increase in temperature in the tank. The transparent larvae lying on their side at the surface were feeding again and recovered. It was the starting point of the "Jukung way", which we named after the island in the Java sea, Jukung, where the farm was located.

What pulled us out of our dilemma with disease was the heat shocks which were able not only to control VNN but also the big belly disease and the iridovirus. There was clearly a host-pathogen reaction and the boosting of the immune system following the heat treatments.

It was our new paradigm. Do not try to kill the virus or bacteria, just learn to live with them. Keep them at a low level and they will act as a natural vaccine for the best protection of your fish. To be in the "air du temps"(current trend), a sustainable management of the "is present in pathosystem" or "an ecosystemic approach of the potential pathogens".

From old to new concept

We have been progressively developing a strategy for culturing fish in a coral environment where the main parameters of the sea water (temperature, salinity and dissolved oxygen) were very stable. We decided to pump raw water directly, without any filtration and treatment even for hatching or larval rearing. This allowed pathogens to enter our system and to be in contact with the larvae. As soon as the clinical signs of each pathogen appeared we started immediately the heat treatment.

> **"the trick is quite simple just manipulating the temperature to put the pathogens out of their preference windows stopping their replication.."**

From the beginning of the project we always faced the same true pathogens: two virus, four bacteria and one parasite. Some opportunistic bacteria appeared sporadically but only when we lost control of the culture system with different kinds of stress factors.

Finally, the trick is quite simple; just manipulating the temperature to put the pathogens out of their preference windows, stopping their replication so as to boost permanently the immune system based on the fact that we are dealing with poikilothermic animals.

The fight against iridovirus was the most difficult as the virus was often breaking out in synergy with *Streptococcus iniae* but by adapting the "Jukung way", we were able to progressively develop a protocol which fitted with the production needs, and we were able to produce several batches of hundreds of thousands of 30 g juveniles.

Pathogens and us

During the trial and error period we applied some hypothesis to try to understand how all these problematic pathogens were acting and when they entered and developed in our culture system, and if there was a way to counteract their detrimental effect. As mentioned earlier, we came to the conclusion that the pathogens were part of our environment and that if we try by drastic water treatment and biosecurity measures to produce pathogen-free juveniles, they will lack resistence when transferred to the sea cages and will not have a sufficient immune defense system.

We also observed that when transferring to the cages, juveniles cultured in 'clean' conditions where they were not in contact with iridovirus, there were more than 90% losses in the first three weeks. In contrast, juveniles not affected were those from a nursery which suffered a small irido mortality. But its systemic presence in early juveniles without clinical signs remains a problem and has to be addressed.

Moto of the Jukung way

Arising from these experiences, the new motto is to welcome pathogens and learn to live with them. This has been applied largely to control pathogens in farming the barramundi. It is also the same for other species which have been susceptible to VNN, iridovirus and *Streptococcus*. In the future it should be particularly helpful to use the new metagenomic tool to characterize each aquaculture site in terms of potential pathogens to forecast their effects on the production.

It was the strategy progressively developed for culturing fish in a coral environment where the main parameters of the sea water, temperature, salinity and dissolved oxygen were very stable allowing the pathogens to be firmly anchored in the wild species after years of co-evolution. To increase the coexistence between the hosts and the pathogens, the raw water was pumped directly without any filtration and treatment for the different steps of the culture from broodstocks to juveniles. Being in contact with the pathogens enhances the immune system of the fish. The heat shock treatment strengthened the immune system of the juveniles which can then better compete with the pathogens surrounding the environment and in the cage.

Paradigm shift

It has taken 12 years to shift from the old concept of trying to exterminate the pathogens in the hatchery and nursery to the new paradigm of welcoming and maintaining them in the culture system at a sublethal level to produce very healthy and well adapted juveniles, both to the culture system and environmental conditions. *The biosecurity concept is insufficient and a change of paradigm in aquaculture is needed for success in the farming of marine fish.*

VNN infected larvae dying with empty digestive gut, red spleen, swimbladder inflated and contracted chromatophores

A serendipity, VNN infected larvae with gut full of artemia as it started to eat again after heat shocks treatment

However, the "Jukung way" may see success not only in this site but is probably successful in other locations. But we believe that the "Jukung way" is flexible enough to be adapted to other sites. To be in line with this strategy, the final step of any selective breeding program for each species should be done in the immediate environment of the culture system.

It appears that it could be the right time to disseminate to a broader audience this "Jukung way". This hypothesis needs to be discussed by the scientific community to be validated, explained and improved.

For the past 16 years, the road for marine fish farming has been long and difficult with periods of low and high yields. This "Jukung Way" is something in our hands which we can use as a new paradigm at the level of commercial hatcheries. After our confrontation with emergent diseases, full control was obtained in 2013 with a production of around 1,000 tonnes which opens the road to a full industrial development of barramundi culture.

Next issue: The story of the development of an industrial barramundi farm in Indonesia and how it mitigated pathogens to achieve success.

Alain Michel is currently a permanent consultant for a new barramundi farm in Sri Lanka. From 1998 until 2014, Alain was scientific adviser to Fega Maricultura, a barramundi farm in Indonesia.

His present main interest at the field level is the boosting of the innate immune system to a better control of aquaculture pathogens. Email: alainhenri@aol.com

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City University of Hong Kong's School of Veterinary Medicine working jointly with the Institute of Aquaculture, University of Stirling, Scotland, is introducing an **MSc course in AQUATIC PRODUCTION AND VETERINARY HEALTH** in **SEPTEMBER 2017**. A team of experienced staff of aquatic veterinary medicine and higher education from Hong Kong and Scotland has created this MSc programme.

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Location	:	Hong Kong
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Mode of Teaching & Learning	:	Full time, face-to-face & thesis research project
Start Date	:	September 2017
Programme Details	:	http://www.cityu.edu.hk/svm/links/msapvh.asp

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A varied growth in 2016

By Zuridah Merican

Higher volumes of shrimp feed as farms have better control on disease

Last year, a general increase in shrimp feed production in several countries confirmed that shrimp farmers are managing production despite the various diseases outbreaks. A stagnant feed usage reflected the dire situation in Malaysia's shrimp industry. Alongside a significant increase in shrimp feed production in Vietnam, more tilapia and snakehead feeds were produced for an expanding industry. In most countries, aqua feed production was below capacity.

Within the Indonesian archipelago and 1,650 km long Vietnam, where transport costs are high, feed millers continued to establish feed mills in major farming areas. In India, integration into feed milling by major processors reflected the need to have full control of the supply chain. The unique situation with the supply of feed in India was explained by Dr Victor Suresh, Aquafeed Consultant. "In a market like India, with a huge geographical spread and challenges with transport logistics for raw materials and finished feeds, it is difficult to qualify overcapacity. In addition, there is the high seasonal demand from May-June for shrimp feeds. There is however, a huge over capacity in shrimp markets in Andhra Pradesh and during the lean seasons it could be 200%. Taking into consideration other markets and peak seasons, I would say that the overall over capacity is 20-30%. Competition is healthy and good for farmers and feed manufacturers. It is only during the lean seasons when everyone has to know how to manage the fixed costs."

There is an active intraregional trade in shrimp and fish feeds. In 2016, a third of shrimp feeds used by farms in Malaysia was imported from Thailand, Vietnam and Taiwan. Active in exports of feeds, Jeff Jie Chuang Cheng, General Manager, Sheng Long Bio-Tech International, Vietnam said, "Our export business has increased to around 45% in 2016. Indian and other markets are all increasing positively. Aside from the present markets, we will be developing export markets continuously including those in Indonesia, Bangladesh and the Middle-East."

The Uni President Vietnam team was at the 2016 Taiwan International Fisheries and Seafood Show in Kaohsiung in November. From left; Alex Thien (Malaysia), James Hung (Vietnam) and Kuek Sian Chai (Malaysia).

Ravi Pelluru, CEO, BMR Industries, India and Su Shi, Vice President, Guangzhou Hinter Biotechnology Group Co., Ltd, China at VIV Asia, Bangkok, Thailand.

Fish meal-free feeds

Many feed millers have programs to reduce fish meal in shrimp feeds but only Charoen Pokphand Foods (CPF) has publicly announced a deadline of 2021. "According to Dr Albert Tacon, in the Fish-in Fish-out (FIFO) calculation, by-products (such as fish head meal, fish visceral meal) from seafood processing, fishing or aquaculture are not considered in the FIFO calculation. This means that we have been producing fish meal-free feed for quite a long time," said Dr Ming-Dang Chen, Senior Vice President, CPF.

"In the case of CPF, the fish meal inclusion rate in feed is reduced continuously. Fish meal availability has remained unchanged for the past 10 years, but aquaculture feed production is increasing year by year. With many fish meal replacements being developed, the fish meal- free shrimp feed is possible in the near future."

In Thailand, although there has been progress in addressing the IUU (Illegal, Unreported and Unregulated fishery) issue with the EU, there is a lot of pressure on domestic fish meal sourcing by feed mills. According to industry, foreign shrimp buyers insist that feed millers use only certified fish meal, requiring authentic MCPD (Marine Catch Purchasing Document) from the Department of Fisheries. The competition for surimi byproducts and tuna byproducts meals is intense. Equally, with regards to fish meal imports, Thai feed millers have little trust in imported fish meal from regional producers and adulteration is a major concern.

Alternatives to fish meal

Seeking alternatives to fish meal is top on the list for the region's nutritionists. While some are using animal byproducts in shrimp feeds, others wait for novel alternatives since for EU markets, retailers and consumers have not yet allowed processed animal byproducts to be used in feeds although such byproducts are permitted by EU regulations. In 2016, new market entry products included CJ's bio-processed protein concentrate and Evonik's methionine dipeptide. There was also a market introduction of a single cell protein as a sustainable fish meal replacement and salmon feeds containing marine fatty acids from microalgae.

In India, Suresh said, "Feed millers face challenges in replacing fish meal, since good quality animal byproducts are not available due to the government policy on importation. Domestic soybean meal price is high as India does not allow the import of genetically modified (GM) soybean." Despite a 15% import duty, imported soybean meal was still cheaper than the domestic product by 7.8% in April 2016 (economic.times.indiatimes.com).

As the aquafeed industry is looking for alternatives, Nathan Preteseille, AETS based In Thailand, suggested insect meal. There are Asian producers in Thailand, Malaysia and Indonesia. They have founded an association, Asean Food and Feed Insects Association (AFFIA). The industry is still at the innovation stage. "Presently, most feed millers are hesitant to use insect meal in feeds and think that its use requires more studies, while over the last two years, some are willing to give it a try. Most highlight especially the low quantity available, but insect companies are now stepping up production to match fish meal production," said Preteseille.

Dr Thomas Wilson, Aquafeed Consultant, Thailand, said, "I expect that insect proteins will start being incorporated into Asian feeds soon, on request by European buyers looking to market the latest trend in sustainability".

Feed performance

Chuang said that palatability, amino acid balancing, digestibility and anti-nutritional factors are the main challenges when reducing fish meal in the feeds. "Too much plant protein will reduce the palatability of the fish feed and therefore we do need to maintain a certain level of fish meal in fish feeds. With regards to digestibility, higher crude protein level in the alternative does not translate to high feed digestibility."

During Aqua India 2016, Wilson demonstrated that reducing fish meal with plant and animal proteins without reducing shrimp feed performance is possible. However, without further increases in fish meal prices, the costs of these fish meal alternatives and additives are high and make using such feeds uneconomical. In commercial pond trials in Thailand during August-December 2008, the average daily growth (0.18 g/day), and feed conversion ratios (1.62-1.7) for white shrimp fed one of two test diets containing either 10% fish meal and 10% poultry-based fish meal analogue or 10% fish meal and all remaining protein from soymeal, fermented soymeal and soy protein concentrate were almost identical to a commercial diet with 22% fish meal (38% crude protein) that was used as a control.

"There are already feeds with very low fish meal or fish meal-free shrimp feeds in China and Brazil, with the claim that these feeds maintain standard feed performance. In Australia, Ridley Aquafeed has demonstrated that fish meal-free feeds for *Penaeus monodon* in Australia perform very well. Traditional fish meal was replaced with co-products from high quality fish for human consumption. However, in all cases such feeds are quite expensive and the market is limited to those shrimp farmers who promote maximum sustainability. Ridley also showed that *monodon* shrimp grew 20-30% faster when fed their no fish meal diets but with inclusions of Novacq ™, a marine microbial fermentation product developed by CSIRO," said Wilson.

In the case of marine fish feeds, the bottleneck with replacements is actually the lack in nutritional knowledge. A typical example is with the turbot or flounder feed where the premise was that at the early developing stage, fish meal needed to be higher than 50% in the feed. It was only when triggered by drops in fish prices and new knowledge that industry changed this. Industry also added taurine for low fish meal feeds and soy lecithin containing choline and biotin.

"Extrusion technology has not been perfected to produce 100% sinking feeds and shrimp farmers are averse to even 0.01% feeds floating." - Dr Victor Suresh

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Table 1. Industry estimates[1] on feed production in 2016 (tonnes) in selected countries in Asia

	Production in 2016		
	Shrimp feeds	Freshwater fish feeds	Marine fish feeds
China	1,800,000 ↑	16,000,000 ↑	800,000 ↓
Thailand	480,000 ↑	590,000 ↑	45,000
Vietnam	700,000 ↑	2,000,000 ↑	20,000
Indonesia	385,000 ↑	1,350,000 ↑	<6,000
India	800,000 ↑	900,000 ↑	-
Malaysia	60,000	48,000 ↓	46,000 ↑

[1] Estimates by industry and other stakeholders. Arrows indicate changes in volumes versus 2015. No arrow indicates no change or adjusted figures with regards to the report for 2015 in issue May/June 2016, Aqua Culture Asia Pacific.

China; shrimp feed- 94% vannamei shrimp; freshwater fish feeds- mainly for the carps, tilapia, snakeheads; marine fish feeds- mainly for seabass, pompano, groupers, yellow croaker, Japanese sea bass, turbot/flounder

Vietnam; shrimp feeds-78% vannamei feeds; freshwater fish feeds-pangasius (70%), tilapia, snakeheads; marine fish feeds-seabass, pompano, grouper.

Indonesia- Aquafeed Division, Indonesian Feed Mill Association (GPMT); freshwater fish feeds-30% Clarias catfish, 15% tilapia, 11% pangasius; marine fish feeds- mainly for seabass and pompano.

India- shrimp feeds- 94% vannamei shrimp; freshwater fish feeds-tilapia, 67% pangasius; 20% pacu, 11% carps (include farm made feeds).

Malaysia- Includes feeds imported from Thailand, Vietnam and Indonesia; shrimp feeds- 93% vannamei shrimp; freshwater fish feeds – Clarias catfish, tilapia; marine fish feeds- seabass, pompano, snappers and groupers, exclude trash fish.

India

The estimate for fish feeds included 600,000 tonnes of extruded feeds, which would be mainly floating feeds for the pangasius. In 2016, the shrimp feed market was dominated by two large producers, Avanti Feeds and Charoen Pokphand India Pte Ltd. Together they have almost 70% of the market share, according to industry. Some 20 feed millers supply the balance, led by Growel, The Waterbase and Godrej. Almost all of the feed mills are located on the east coast of India, mainly in Andhra Pradesh. Avanti Feeds has a shrimp feed mill in Gujarat.

Growel Feeds is producing extruded shrimp feeds which are well received by farmers. Suresh said that extrusion can help achieve a product of high quality and performance that pelleting cannot match. “However, pelleting will continue to play an important role due to its lower investment cost. Extrusion technology has not been perfected to produce 100% sinking feeds and shrimp farmers are averse to even 0.01% feeds floating.”

In general, farmers prefer branded shrimp feeds with 32 to 36% crude protein. “The market is very competitive and farmers have many offers, discounts and credits. In the long term, I do not think that this is good for the feed industry. Feed millers should enhance farmers’ awareness on sustainable shrimp farming, and educate them on sustainability, stocking density and culture practices. Then both the farmer and feed miller will survive,” said Dr Manoj Sharma, Managing Director Mayank Aquaculture, Gujarat.

In the fish feed market, the top five feed millers, IB Group, Deepak Nexgen, (see page 53), Growel Feeds, Uno Feeds (see page 47) and Godrej Agrovet have a total share of 65%. According

to a feed miller, there was excess capacity for the production of extruded floating feeds, and many feed millers have tightened credit terms. Pangasius farmers actually would love to use extruded floating feeds but they are very much constrained by low and fluctuating ex-farm fish prices, at INR 50/kg. Feed cost at INR 26-29/kg makes it difficult for farmers to always stay with extruded feeds. Many farmers mix complete feed with DORB (de-oiled rice bran) or other agriculture byproducts to save on feed cost.

There has been progress to market floating feeds for the rohu fish. Rohu farmers use a combination of DORB/pelleted feeds as well as floating feeds. More farmers in West Bengal and Odisha have started using pelleted feeds after seeing the benefits. There is a trend for farmers to use complete feeds in their nursery tanks. The fish grow faster and are even in size. It has been shown that rohu can grow well on extruded feeds but protein level must exceed 28% which is not economical. The challenge now is to formulate a feed at around 25% protein level or lower for optimum growth.

Integration into feed production

Several shrimp processors were active in 2016 with integration; into feed production; Devi Seafoods, BMR and Falcon were among these processors. Devi Seafoods, with a 4-star BAP (Best Aquaculture Practices) certification is one of the largest shrimp processors; It opened its first feed plant with a 100,000 tpy capacity in March 2016 in Samarlakota near Visakhapatnam, Andhra Pradesh. The company has two state-of-the-art shrimp processing plants with a total capacity of 11,000 tonnes in Andhra Pradesh. Recently it announced the opening of a second feed mill with a capacity of 50,000 tpy in the same location in March 2017. Devi Seafoods said that it will have full control over the

Jackson Fung, Nam Hoa Trading (left) with CJ Cheiljedang Corp's Alex Chung (second right) and James Kim (right) at Vietfish 2016, Vietnam

feed that goes to its farms and those farms it works closely with, thereby gaining more control over the quality and safety of the raw shrimp to be used in its processing plants. The other benefit for Devi Seafoods is lower feed costs for its shrimp farms and its customers' shrimp farms. The company is also targeting BAP certifications for the customers' farms (undercurrent news.com).

Vertically integrated, the BMR group leads in the shrimp hatchery business with 12 hatcheries with a total of 10 billion post larvae capacity. The hatcheries are located along the east coast in Andhra Pradesh, Tamil Nadu and Visakhapatnam. It also has 1,200 acres (485 ha) of shrimp farms, targeted to produce 5,000 tonnes/year of shrimp, all located around Nellore, Andhra Pradesh and a 60 tonnes/day processing plant in Damavaram, Nellore. BMR recently opened a 75,000 tpy shrimp feed mill located in Nellore. Ravi Pelluru, CEO, BMR group, said, "The feed mill will only produce shrimp feeds and will supply all of our farms. We

will also supply seed and will buy back the harvest for processing. Next, we will build and start a brood stock multiplication centre."

In early 2018, Vietnam's Sheng Long will start production at its 50,000 tpy shrimp feed mill and will also begin to supply 1 billion SPF post larvae. Although Chuang sees a crowded market in India, he said, "There is already an oversupply in India. However, we anticipate potential markets in north India in the next few years especially when more paddy fields convert to shrimp farms. Our only concern is the potential carrying capacity of these water resources."

Thailand

The first three months of the year brought droughts and the last three months brought floods, and these adverse conditions affected shrimp production which was officially recorded at 262, 235 tonnes in 2016. In 2016, a higher acceptance of the new generation of post larvae and a new clean water culture system and bundling of post larvae sales with feeds, increased CPF's share in the shrimp feed market, estimated at 60-70% by industry. Among the top five feed millers in 2016 were Thai Union Feedmill, Intecq Feeds, Grobest and Cargill. Inteqc Feeds also gained more market share because of the strong technical support provided to farmers until harvest, according to one industry source.

Thai feed millers are challenged with the demands by farmers for stable quality feeds as farms struggled with *Enterocytozoon hepatopenaei* (EHP) and white faeces disease (WFS). Small farmers accept average daily growth (ADG) from 0.16 to 0.18 g but larger farms require ADGs of 0.2 as they have made large investments in infrastructure. Stocking density has been reduced to 60 to 100 PL/m^2 which meant less feed used. Farmers blame the poor farming situation on feed millers switching from fish meal to cheaper ingredients but industry said that changes in formulation have been in place since 2008, due to higher oil prices and extreme commodity prices, without any major disease outbreaks reported.

Throughout 2016, shrimp farming groups announced that they intended to cap shrimp production at a maximum of 400,000 tonnes/year, which would be 60% of the production in 2011. Industry leaders realised that with the increase in Ecuadorian production and a substantial increase in production elsewhere in Asia (Indonesia, Vietnam and India), prices would collapse if Thailand tried to overproduce. At a feed conversion rate (FCR) of 1.5, this would curtail feed production to only 600,000 tonnes per year which would be 71% of the production in 2011.

Australia's Ridley Corporation expanded into Thailand with a joint venture with the 30,000 tpy Pen Ngern Feed Mill Co (PNFM), part of the Sureerath Farm in Chanthaburi. Feeds will be used in the farm and will be sold to third parties.

"..we will also carry out an in-depth research and survey on the tilapia industry, including processing and marketing the finished tilapia product which are major concerns among farmers." - Jeff Jie Chuang Cheng

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At VIV Asia 2017, Dr Pajaree Jueliang, R&D Manager (left) and Dr Jarin Sawanboonchun, Nutritionist, Gold Coin Specialties (Thailand)

Vietnam

More shrimp feed was produced in 2016 with 78% of the production for vannamei shrimp. The leading producer was Grobest Feeds, followed by CP Vietnam, Uni President Vietnam and Sheng Long. Production of feeds for the pangasius in 2016 declined but volumes were compensated by higher volumes for the tilapia, estimated at between 250-300,000 tonnes and feeds for the snakehead. Some 20,000 tonnes of feeds were produced for the marine fish, namely for the seabass, silver pompano and the groupers. With the demand for its fish feed rising, Sheng Long has installed an additional extruder line, thus increasing the capacity to 140,000 tpy for shrimp feeds and 150,000 tpy of fish feeds.

As part of its strategy to expand feed sales for the tilapia, Sheng Long started a brood stock culture program (Aqua Culture Asia Pacific, Issue September/October 2016). Chuang explained "We will start fry production in July 2017. The target will be 20 million fry in the first year. Meanwhile, we will also carry out an in-depth research and survey on the tilapia industry, including processing and marketing the finished tilapia product which are major concerns among farmers."

In 2017, industry is optimistic that farm production will improve and shrimp feed production will increase by 5%. Cargill opened a new factory in the north (see page 60). De Heus opened a new R&D centre in Vinh Long in May, 2017 (see page 6). The facility will first focus on the pangasius and tilapia farming systems. Sheng Long will invest in another fish feed plant with a capacity of 40,000 tpy. In addition, it will introduce new product lines such as fermented feed and advanced disinfectants through distributors.

China

Feeds for the tilapia, a major export product were 1.8 million tonnes while 400,000 tonnes of feed were produced for snakehead fish in 2016. Marine fish feeds were mainly for the Japanese sea bass, yellow croaker, pompano, turbot and flounder. There were changes with shrimp feeds, according to industry. The higher prices and limited supply for Peruvian fish meal forced the use of fish meal from other countries and replacement with high quality poultry byproduct meal. However, large feed mills ensured that the lower inclusion of fish meal did not result in lower feed performances. Feed performances were sustained with the use of new functional additives, probiotics and processing technology in combination with better farm management. Industry said that it is more likely that in small feed mills with weak technical capability, such changes may affect feed performance.

In early 2017, Indonesia's PT Matahari Sakti began to produce extruded starter feeds for shrimp. (see pages 52-53).

Dong Qiufeng, Guangzhou Nutriera Biotechnology, reported on several major issues affecting feed production in 2016 up to the early part of 2017. "The impact of the 13th five-year development plan indicated a reduction in feed demand in China which may push large feed millers to invest in other parts of Asia and Africa. The government plans to check feed quality thoroughly and set more conditions for the large players to be involved in the whole value chain including activities like breeding, feeding, farming, processing and marketing. It has also initiated a strong "environmental protection policy" for the whole of China resulting in the closure or temporary suspension of 100 feed mills with strong odour emission. It also changed the marketing strategies of domestic corn, by providing more support for export of corn products. Costs of imported raw materials rose due to: higher transport costs following the bankruptcy of the shipping line Hanjin and new transport regulations, anti-dumping rules on DDGS from the US, strict inspections on rapeseed meal from Canada and devaluation of the Chinese Yuan. The short supply of soybean meal from Latin America was compounded by a short supply of local soybean meal because of the heavy floods in south and central China."

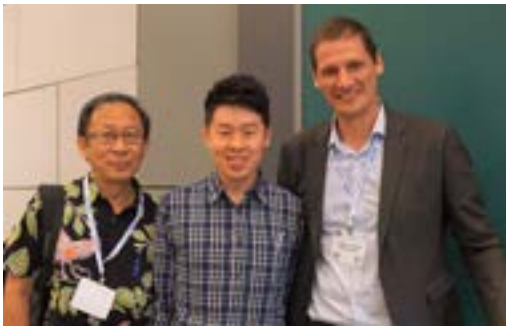
In the freshwater fish farming sector, there is concern on the adverse impact of fish farming and the Chinese government has issued a new law, the Environmental Protection Taxation Law, effective from Jan. 1, 2018. This will further limit the use of land and water resources for fish farming. "At the same time, consumers are more and more concerned on food safety and this should impact the feed industry as well as price increase for aquaculture production as a result of higher feed, labour and energy costs," said Zhou Enhua, Aquaculture Technical Manager, U.S. Soybean Export Council, China.

In November, BioMar-Tongwei Biotech (Wuxi) Ltd, acquired the feed company Haiwei, which produces feeds for high value fish species such as the Japanese sea bass in south China. The acquisition will add more than 60,000 tonnes of volume to this joint venture company. Fish feed is already being produced in Chengdu in south central China, and more capacity will be added with a new factory in Wuxi, Shanghai, operational after mid 2017, initially with 50,000 tpy capacity and with future expansion to 100,000 tpy. Denmark's Aller Aqua is also building a feed mill in China (see page 64).

Indonesia

Data provided by GPMT (Indonesian Association) showed small increases in shrimp and fish feed production in 2016. Fish feeds comprised 150,000 tonnes for the pangasius fish, 200,000 tonnes for the tilapia and 400,000 tonnes, for the Clarias catfish and the rest for various freshwater species. Only 6,000 tonnes of feeds were used for marine fish production. The top fish feed producers were PT Sinta Prima, PT Matahari Sakti, PT Grobest and PT Cargill Indonesia. In the open shrimp feed market, PT CJ rose to be a market leader, and it operates at full capacity (2,400 tonnes per month) its new plant in Lampung. According to Denny Indradjaja, GPMT, freshwater fish farmers continued to seek help from feed millers and the government, to lower selling prices of feeds. In 2017, the government will have a 1,800 tpy feed mill in Belawan to produce feeds for marine fish and tilapia. Feeds will be sold at IDR7500/kg, below the market price of IDR9,500/kg (pressreader.com).

The overall shrimp feed sales were affected by WFS. In 2016, farmers shortened the growth cycle and harvested smaller shrimp (80 - 120 pcs/kg). Some innovative farmers have developed an automatic feeder to increase average growth rates and shorten growth period to 70-80 days for shrimp size 50-60 pcs/kg. Haris Muhtadi, General Manager, Sales and Marketing, PT CJ Indonesia, said, "CJ has developed a low fish meal formulation which has shown no negative effect on growth, ADG was better and so was pond water quality."



Erwin Suwendi (middle) and Irwan Hartanto (left), Aquaculture Division, Japfa, Indonesia. with Frederic Jozwiak, Mixscience

Puspita Dewi Prijadi, President Director, PT Matahari Sakti, (MS) added, "In 2016, WFS was well controlled as compared to 2015 since the farmers took some preventive measures including better water management to avoid outbreaks. They have learnt from their previous experiences. In this regard, there is a positive impact in the feed industry since sales volume is increasing slowly for 2017. MS is continuously improving feed formulations for better performance so that there will be no wastage."

In 2017, GMPT expects that shrimp feed production will be 15-20% less than the capacity as CP Prima shuts down operations of an integrated farm while farms in Kalimantan, Medan, Sumatra and some parts of Sulawesi are still struggling with disease. However, industry countered that an excess of capacity is not expected with the many new and large farms being built, in Bengkulu, Sumatra, Southwest Java and Madura. There are also some new feed mills; China's Evergreen and New Hope, will each start a shrimp feed mill and fish feed mill, respectively, in Lampung while CJ has just opened a new fish feed mill in Central Java. With regards to marine fish feeds, the association expects an increase of 20-30% in production in 2017. "New additions will increase the numbers of large feed mills to 22 and capacity to 1.4 million tpy," said Denny (trobos.com).

Malaysia

With stagnant shrimp production in 2016, there was no change in the volume of shrimp feed usage. Despite Cargill leaving the shrimp feed segment in 2015, the industry is overcrowded. In 2016, local production of shrimp feed was led by Star Feedmills and Gold Coin, and for fish feeds, Star Feedmills, Cargill and Dindings Soya & Multifeeds.

There was a surge in the production of the monodon shrimp in 2016 but according to a feed miller, this is still a niche market and will not impact greatly the feed market. Monodon shrimp farmers use the premium feeds marketed for both shrimp, such as Gold Coin's premium feeds with 38% to 42% crude protein. The biggest challenge for feed millers in Malaysia in 2016 was the 12% depreciation of the Malaysian Ringgit and increase in raw material prices. Some 75% of feeds for the marine fish were imported from Taiwan, Indonesian and Vietnam.

In 2017, stiff competition in the industry is expected with the entry of new players. Vio-Star International, a subsidiary of Grobest Feeds from Taiwan opened its feed mill in March 2017, with a capacity of 24,000 tpy of shrimp feeds and 36,000 tpy of extruded fish feeds, both operating on three shifts. Dindings is building a large fish and shrimp feed factory in Perak. The GST group, Malaysia's leading producer of marine fish and China-based Evergreen will jointly construct a fish and shrimp feed mill for completion in November 2017 in the northern part of peninsular Malaysia.

Acknowledgement: I wish to express my sincere thanks to feed millers and other stakeholders in the aqua feed industry for their contributions in the preparation of this article.

Extrusion and the movement towards environmentally clean aqua feeds

By Joe Kearns

Advances follow the desires of industry on an environmental basis as well as higher output targets.

The aquatic feed production industry continues to evolve and change to meet demands for a cost effective and environmentally friendly feed. The industry is learning, researching, reporting and discussing the requisites for the feed in relation to the surrounding environment where the organism is cultured. Feed producers normally have topics to discuss, such as the machinery for making feeds or the conversion of a raw material formula to a final product with defined characteristics. As a result of all the interactions within the industry, the research directions are determined and technically oriented parties work towards the sustainability of this evolving industry. This is typical for an industry which has a humble beginning and has grown tremendously as aquaculture expands over the years. Forty years ago, during my first trip to Thailand, the topic raised was how to change the technology from making full fat soya to floating fish feed. I did not realize it then but thus started my career in extrusion technology for aqua feeds.

Years ago, when pellet mills dominated the feed production arena, and extrusion was a newcomer and a novel undiscovered process, discussions on extrusion always began with why this process was the one to consider for feed production. The aquaculture industry had started by feeding fish to fish, with trash fish being fed to fish of higher value. Pelleted feeds had a better conversion ratio and in fact was no doubt less polluting for the environment. Then, fish fed 8 to 10 kg of fish gained 1 kg of weight. The use of sinking pelleted feed grew and aquaculture was off and running whilst the feed industry gained experiences with techniques as well as finding out potential pitfalls.

Figure 1. Four Photo Collection, First 3 cause fines in bag. 1st incorrect knife adjustment (top, left), 2nd wrong running conditions (top right) and 3rd coarse grind (bottom left), all cause fines development. 4th good grind and cut, reduced fines (bottom, right)

Extrusion technology entered the scene when it was discovered that fish could eat floating feeds. Catfish, carp, tilapia and milkfish are some of the few species extensively fed feeds made by extrusion cooking. Why floating feeds? They enable the farmers to visually see the fish eating and how much. When fish stops eating, the feeding ceased. Feed conversion ratio (FCR) improved as well as water quality because of less uneaten feed and their breakdown. Feeding regimes are easier to develop based on visual results; therefore we need to make further improvements to how much to give and when to feed.

The extrusion process has several advantages over the pelletizing process. The gelatinization of starch, use of higher levels of vegetable proteins and liquid ingredients, density control, pellet size control, production of semi-moist feeds and production of high capacity sinking feeds with controlled durability all have increased the use of extrusion in aquatic feeds. How these innovative approaches improve the environment in relation to aquaculture are discussed below.

Starch gelatinization

In extrusion, starch gelatinization is usually in the 90% range while it is typically about 45 to 60% in pelleted feeds. The starch holds the ingredients together and increases the durability in either the floating or sinking feeds. Better binding will result in less fines in the feed bags as the pellets were bound together and not pressed together.

Lower starch levels are possible, such as 10% for sinking and 20% for floating feeds. This is an advantage as the lower starch level in the formula will result in more space for the needed proteins. Traditionally, in many fish feeds the use of fish meal is high. Studies and research proved mainly soybean meal and other vegetable proteins are readily accepted by many fish and aquatic species. Lower starch levels allowed for these lower protein ingredients to be used and still achieve the desired protein level. Environmentally, this reduces the use of wild caught fish for fish meal production while maintaining the FCRs at profitable levels. This advance is also because of huge increases in fish meal and fish oil costs.

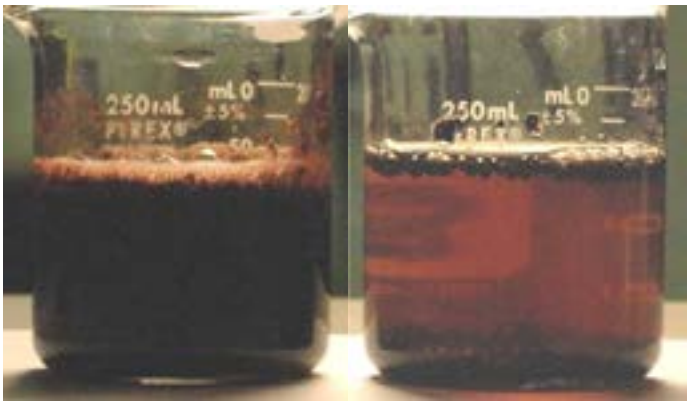


Figure 2. Solubility or functionality comparison of animal proteins. Left, spray dried blood haemoglobin and right, ring dried blood meal. Ingredient quality is greatly affected by heat. Spray dried, lower heat drying produces a more functional ingredient with greater binding characteristics than ring dried which is a higher temperature process. Similar results are seen in fish meal and vegetable proteins.

An additional development is the use of terrestrial animal proteins which also have excellent amino acid profiles. Examples are poultry as well as meat and bone meal and others. Extruders advanced the use of these meals with the ability to handle higher moisture levels allowing the terrestrial ingredients to be used in liquid forms. These ingredients are ground into a pulp paste and are usually chilled. Drying is not required and these ingredients are pumped directly into the conditioning cylinder on the extruder in the raw form. With this process, the ingredients remain functional in that the proteins have not been denatured and thus more extrudable at high levels than over dried non-functional ingredients.

In contrast, double cooking of proteins yields lower functionality and removes some of the flavour or attractability gained with the use of liquid fish or animal protein sources. Fish meal contains certain chemicals or additives that are beneficial to aquatic animal nutrition. Taurine is quite important for marine fish feeds which explains the high requirement of fish meal in traditional diets. Technology is now available to attach short chain amino acids to vegetable proteins in the production process using the extruder as a reactor in addition to final feed production. An engineered liquid with crystalline amino acids, usually the short chain such as lysine, methionine and taurine can be used in this process, thus greatly increasing the possibilities of lowering fish meal usage. Fish oil, another big requirement in marine fish feeds is now used at lower levels as a top coating over other oil sources giving the desired final oil level with properly designed vacuum coaters. Fish oil inclusion approaches 35 to 40% in salmon feeds. The use of lower fish meal and fish oil and inclusion of vegetable proteins results in environmentally friendly feeds.

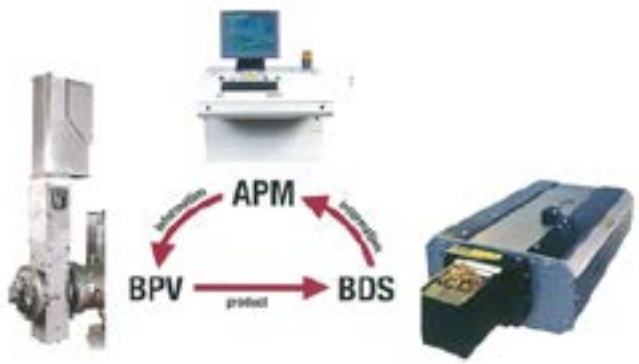


Figure 3. Controls improve environmentally friendly feeds production by automatic controlled density, verified every 45 to 60 seconds.

Density control

Density control and pellet sizes via the extrusion process also allow for lower pollution or damage to the pond or ocean bottom under cages. In many cases one characteristic of feeds is to sink at a controlled rate, which is slow enough and the feed will be consumed before it exits the cage or reaches the pond bottom. A typical sinking rate is about 15 seconds per metre. Density control or close attention to the feed density is critical. Several years ago, a typical method is to have density control measured at the end of the extruder using water to observe the sinking rate in either fresh or sea water. Today, the developments now allow for computer control and in-line density measuring equipment to adjust the density to a set range and maintain it with constant verification.

Large, 50 mm diameter semi moist 50% fish offal tuna feed. Note the typical smooth surface on these semi-moist feeds

Semi moist feeds

Semi moist aquatic feeds are feeds that have higher than standard moistures, usually between 20 to 30% moisture. Historically, work was done on sea urchin and abalone feeds with the feed technology being patented about 20 years ago. The theory was to create a feed that these animals would consume with a softer pellet texture. Testing showed that these pellets with elevated moisture resulted in stable pellets with 5 to 7 days' durability. The stability of the pellets is due to less swelling from moisture uptake as well as the use of higher kelp levels in the formula. Some countries such as Korea, prefer semi moist pellets for fish culture to reduce water pollution coupled with fish preference. This technology leans towards formulas high in liquid ingredient inclusion such as fish or terrestrial offal. High moisture ingredient inclusion (approximately 50%), coupled with the dry ingredients extrusion and cooling yield a feed of approximately 30 to 35% moisture. Feeds of this design included those for the blue fin tuna which also attract fish to eat during non-feeding periods of the year.

Shrimp feeds

The interest in sinking feeds has centered on shrimp feeds, and recent technology has greatly increased the capacity of extruders. Extrusion could always make sinking feeds in various degrees of water durability, measured in hours. In terms of output, now 8 to 10 tonnes per hour is achievable with sustainable environmentally friendly low fish meal formulas at grow out feed diameters with possibilities to produce down to 0.5 mm floating or sinking feeds.

In general, the use of extrusion follows the desires of the industry to produce feeds which meet the needs of the industry to address environmental concerns. The following quote sums up the current situation, "Extrusion technology has made possible many improvements in feed performance, by increasing the energy levels in the diet through higher fish oil inclusion and improved starch digestibility, by destroying anti-nutritional and potential pathogens and by improving physical properties of the diet. Water stability has improved while the production of dust from feeds is now minimal. The utilization of vegetable proteins is also enhanced by extrusion, reducing the impact of the feeds on the environment (Lopez Alvarado, 1997). This publication also discusses the other farm management practices which also has minimal impacts on the environment. Further advancement to innovative approaches will be developed due to the interaction of all stakeholders including farmers, researchers and feed equipment production companies.

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Benefits of feed enzymes for sustainability and responsible aquaculture

By Thomas Wilson

Excessive water-borne phosphorus and free nitrogen in aquaculture should be dealt at source with feed enzymes to improve feed digestibility.

The UN Food and Agriculture Organization (FAO) has projected world population to increase from the current 7.5 billion to 9.1 billion by 2050 (FAO 2009). A significant increase in food production will be required to feed this population growth and the FAO in its report on "How to feed the world in 2050" estimated that food production in developing countries will need to double (FAO 2009). Human diets are also shifting to more meat and dairy foods. However, the FAO data showed that world per capita meat consumption is increasing only for chicken and fish. As the conversion of feed to edible meat from fish is the most efficient for all animals farmed for meat, aquaculture is potentially the most viable source of future protein to meet global needs.

Sustainability

The future of aquaculture to meet the future demand for protein depends on its sustainability and that aquaculture farms operate responsibly. While "sustainability" has environmental, economic, and social components, the main focus with aquaculture has always been on environmental issues. The main issue in aquaculture revolves around fish meal reduction in feeds and fish oil substitution in high energy diets. However, reducing fish meal in feeds changes the origin of proteins from wild marine sources to proteins from crops and to recycled protein by-products from food processing of farmed animals (including fish), which shifts the responsibility for sustainability elsewhere.

Responsible aquaculture

This is focused on the ethical behaviour and social responsibility of aquaculture practices, and in this respect requires sensitivity to local environmental, social and economic norms. An expanding aquaculture industry in Asia, undoubtedly, will have to contend with constraints on land use and access to fresh water. It will undoubtedly encounter land and water use conflicts.

Expanding production by land-based aquaculture may only be possible through intensification using existing resources rather than new resources. It is vitally important, then, that current aquaculture operations exist as "good neighbours", so that they continue to be accepted by local communities; otherwise local approvals for future expansion may be withheld. This is why aquaculture farms should be closed systems to minimise pollution of shared water resources.

Successful aquaculture intensification requires high quality feed and good water quality. Low-polluting feeds are necessary and feeds must be properly balanced with high feed conversion and high nutrient digestibility. While good feed management and proper aeration are important in maintaining acceptable water quality, poorly digested feeds lead to high organic wastes that increase the levels of dissolved phosphorus (P) and nitrogen (N) in the water body.

Finally, responsible aquaculture is vitally important for consumer acceptance of aquaculture products and subsequently will promote growth of the industry.

> **"a lack of reliable information about P requirements makes P reduction in feeds quite challenging.. Rather than lowering dietary P, shifting the focus to making the endogenous P more digestible is probably a safer approach."**

Phosphorus

Excessive water-borne P leads to eutrophication of fresh water systems and algal and plankton blooms in brackish water and coastal marine environments. This causes so many problems in water sharing between multiple users that most governments in developed countries now regulate P emissions from all sources, including aquaculture. Most Asian countries have such regulations but they are poorly enforced.

While the European salmon farming industry responded by reducing P levels in feeds to the minimum and trying to increase P digestibility, the Asian aquafeed industry has not paid much attention to this.

P emissions

Shifting from marine proteins to plant proteins exacerbates the problem of P emissions because so many plant ingredients, such as soybean meal (SBM), rapeseed meal and wheat bran contain significant amounts of phytic acid, which binds much of the endogenous P found in the ingredient. For example, approximately 70% of the P in SBM is bound to phytic acid, which makes it indigestible (unavailable as a nutrient) and it is excreted via faeces.

With so many fish species being farmed across Asia, a lack of reliable information on P requirements makes P reduction in feeds quite challenging and prone to failure. Rather than lowering dietary P, shifting the focus to making the endogenous P more digestible is probably a safer approach. The trend of increasing levels of plant ingredients (with known amounts of phytate-bound P) in aquafeeds makes the incorporation of phytase enzymes into feeds a sensible option.

Increasing P digestibility

Phytase enzymes degrade phytic acid, liberating bound P and increasing its digestibility. Research by the DSM Aquaculture Centre, Asia Pacific has shown that digestibility of P in tilapia feeds containing SBM and other plant ingredients improved considerably with the addition of phytase enzyme.

In Thai trials with tilapia feeds, adding phytase reduced P excretion by more than 40% compared to no phytase addition. This is a significant reduction in P loading to the environment. With the recommended dosage of phytase enzyme improving digestibility of endogenous P in feed, supplementation of dietary P from monocalcium phosphate (MCP) or monodicalcium phosphate (MDCP) can be reduced by 10 kg/tonne of feed, which further reduces the P loading into farm water. This also leads to potential formulation cost savings, since in practice the cost of the added phytase enzyme is lower than the cost of the added MCP/MDCP that was removed. (Related article: Wilson, Thomas,

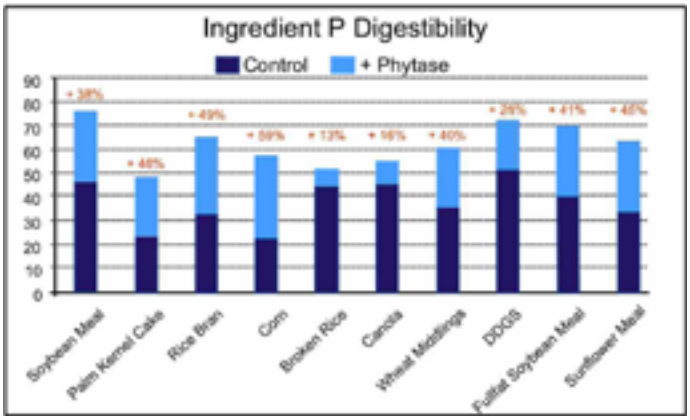


Figure 1. Improvement of phosphorus digestibility with phytase enzyme added to selected feed ingredients used in tilapia feed (after Verlhac-Trichet 2016).

2016. Phytase acts against the anti-nutritional effects of phytic acid in fish, Issue September/October, Aqua Culture Asia Pacific, Vol 12 (5), p42-45.)

Nitrogen

Nitrogen inputs in aquaculture have several components: mainly fertilizer, fish fingerlings/shrimp post larvae biomass, and feed. The inputs vary, depending on the type of farm and the stocking densities used. Once the nitrogen source is in the pond, the N is partitioned into the harvested animal biomass, sediments and water. Table 1 shows a few examples of N partitioning in fish and shrimp ponds.

A well-managed closed farm can virtually eliminate N emissions into external waterways, and if pond sediment is captured and recycled as fertilizer for crops, the environmental impact is minimal. However, modern closed farms will then have to deal with the free nitrogen in the water, found as dissolved nitrate, nitrite, unionized ammonia (NH_3) and ionized ammonia (NH_4^+).

Every species has its own susceptibility to dissolved N, and there is no set recommendation on N levels in pond water although 0.2 ppm maximum unionized ammonia is often suggested as a guideline. Allan et al. (1990) reported that the growth rate of the school prawn (*Metapenaeus macleayi*) was reduced by 5% when unionized ammonia reached 0.35 ppm, but for the tiger prawn (*Penaeus monodon*) only 0.21 ppm ammonia reduced growth by 5%, so even closely related species may have different tolerances.

There are a number of reasons why N levels in pond water should be kept as low as possible. As the ammonia concentration rises in water, the reduced N gradient across gills leads to decreased ammonia excretion. This causes an increase in blood pH and affects numerous metabolic processes due to ammonia toxicity. Some of the main effects of high ammonia levels include growth reduction due to reduced oxygen uptake, impaired osmoregulation, and increased energy demand for alternate ammonia detoxification. Exposure to high levels of ammonia has also been shown to cause immunosuppression and reduced resistance to disease in both fish and crustaceans.

Improving feed utilisation

The nitrogen budgets shown in Table 1 demonstrate that for semi-intensive and intensive aquaculture, feed N is the biggest contributor to dissolved N in the pond water and in bottom sediments. The most effective way to reduce N then is to focus on improving feed utilisation and feed management. The first step in controlling N in wastes is to determine the protein and amino acid digestibility of ingredients, because these are the components in feeds excreted with the faeces that contain nitrogen. Ingredients should be selected for protein quality, ideally having a good amino acid balance, but more importantly, need to be cooked/processed in a way that does not reduce digestibility. Aquatic animals have a requirement for amino acids, not for protein itself, so the protein level and the origin of the protein is not so important.

Proteins of plant origin, assuming they have good digestibility, often have amino acid digestibility equal to or better than fish meal, but attention needs to be paid to any amino acid imbalances. It is wise to note that the measurement of crude protein is usually based on the analysis of nitrogen, and there are certain ingredients that contain substantial amounts of non-protein nitrogen such as chitin/glucosamine in shrimp head meal, and nucleosides and nucleotides in bacterial and yeast fermentation proteins, that lead to overestimation of protein and their value in adding amino acids to feeds.

Tabl e 1. Some nitrogen budgets reported for pond-based aquaculture of fish and shrimp.

Country & Species	Intensity & Farm system	Main N input (%)	% of total N input in harvested biomass % of total N input in pond sediment (%)	% of total N input in pond sediment (%)	Reference
Bangladesh *P. monodon*	Low intensity	Fertilizer 60% Feed 21%	33%	40%	Rouf et al., 2012
Thailand *P. monodon*	Semi-Intensive Closed	Feed 96%	24-25%	42-46%	Songsangjinda and Koolkaew, 2002
Puerto Rico Hybrid red tilapia	Semi-Intensive Closed	Feed 87%	17.5%	65%	Acosta-Nassar et al.,1994
USA Channel catfish *Ictalurus puntatus*	Semi-Intensive Closed	Feed 88%	31.5%	22.6%	Gross et al., 2000
USA Striped bass *Morone saxatilis*	Semi-intensive PE-lined ponds	Feed 88%	20%		Daniels and Boyd, 1989

Improving protein digestibility with protease enzyme

As the feed industry inevitably moves towards alternative proteins to replace fish meal, issues with poor protein digestibility have arisen. Digestibility of protein and amino acids in alternative ingredients of plant and animal origin can be improved by adding protease enzyme to feeds. ProAct protease (DSM, Switzerland) is at the moment the best solution for improving protein digestibility available to the feed industry. Experiments using an *in vitro* poultry gut model show significant improvements in ingredient digestibility when ProAct is provided on top of endogenous digestive enzymes, and results are not expected to be different with fish.

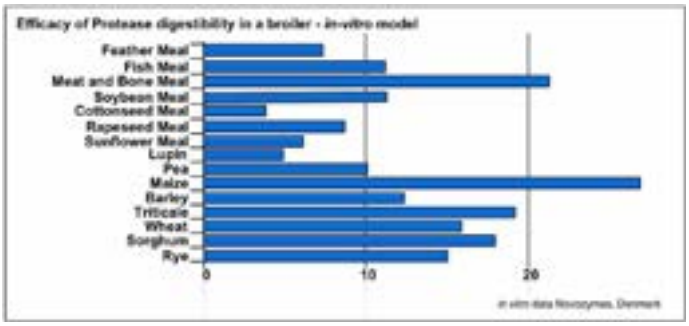


Figure 2. Improvement in protein digestibility of selected feed ingredients with the addition of protease enzyme on top of typical endogenous proteases in an *in vitro* poultry model (source: Novozymes).

The adoption of protease by the aquafeed industry is just beginning, so there is not much information available on the benefits of protease. However, Dalsgaard et al. (2012) were able to show a significant improvement in apparent digestibility of soy (34% inclusion level in the feed) and a significant decrease in solid N waste excretion when protease alone or protease combined with xylanase was added to rainbow trout feed. Plant ingredients such as soy, rapeseed and canola contain trypsin inhibitors that stop trypsin from cutting protein into peptides before further digestion by other proteases in the intestine. ProAct has been shown to digest trypsin inhibitor proteins, thus improving digestive function; It is less specific in selecting active sites on proteins for digestion than trypsin, hence it actually accelerates the initial stages of protein breakdown.

In an experiment with tilapia with three different protein levels and three different dosages of ProAct enzyme (Verlhac and Diaz 2012), apparent protein digestibility was improved from 2–4% in a 31% crude protein (CP) diet, and from 3-8% for 28 and 26% CP diets (Table 2), suggesting that in feeds with lower quality protein the benefit of using protease may be greater.

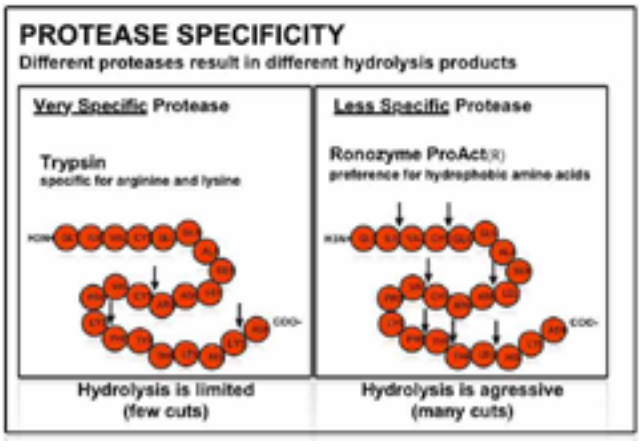


Figure 3. Ronozyme® ProAct is a faster acting protease than trypsin because it has less specificity for amino acids at binding sites (source: T. Hoff, Novozymes R&D, 2013).

Table 2. Improvement in apparent protein digestibility (protein ADC) with increasing protease supplementation.

Percentage (%) improvement of apparent protein digestibility of different quality diets relative to control			
	Protease supplementation		
Diet	200 ppm	400 ppm	600 ppm
CP31 (8% fish meal)	2.05	3.32	4.41
CP28 (4% fish meal)	3.63	4.29	8.01
CP26 (2% fish meal)	3.65	4.39	8.33

Protease, then, has a lot of potential to improve digestibility of all types of protein ingredients, and will assist nutritionists in formulating feeds that are more digestible and less polluting, while at the same time offering the possibility of choosing less expensive ingredients to control formulation costs.

Better nutrient uptake with xylanase enzyme

Non-starch polysaccharides (NSPs) can be water soluble or insoluble. Soluble NSPs such as arabinoxylans swell and form viscous gels when hydrated in the intestine, thus preventing secreted enzymes from reaching digestible substrates, and impeding digested nutrients from migrating to the gut wall for absorption. Insoluble NSPs such as cellulose and lignin induce a "cage" effect, and nutrients are trapped within the folds of the NSP molecules. Ronozyme®WX (xylanase) works to reduce the viscosity of NSP gels, and breaks down insoluble NSPs as well as improving assimilation of digested peptides and fats.

This is why the Dalsgaard experiment reported above, improved protein digestibility when xylanase enzyme was added to the feed. In fact, adding phytase and xylanase together with protease improves protein utilization the most, with phytase reducing phytic acid-protein interactions, and xylanase improving protein, peptide and amino acid migration in the intestine in feeds containing large quantities of NSPs.

Enzyme research for the future

With the increasing use of more plant ingredients such as rice bran, wheat bran, copra meal, and palm oil milling byproducts in aqua feeds, there is merit in improving digestion of plant cell walls to unlock valuable nutrients trapped inside cells. Cell walls of cereals (wheat, corn, barley, rice) are mainly made of arabinoxylans and β-glucans, whereas oilseed crops (soy, canola, rapeseed, sunflower) are mainly xyloglucans and pectins.

Feed enzymes that digest cellulose, xylans, glucans, mannans and pectins are now widely used in livestock and poultry feeds, but have yet to be applied to aqua feeds. The DSM Aquaculture Centre Asia Pacific intends to investigate some of these enzymes in combinations to further improve the feed efficiency of warm water fish feeds in Southeast Asia.

Dr Thomas Wilson is an Aquaculture Nutrition Consultant for DSM Aquaculture Center Asia Pacific, Thailand. He is based in Bangkok, Thailand. Email: thomas.wilson@fishnutritionexpert.com

A milestone: snakehead fish culture using extruded feed in India

By Zhang Taoping, Xiao Haidong, Narasimha Rao Tatavarthy, Dong Qiufen, Zhang Song and Yang Yong

A partnership scores a first in India with large scale fry breeding, commercial farming and dedicated extruded feed for the snakehead fish.

The snakehead fish, also known as the murrel in India, constitutes the most common and dominant group of air breathing fishes and is highly regarded as a high value freshwater fish in India. Three murrel species are widely available as food fish in India: giant murrel (*Chana marulius*), striped murrel (*Channa striatus*) and spotted murrel (*Chana punctatus*). Among these, the striped murrel or striped snakehead fish (called koramenu in Telugu) has a high market demand in several states, such as Andhra Pradesh, West Bengal, Telangana, Tamil Nadu and Karnataka.

As the "state fish" of Telangana state, the snakehead fish fetches a high price, ranging from INR 400 to 500/kg (USD 6-8/kg) in different retail markets. There is a price variation depending on markets and season. Snakeheads have a good market value due to their nutritional properties (68-80% crude protein, 7-10% fat), delicate flesh and fewer intramuscular bones, as compared to the Indian carps. As an air breather, the snakehead can survive out of the water for around one week, provided the body is wet.

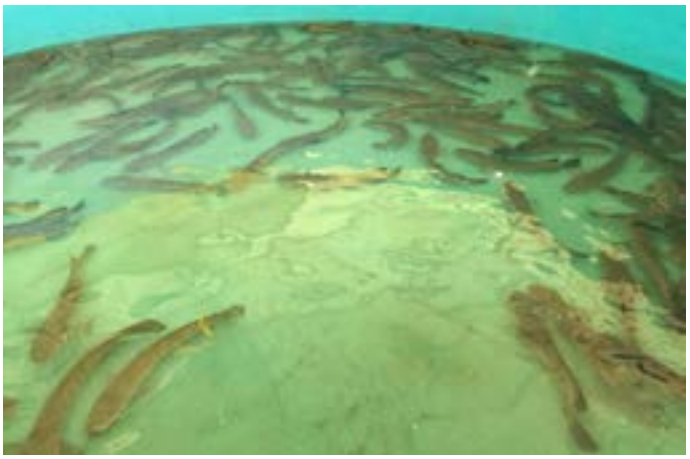
The snakehead is also believed to play an important role in human health, especially in wound healing, muscle strength and immunity enhancement. In India, snakehead fingerlings are used in giving medicine to asthma patients gathered in Hyderabad on the eve of *Mrigasira Karthi*. A unique and secret herbal medicine is put into the mouth of live snakehead fingerlings, then the patients are made to swallow the fish.

Snakehead farming in India

Snakehead farming has a long history, more than three decades in India, but currently there is still no specialised farming of this species in India. Wild caught fingerlings and sub-adults are stocked in extensive carp ponds to control populations of low value wild fish like tilapia and provide an additional source of income to carp farmers. However, snakeheads are harvested every two to four years when the carp ponds are dried.

Considering the high market demand and dwindling wild catch, many attempts have been made previously to breed this species in India. Some of the breeding attempts have been successful,

Selecting broodstock



Culture of suitable broodstock for artificial breeding

but commercial quantities of fry have not been raised due to difficulties in rearing and weaning this highly carnivorous species.

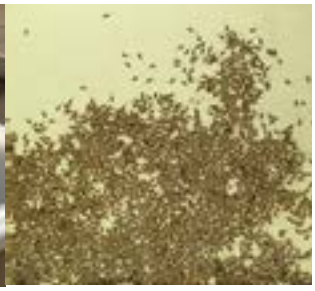
The Indian fresh water fish farming sector is predominantly dominated by Indian carps (rohu, catla and mrigal). Pangasius (*Pangasius hypophthalmus*) and Paku (*Colossma brachypomum*) are a few recently introduced species that have been successful. GIFT tilapia has also been introduced, but has yet to catch on. In this scenario, the focus has been to commercially farm more high value species. However, due to the increasing demand for snakehead fish and high profitability in farming the fish, availability of the wild stock is decreasing annually.

The Uno Group, ranks among the top three in the fish feed industry in Andhra Pradesh (where 90% of Indian fresh water fish farming is carried out). Uno Feeds started extruded feed production in 2007. Since inception, Uno Feeds has been trying to introduce the best practices and concepts that are popular in fish farming. In 2015, Uno Feeds signed a strategic co-operation agreement with Guangzhou Nutriera Biotechnology Co. Ltd to develop snakehead fish farming.

Nutriera, a leading aqua feed premix and additives supplier in China, focuses on integrated services for aqua feed enterprises. It has 15 years experience in snakehead farming in China, Vietnam, Myanmar and Bangladesh etc. Prior to entering India, the company successfully helped customers apply and promote snakehead breeding and farming technology in China, Vietnam, Myanmar etc. Over the years, it has published technical articles covering artificial breeding, commercial farming and dietary R&D for the snakehead, such as on extruded snakehead feed in Vietnam, hybrid snakehead fish farming in China and the snakeheads' success in Myanmar.

In 2016, the large scale artificial breeding and intensive culture of *C. striatus* was carried out. A special extruded snakehead feed was produced and tested under farming conditions. Through these practices in 2016 and with the help of Nutriera, Uno's technical team accumulated several successful experiences on artificial breeding, commercial farming and extruded snakehead feed production.

Hormone injection



C. striata fry, 60-hours old larvae after fertilization

C. striata, 25-days old, fed commercial feed

C. striata, 2-days old after initial feeding

C. striata, 14-days old after intial feeding

Juvenile C. striata at 10g

Broodstock

In 2015, with the local resources of Uno, Nutriera experts designed a special hatchery and carried out broodstock rearing. Broodstock were mainly wild-caught. However, as the wild population of snakehead is very limited, the team searched for suitable broodstock all around the state of Andhra Pradesh. After one year of searching and selection, 2,000 good quality, healthy breeders were collected and stocked for the following year. They were raised on a special diet up to maturation.

Artificial breeding

From April to September 2016, four breeding trials were successfully carried out and produced 2 million of snakehead fry for the nursery stage. The spawning rate, fertilization rate and hatching rate were around 95%, 60%, 80%, respectively. Within 45 days post hatching, the fish body weight could reach 15~20g/pc.

However, during the breeding stage, there were several difficulties. Due to the extremely high temperatures in May, up to nearly 50°C in Andhra Pradesh, thousands of fingerlings were lost due to heat stress. There were also challenges with the water source and quality. In Andhra Pradesh, the rainy season is also the rice planting season. Fish breeding work had to wait and only use the water source after rice farmland irrigation. That was a major restriction during the breeding in 2016. In addition, frog juveniles, aqua insects, turtles, snakes, crows and other predators would reduce the survival rate of younger snakeheads.

Throughout the last two-years of hard work, Nutriera and Uno gained a major success in the artificial breeding technology of stripped snakehead *C. striatus*.

An exclusive extruded feed

Snakeheads are ferocious carnivorous bottom feeders and require higher levels of dietary protein (38%-50%) and fat (6%-12%) for the different life stages and farming conditions in comparison to the Indian major carps. Presently, except for the low density poly culture with Indian carps (mentioned above), a few wild collected snakehead seed are still fed with live fish, trash fish, and part of by products of poultry processing for the grow-out stage in some culture areas. The lack of specially formulated feed for the snakehead has been a major constraint for development of its commercial culture for a long time in India.

In June 2016, with the assistance of the Nutriera team, Uno Feeds produced extruded feed for this fish by using local raw materials and Nutriera's special premix for snakehead fish.

Intensive farming techniques

In 2016, despite the high temperatures, water resource shortage, power supply shortage and predators of fingerlings, but with the careful management and lots of efforts, we finally obtained 150,000 10g juveniles snakehead fish for intensive grow-out farming in earthen ponds. In order to have a higher yield and better price, the farmed fish was sold at large marketable size of 1-1.5kg/pc (The usual marketable size is 0.8-1kg/pc).

In Table 1, we show results of commercial farming practices for the snakehead. The stocking density ranged from 25,000 juveniles/ha to 35,000 juveniles/ha; survival rate was above 98% from 10g juvenile to sampling size. As the result of efforts in artificial breeding and commercial culture in India, we have explored different methods to adapt to local conditions in each fry breeding batch and have accumulated valuable experiences for production in the following year.

Future plans for the snakehead

Hardy biological traits, fast growth and good market potential make the snakeheads an alternative species for aquaculture, alongside carps and catfish in India. To meet the market demand for snakehead fish and develop intensive commercial farming in India, the target is to produce one million 10 g *C. striatus* juveniles for grow-out in 2017 and henceforth double the annual production for sale to the farmers in the next 2-3 years. It is very likely that striped snakehead will establish itself as an important aquaculture species in India. With the guidance of Nutriera, Uno feeds will continue its efforts to work with this species and also try to evaluate the faster growing giant snakehead *C. maurilius*, as well as look into possible hybrids between *C.striatus* and *C. maurilius*.

Table 1. Some results from commercial snakehead farming of Uno Feeds

Item	Pond 1	Pond 2	Pond 3	Pond 4
Pond area (ha)	1.2	1.5	1.2	0.8
Water depth (m)	1.2	1.2	1.2	1.2
Stocking size (g/juvenile)	11	44	12	32
Stocking density (juveniles/m^2)	3.5	2.5	3.0	3.5
Stocking quantity (numbers)	40,000	38,000	36,000	28,000
Stocking date	23/8/2016	28/9/2016	28/9/2016	13/12/2016
Sampling date	1/3/2017	1/3/2017	1/3/2017	1/3/2017
Sampling size (g/fish)	664	612	478	280
Feed consumption (kg)	34,720	25,440	20,280	8,800
Feed conversion ratio (FCR)	1.33	1.18	1.21	1.27

Extruded feed (1.2mm) for C. striata

Extruded feed (6.0mm) for C. striata

Grading snakehead juvenile

Snakehead of size 600g/fish competing for feed

Zhang Taoping

Xiao Haidong

Narasimha Rao Tatavarthy

Zhang Taoping, Xiao Haidong, Dong Qiufen, Dr Zhang Song and **Dr Yang Yong** are experts in aqua nutrition and aquaculture from Guangzhou Nutriera Biotechnology Co.,Ltd. Nutriera mainly delivers whole practical solutions for aqua feed mills to help them produce high quality aqua feed and create more value for the farmers. **Narasimha Rao Tatavarth** is the Managing Director of Uno Feeds Group, India. Email: qiufendong@gmail.com (Dong Qiufen).

First in Indonesia with extruded shrimp feeds

PT Matahrari Sakti is producing high-density sinking shrimp feeds using advanced extrusion techniques.

The white shrimp, *Litopenaeus vannamei* is a high-value aquaculture commodity with increasing demand in the world. With a global market output of almost 3.5 million tonnes in 2016, this shrimp has stimulated increases in feed production, resulting in a tighter competitive environment among shrimp feed producers. As a result, the aqua feed industry is racing to be more innovative and at the same time seek more efficient low-cost processes without compromising shrimp growth performance and feed value.

Conventional pelleted shrimp feed

In Asia, most shrimp feed is manufactured through the pelletizing process, where raw materials are finely ground and then moulded into pellets through the application of heat, moisture, and mechanical pressure. This conventional technique has a temperature limit, which often causes low starch gelatinization, affecting the durability of the feed. Additionally, this method also has limitations when producing small-size pellets. For post larvae starter feeds, these pellets are crumbled into smaller sizes. However, this process generates significant dust, up to 3% of the feed mass. Feed handling during distribution can further increase dust. This physical waste cannot be eaten by the shrimp and also cause water pollution.

An advanced extrusion process

The extrusion process is traditionally used to produce floating fish feed, as opposed to shrimp feed that requires the feed to sink. With advanced techniques of manufacturing, the extrusion process can now be used to produce high-density shrimp feed, allowing it to sink. Cooking at a higher temperature increases starch gelatinization in extruded feed, which in turn increases carbohydrate bioavailability. This means that there are more nutrients for the shrimp to digest. The extrusion process also enables the production of small-size feed, sometimes as small as 0.7 mm in diameter. Since the crumbling process is no longer required, extruded feed products do not generate dust in the production process and is therefore more eco-friendly.

Benefits of extruded feed

Extruded shrimp feed provides several benefits, such as improved nutrient digestibility, increased intake stimulation and efficiency, no dust generation, better water quality, and reduced nutrient leaching. All these benefits result in an overall increased potential shrimp growth and profit per unit of feed intake (Table 1).

There is also the benefit of better water stability. The leaching rate of dry matter was initially rapid but gradually slowed with extended exposure time. Water stability of the feed granule was better than for pelleted starter feeds.

Table 1. Comparison of benefits of extruded vs pelleted shrimp feeds

Pelleted	Extruded
Lower digestibility	Higher digestibility
Less feed intake stimulation	Better feed intake stimulation
Lower water quality due to dust	More stable water quality
More nutrient leaching	Less nutrient leaching
Not auto-feeder applicable	Auto-feeder applicable

Water stability test. Extruded starter feed size 2B (1.2 mm – 1.6 mm, late starter feeds, left), do not leach as much as shrimp crumbles (right) after 30 minutes

Auto feeder application for extruded feed is more convenient for farmers. Picture courtesy of Nefo Ponds

Extruded granules

Established in Margomulyo, Surabaya, PT Matahari Sakti (MS) is one of Indonesia's leading fish and shrimp feed producers. In early February 2017, PT MS introduced the extruded KJV granule. This is a breakthrough in extruded shrimp feed production and is produced at its Gempol Plant, Pasuruan, Indonesia. There are two different sizes:

- 2A (diameter : 0.7-1.1 mm, length : 0.7-1.1 mm) suitable for PL15-PL45
- 2B (diameter : 1.2-1.6 mm, length : 1.2-1.6 mm) suitable for PL with 1.0-5.0 g mean body weight (MBW)

This is the first stage of the company's progress in using extrusion technology for its shrimp feed. In this first stage, PT MS has produced early and late starter feeds and subsequently in the next stage, there will be development of extruded shrimp feed for grower and finisher stages.

Extruded feed has no dust compared to pelleted feed

Nutritional facts

The nutritional composition for the KJV granule is detailed below.

Proximate analysis	KJV granule
Protein (%)	Min 36
Fat (%)	Min 5
Fiber (%)	Max 3
Ash (%)	Max 10
Moisture (%)	Max 11

Farmers attestation

Large-scale trials were carried out in several commercial farms in Indonesia such as in Tuban, Banyuwangi and Lampung). Results show that this extruded feed is more efficient compared to pelleted feed, with a better feed conversion ratio (FCR) and a higher survival rate with shrimp fed the extruded feed. The feed also has a more appealing smell for the fish, stimulating better feed-intake than pelleted feed. Significant differences in water quality was observed where ponds with the extruded feed have a significantly better water quality.

More information: www.mataharisakti.com; Email: rudy.purwono@mataharisakti.com (Rudy Purwono, director)/ sales.marketing@mataharisakti.com

Launch of shrimp feed

In February, Deepak Nexgen Foods and Feeds Pvt. Ltd. launched its shrimp feed brand 'ifeed' at a factory in Bommaluru, Krishna District, Andhra Pradesh.

Launch of Deepak Nexgen's shrimp feed, the 'ifeed'

The elaborate ceremony was attended by 8,000 farmers and industry stakeholders. The shrimp feed plant was inaugurated jointly by Dr K Srinivas, Minister for Health and Medical Education, Government of Andhra Pradesh and Mr K. Ravindra, Minister of BC Welfare & Empowerment, Handlooms and Excise, Andhra Pradesh.

In 2012, Deepak launched the 'Kingfish' brand of fish feed and sold 20,000 tonnes from a production capacity of 60,000 tonnes per year (tpy). In 2015, it increased fish feed production capacity to 120,000 tpy. By 2016 and within 4 years of establishment, fish feed sales increased to 150,000 tonnes, making it the number one floating feed producer in India, with 25% market share. in The company, which uses equipment from Muyang, China, plans to increase fish feed capacity to 180,000 tpy in 2017 and then to 240,000 tpy in 2018.

Shrimp feeds

The decision to enter the shrimp feed segment was spurred by the huge potential in shrimp production in India. The target of Deepak Nexgen is 100,000 tonnes of shrimp feed by 2018. This new factory has a capacity of 60,000 tpy and was set up with pelleting machinery from Idah, Taiwan and the formulation consultancy was provided by Aqua Food Technologies, USA. "ifeed" is now available through distributors.

"Our vision for the shrimp feed sector is to continue to expand production with market demand. At the moment, we expect to expand capacity to 120,000 tpy in 2018 as well as set up shrimp hatcheries. We will expand capacity to 160,000 tpy by 2020," said Akkina Venkata Seshadri, COO.

Deepak Nexgen Feeds Pvt. Ltd was incorporated in 2010 by a group of farmers, traders, technocrats, engineers and marketing professionals with the ambition of serving the right feed for their co-farmers. The floating fish feed sector in India began with a production of 1,000 tpy in 2005 and expanded to 700,000 in 2016. It is expected to reach 800,000 tpy in 2017.

These are exciting times for Deepak Nexgen. "We see ourselves as the market leader in India's aquafeed industry and will constantly innovate to provide the best-value products and services to meet the ever changing needs of our customers," added Sheshadri.

More information: www.nexgenfeeds.in; Email:seshucoo@nexgenfeeds.in (Akkina Venkata Seshadri).

At the launch, Narendra Varma Raju Vagisana, Royale Marine Impex (right) receiving his first bag of feeds from A.V.Subramanyam, Managing Director. Looking on is Dr Tim O' Keefe, Aqua Food Technologies, USA.

Aquaculture at VIV Asia 2017

The 2017 edition of VIV Asia had a special focus on aquaculture-Aquatic Pavilion. There were only 14 booths located within the pavilion. However, all over the VIV Asia 2017 trade show, there were more than 100 booths with products for aquaculture, said Roel Schoenmaker, Sales Manager, VNU Exhibitions. Aside from booths with displays of products, seminars were organised where feed ingredients and additives, health and culture management were the leading topics. VIV Asia 2017 was held from March 15 – 17 in Bangkok, Thailand.

VNU exhibitions, organisers of VIV Asia, announced that the total number of visits at VIV Asia 2017 recorded during the three days of the biennial event rose by nearly 20% compared with VIV Asia 2015. There was a record of 45,952 visitors from 127 countries, which included 75% more visitors from China. The interest in this year's event reflected the rise in Asia's animal husbandry economy and demonstrated the interest in Asia as the region with the most activity and potential for expansion.

"I firmly believe that the 2017 show has brought VIV Asia into a new league," said VIV worldwide Manager, Ruwan Berculo. "The number of exhibitors grew so fast that we had a more complete offering for visitors to examine. I appreciated the extent to which companies at this edition invested more than ever in their exhibits." With the growth in the total number of visitors has come a further increase in quality there too, as exhibitors expressed to the organisers. "The quality of the event is there already. Now that it is definitely in a new league of global platforms, our ambition is to make sure that VIV Asia develops even more as the window on the complete value chains of meat, eggs, milk and aquaculture."

The visitor profiles indicated that Thailand led with 39.6%, followed by China, Vietnam, India, Malaysia, Indonesia and Bangladesh. This year, there was an upsurge in visitors from South Asia. Most countries showed a significant increase compared with two years ago. "We have found that the fastest growing attendances were from China, Philippines, Indonesia, Vietnam, Sri Lanka and Bangladesh," said Show Manager Zhenja Antochin. "It is a trend that we welcome warmly, not least bearing in mind, the dynamic nature of the business in the countries of South Asia. Bangkok is close to them geographically so it is a highly convenient location for professionals from the Indian subcontinent. In a real sense, it means that VIV Asia is their local show!"

Visitors from the Philippines. Seated, Dr Roselyn Usero, Negros Prawn Producers Cooperative Analytical and Diagnostic Laboratory (left), and Mary Ann C Solis, Biosolutions International. Standing, the Aqua Cards Inc team, Christopher Ulric Yanson (second right), Eusebio Tanaman (middle) and Fernandoo Gea (second left). The Mandal Corp team, Arthur Christopher D Maranon (right) and Eliud Medieta (left).

This year, the number of visitors with interest in aquaculture was 14%. At the Aquatic Pavilion, there was a range of companies, exhibiting from feed ingredients and additives to health solutions and supplies for farming. There was **Liptoaqua**, the aquaculture division of the Spanish manufacturer of phytobiotics and nutraceuticals for animal feed, Liptosa (www.liptoaqua.com) and the team from **Empyreal** marketing Empyreal® 75, an all-natural alternative protein concentrate. Taiwan's biotechnology company, **Genereach** had diagnostic solutions for aquaculture diseases (www.genereach.com). A first time exhibitor was Qingdao ZuoSiDaEr International marketing squid liver paste and oil produced by **Qingdao XinHaiYaYuan Bio-technology**. Products are exported to Thailand, Vietnam and Indonesia. The raw materials are from four factories in the north east of China. At their booth, both Kevin Zhang and Tim Kang were pleased with the visitor flow. The company also produces squid liver meal which is not exported as prices are much higher than squid liver meal marketed by producers in Korea, possibly due to the carrier used (www.xinhaiyayuan.com).

In the main event halls, a new exhibitor was **Nagase Sanbio Co Ltd**, marketing Bio-CP GS, a small peptide ingredient produced via enzyme treatment of squid meal. Trials, replacing squid meal with this product in post larvae, PL 15 to PL45 diets, showed higher survival and growth performance of *Penaeus vannamei* post larvae. Another product was Bio-CP, an enzyme treated fish

Maarten Jay van Schoonhoven, centre with the Olmix team inlcuding Olivier Biannic, Antibiotic-free Production Manager (left) and Marie Gallissot, Technical Supervisor (third left).

Cristina Garcia Diez and Álvaro Rodriguez Sánchez-Arevalo, from Liptoaqua, the aquaculture technical department, Liptosa, Spain

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Organizers:

China Aquatic Products Processing and Marketing Alliance (CAPPMA)

Fujian Aquatic Products Processing&Marketing Association (FAPPMA)

China Great Wall International Exhibition Co. Ltd. (GIE)

Wenger at VIV Asia 2017; from left, Curtis Straham, Joe Kearns, Cliff Zhou, Marc Wenger, Julius Lin, Ramesh G. and Jesse Mitchell.

Kevin Zhang and Tim Kang

meal, incorporated into feeds for the larvae of amberjack *Seriola dumelili*. Trials at Kindai University, Japan showed better feed efficiency and improvements in growth.

In aquaculture, there was considerable interest in algae, as feed additive/ingredient and for their biological properties. At the **Olmix** booth, Maarten Jay van Schoonhoven, Aqua Care Manager, was marketing Searup and DigestSea, natural algae solutions to improve performance of fish larvae and shrimp post larvae. Searup is recommended during stressful conditions such as handling in the hatchery or for sudden changes in environmental conditions. DigestSea is recommended to improve overall digestive health. The company also showed how Searup improved survival rates of post larvae after an EMS/AHPND challenge two weeks after the last application. Both products can be used together for animal welfare and performance (www.olmix.com).

US based **Wenger Manufacturing** which offers a range of premium single-screw extruders, twin-screw extruders, dryers/coolers and control systems, was present with a large team, from Asia and US. "This is a growing and hectic show. We have invited our Asian customers to come and meet us. However, we have seen customers from Europe as well. We are now seeing increased interest into production of small aqua feeds and feed millers moving from pelleting to long lasting extruders," said Ramesh G., Wenger, India. Joe Kearns, Wenger, US added, " Aquaculture is really doing well with the focus on volume. Like the poultry industry, interest is in larger machines with increased outputs. There are new demands from the industry such as extruding and rendering when producing a feed in one go so that nothing is wasted." (www.wenger.com).

SPC for aqua feeds

Selecta is a South American company (Chile-Brazil), with over 30 years of experience in agribusiness, committed to manufacture products from soybeans for several segments.

Its mission is to provide high value-added soybean products destined to animal nutrition, food, chemical and pharmaceutical industries worldwide. Focused on respecting international quality standards.

The commercial team was present at VIV ASIA 2017. This was part of the effort to increase sales in Southeast Asia, especially for the shrimp, fish and swine animal nutrition industry. At their booth, the team advised clients on the products X-SOY ™ - Selecta's Soy protein concentrate, for the aqua feed industry and young animals. Besides SPC, Selecta also produces soybean oil, lecithin, hulls and soy molasses. Through innovative projects, Selecta is known as one of the main manufacturers of sustainable vegetable proteins for the animal feed industry in Brazil and abroad.

Due to these main characteristics, SPC is well known as the best vegetable protein to replace fishmeal in aquaculture diets. SPC is also being widely used for young animals feed (such as piglet and starter chicken), as well for pet food, among other applications. Selecta's SPC is recognized as one of the highest quality soy protein concentrate available in the market. SPC is obtained by removing the antinutritional factors of soybeans, thus increasing protein content to over 60% and increasing protein digestibility to above 90% levels. (www.selecta.com.br).

Soraphat Panakorn, Novozymes Biologicals, Asia Pacific (left) and shrimp farmer, Man from Sanguansin Farm in Chantaburi, Thailand

Selecta at VIV Asia, from left, Guilherme Tancredi, COO and Wagner Camargo, Commercial Manager

Supplying shrimp and giant prawn farmers

Based in Bangkok, **Marine Leader** Co. Ltd is Thailand's leading supplier of products for shrimp and prawn farming as well as the ornamental. This is the second time that the company exhibited at VIV Asia. Marine Leader markets various feeds, supplements and probiotics for the shrimp and giant prawn farmers. There is the Red Dragon™ broodstock feed, which is a nutritionally complete diet for better reproductive performance of broodstock, both for marine shrimp and giant prawn. It is a soft pellet containing DHA algae (*Schizochytrium*) and krill meal. In addition, there are live polychaete and various frozen feeds for marine shrimp broodstock such as frozen squid, and krill as well as *Artemia* enriched with high omega 3 fatty acids.

Aside from marketing supplies for the shrimp farmers, Satit Phanich who set up Marine Leader in 2000 said that he is very concerned with developments in the shrimp farming industry, especially with the constant threat of disease outbreaks. The company has the Q-test, a real-time strip test for the detection of the white spot syndrome virus, which is affordable and easy to use at the pond site. Moreover, innovative methods to detect toxins of early mortality syndrome (EMS) are in development. (www.marineleader.co.th)

Following VIV Asia, Chatirot Intaraksa, Sales and Technical Support supported the Giant Prawn 2017 conference, at the AIT campus (see pages 4-6). Marine Leader has various products for giant prawn hatcheries. It supplies male and female broodstock and healthy post larvae (PL 22-25). The gravid female weighing 40-45g may spawn within 7-10 days. The company also has larval feeds, supplements and probiotics. With the Red Dragon™ maturation feed, the recommendation is to add astaxanthin, omega 3 fatty acid from krill oil or astaxanthin from *Paracoccus carotinifaciens* for better results. Marine Leader has a dedicated website for products specific for the giant prawn -www.giantriverprawn.com

Satit (third right) with Marine Leader staff (Khwanjira, left, Savaram Durgaprasad, Chatirot and Pornphaka, left) second right is a visitor, Pairat Thitisak.

Nutritional way to challenge disease in aquaculture

Dr Lin (middle) with the DaBomb Protein Corp team at their booth. CEO Alice Liu is second left and Jeffery Jiang, product manager, is on the right.

Intensive farming tends to bring better cost-efficiency to farmers but it is often accompanied by the occurrence of environmental pollution and disease. The latter restricts the global expansion of farming and productivity. However in the past, the use of immunostimulants and specific vaccines can effectively resist the specific pathogens. But price is a major reason for their limited use.

In contrast, antibiotic growth promoters (AGPs) are very commonly used in the aquaculture industry with positive effects on immunity and growth. Nevertheless, the adverse effects of the rampant use of antibiotics on the environment, on the animals and on food safety are growing concerns.

At VIV Asia, Taiwan's DaBomb Protein Corporation invited Dr Lin Yu-Hung from the Department of Aquaculture, National Pingtung University of Science and Technology, to speak at its seminar on "Multiple functions of *Lactobacillus* spp fermented soybean meal in aqua feeds". Lin's discussion was on nutritional strategies for antibiotics-free aquaculture.

Lin's presentation covered the essential and non-essential nutrients and intestinal health. He described strategies developed with essential and non-essential nutrients to achieve optimal immune and growth status and to improve intestinal health.

Essential nutrients

Nutritional requirements can be quantified by the growth and health status of fish and shrimp, such as amino acids, fats and mineral. When the docosahexaenoic acid: eicosapentaenoic acid (DHA: EPA) and n-3 : n-6 ratios were >1 (Wu et al., 2003) or 1-2 (Lin and Shiau, 2003), it could effectively improve fish health. "Besides vitamin E and C, similar levels of nutrients are optimal for growth and health," said Lin.

Studies have shown different optimal dietary levels of vitamin E and C for growth and immunity. For example, Ortuno et al. (2000) showed optimal growth and immunity in gilthead bream fed diets with 60 and 2000 mg/kg vitamin E, respectively. Sato et al (1982) showed that in the rainbow trout, it is a diet with 20 and 500 mg/kg vitamin C for optimal growth and immunity (Navarre and Halver, 1989), respectively.

Non-essential nutrients

Some nutrients are not necessary for growth, but they have some immune-promoting or gut health improvement functions for animal such as nucleotides, algal extracts, plant products and probiotics. In recent years, the importance of non-essential nutrients has gradually been taken into account, when shrimp and fish are fed low fish meal diets. Lin said that the nucleotides can improve the immune response of shrimp and fish. In addition, algal extracts and plant products, such as herbal extracts, essential oils and agricultural wastes (banana peel), can stimulate the immune response of shrimp and fish.

According to Lin, probiotics are still an attractive additive in aquafeeds, including lactic bacteria, *Bacillus* spp. and yeasts, which can reportedly improve the animal's utilisation of nutrient and immune response, reduce environmental nitrogen waste and inhibit pathogens.

Intestinal health

It is well known that plant meals such as soybean meal used to replace fish meal causes some damage to the intestinal villi as well as morphological changes and inflammation. "In general, we know that the tilapia can tolerate lower crude protein diets but in the case of the shrimp, which has a short gastrointestinal tract, anti-nutritional factors (ANFs) can damage the hepatopancreas leading to diseases," said Lin.

"A nutritional strategy can reduce the risk caused by soybean meal in feeds. Nucleotides, some amino acids, probiotics as well as 1% butyrate or lactate (organic acids) can be used to repair damage of intestinal villi."

Some of the studies supported by DaBomb Protein Corporation of Taiwan showed that bio-hydrolysed soya by *Lactobacillus* spp. have less anti-nutritional factors and lower protein molecular weight, but more metabolites than untreated soybean meal (Cheng and Lin, 2016). Another study showed how such a bio-hydrolysed soya can enhance non-specific immune response, oxidant capability (Lin and Mui, 2017) and repair intestinal villi. The conclusion was that nutritional strategies enhance the utilisation of nutrient and health for animals. At the same time, it will reduce environmental pollution to achieve sustainable aquaculture.

Bio-hydrolysed soya product

DaBomb Protein Corporation has a premium soymeal product, rich in metabolites and is produced via bio-hydrolysation with *Lactobacillus*. The characteristics of the ISO 22000 certified product include high protein digestibility, gut health improvement and enhanced immunity functions. "As global feed trends are divided into three functional areas: high digestibility, immunity and intestinal health, it was an appropriate step for us to be marketing the product to aqua feed millers at VIV Asia. Environment friendly, biosecurity and animal welfare, are our core values from feed to food." said Alice Liu, CEO.

More information: www.dabombprotein.com; Dr Yu-Hung, Lin, NPUST (yuhunglin@mail.npust.edu.tw); Jeffery Jiang, DaBomp protein group (Market@dabombprotein.com); Steven Huang, DaBomb protein group (zicho0414@dabombprotein.com).

Asian launch of the probiotic portfolio

Peter Freisler (right) with Dr Alexandros Samartzis, Senior Technical Service Manager – Aquaculture, Nutrition & Care, Animal Nutrition, Evonik (SEA) Pte Ltd, Singapore

During VIV Asia 2017, Evonik launched the probiotic Ecobiol®, designed for use in aquaculture and poultry production. The product was acquired by Evonik from the Spanish company NOREL S.A. in 2016. Ecobiol® contains a fast growing strain of the bacteria *Bacillus amyloliquefaciens* CECT 5940 with scientifically proven benefits.

Ecobiol® helps to maintain a balanced intestinal microbiota in aquatic animals. It has the ability to modulate the microbial population combined with the inherent capacity to produce large amounts of enzymes in the gut, enhancing digestion and lowering waste excretion. "Ecobiol® is new in our portfolio. We are convinced of the product's high potential and its applicability in various fields by virtue of unique properties", said Dr Emmanuel Auer, Head of the Animal Nutrition business line at Evonik.

"The product Ecobiol® shows very positive results in both poultry and aquaculture, for instance under various stress conditions. This has been demonstrated in scientific studies as well as in commercial use. For our customers in South East Asia this is of focal interest, particularly in shrimp farming", says Peter Freisler, Head of Gut Health Solutions.

In trials with *Litopenaeus vannamei*, Ecobiol was able to inhibit the *Vibrio parahaemolyticus* pathogen (EMS/AHPND) and modulate the immune system of the shrimp. The probiotic showed a capacity to increase protease activity in the gut, thus enhancing protein digestibility and reducing nitrogen excretion. In trials with the red tilapia *Oreochromis sp*, the probiotic gave a reduction in organic matter and suspended solids. The recommended dosage is 1 kg/tonne of feed for Ecobiol® (concentration of $1x10^9$ CFU/g) or 100g/tonne of feed for Ecobiol® Plus (concentration of $1x10^{10}$ CFU/g). More information: www.evonik.com/animal-nutrition

Balanced Immunity in fish and shrimp

Diamond V's unique fermentation metabolites product is used successfully in shrimp and fish diets and this was the focus of the Managing Director for Asia JC Filippi and the DV Aqua team at VIV Asia in March 2017.

"Many companies are usually not aware of the differences between our fermentation metabolites product and other yeast products. DVAQUA is a unique product obtained through fermentation of a specific yeast strain in anaerobic conditions. The finished product is fully deactivated, stable and contains various nutritional metabolites including proteins, peptides, antioxidants, polyphenols, organic acids and nucleotides, as well as mannans and beta-glucans. Research has proven that the combination of the functional metabolites in DVAQUA strengthens the immune system over a long period of time" said JC Filippi.

Over the last 10 years, Diamond V has conducted various studies in shrimp demonstrating that there is protection throughout the 3-month grow-out cycle of the shrimp. Due to the long-term immune strengthening effect, we see a 24 % increase in survival. A small difference of 5 % higher survival in an aquaculture operation can make a difference between profit and loss. Challenge tests, even after using the product continuously for 2 months, showed significantly improved survival rates. So far, we could see significantly improved survival in challenge tests with white spot virus syndrome, *Vibrio harveyi* and *Vibrio* sp. in shrimp and in challenge tests with *Vibrio*, *Streptococcus agalactiae* and *Edwardsiella tarda* in tilapia, flounder and catfish.

The team also explained that recent studies showed that

The Diamond V team, from left, Visiel Tolentino (Strategic Marketing Director, Asia), JC Filippi, Mike Goble (COO) and Don McIntyre (Global Technical Director)

DVAQUA reduces the various pathogens (*Vibrio, Pseudomonas, E.coli* 020) in the environment and in the intestine of fish while at the same time promoting beneficial bacteria.

US based Diamond V has a long history in Asia, selling its products in Japan and South Korea for more than 30 years. Its Asian office is located in Bangkok, marketing products in the region for all species, focusing on swine, poultry and aquaculture, through a well-established network of distribution partners. DVAQUA optimizes digestive health and immunity, which promotes health and disease resistance, survival and yields leading to production efficiency. More information: www.diamondv.com/email: dvasia@diamondv.com

Platform to share insights on feed additives

VIV Asia was an excellent platform for multinational feed additives producer NUTRIAD to share insights on how feed additives can help the reduction of non-therapeutic use of antibiotics. Nutriad attended industry experts from across the world at its booth and participated in several conferences and seminars during the week.

Borutova, Business Development Manager at Nutriad, presented "Mycotoxins: A gateway to infectious diseases". She said that consumption of some mycotoxins, at levels that do not cause overt clinical mycotoxicosis, suppresses immune functions and may decrease resistance to infectious disease." Asia Pacific countries are still importing most of their raw feed ingredients, and since the mycotoxin situation in Europe and USA seem to be quite serious, APAC poultry, swine, ruminants and aquaculture producers are exposed to an increased mycotoxin risk in 2017".

On the last day of VIV Asia, Dr Tim Goossens, Business Development Manager at Nutriad, presented on challenges that producers of gut health promoting additives are facing. "By now, it is clear that many active ingredients can be linked to gut health. But to develop a product that is just as robust as AGPs, their potential needs to be maximized". Goossens talked about butyrate as an example. "Butyrate has the potential to trigger several physiological responses that are beneficial for gut health and performance. That potential will only be met, if you invest in a coating that is able to deliver butyrate throughout the entire digestive tract, like Nutriad does with ADIMIX®Precision".

Erik Visser at the Nutriad booth

Erik Visser, CEO Nutriad, concluded, "Pressure from government regulations and consumers will shape the demands on livestock and aquaculture producers in Asia as far as antibiotics usage is concerned, just as we are seeing and have seen in other parts of the world. With a proven track record of additive solutions across the world, Nutriad is well positioned to work alongside producers to define answers for today's and tomorrow's challenges. Feedback from industry at the recent VIV once more showed how our collaborative approach to the market is appreciated and valued."

Launch of website in Vietnamese

Nutriad has added a Vietnamese version of their comprehensive website. The addition of Vietnamese brings the total of languages supported by the Nutriad website to seven. The multilingual website opens up the comprehensive world of Nutriad to an even wider international audience.

Visser commented on the launch of the Vietnamese website: "We have invested in our online presence, allowing us to communicate more directly with our customers in Vietnam. Vietnam is a very important market for Nutriad, both in livestock and aquaculture. We have a strong ambition to grow our presence in this market even further. Allowing our customers to find information about Nutriad and the products in their own language confirms that commitment." More information:www.nutriad.com

Inauguration of new aqua feed line in Vietnam

Cargill in Vietnam marked a milestone with the opening of its 10th aqua feed line at its feed mill in Ha Nam in late April. This is Cargill's second aquaculture feed line in the North of Vietnam. With a production capacity of 3,000 tonnes/month, this modern line focuses on high quality extruded feed for tilapia and other local species to serve the local demand for floating fish feeds.

With its strategic location in Ha Nam province, the new aquaculture feed line will improve access to customers in the major agricultural areas of Ha Nam, Hanoi, Thai Binh and the broader North Central Vietnam region where farmers are rapidly switching from extensive to intensive farming practices. It will help reduce delivery time to customers and enable fish farmers to grow healthy seafood, increase their output, and lower their production costs per kilogram while reducing their impact on the environment.

"Vietnam is a critical aquaculture market for Cargill, and we are excited to be expanding our aquaculture feed capability to our 6th plant location to continue our growth in Vietnam and in Asia South," said Chad Gauger, Managing Director, Cargill Aquaculture Nutrition Asia South. "Cargill's global innovation and expertise combined with our strong plant operations in Vietnam and commercial teams will bring exciting new technologies to the Vietnamese farmer to help them thrive."

Cargill's first aqua feed facility in Vietnam was inaugurated in Bien Hoa in 1998. Upon the acquisition of EWOS in 2015, its manufacturing facilities in Vietnam were integrated into Cargill's plant network in the country. In February 1995, Cargill established its presence in Vietnam with the opening of representative offices in Hanoi and Ho Chi Minh City. More information: www.cargill.com.vn

Series D funding for production of sustainable protein

US based Calysta, Inc. announced a USD 40 million in Series D funding, in a financing round led by Mitsui & Co. Ltd., Tokyo, Japan. Also participating were Temasek, a Singapore-based investment company and current investors Cargill, the Municipal Employee Retirement System (MERS) of Michigan, Walden Riverwood Ventures, Aqua-Spark and Pangaea Ventures. Calysta intends to use a majority of the proceeds of the Series D investment to advance commercial scale manufacturing of Calysta's FeedKind® protein, a family of sustainable, traceable nutritional ingredients for fish, livestock and petfood.

Tom Baruch, Executive Chairman of the Board, said, "Calysta's FeedKind protein, expected to enter commercial production in 2019, can help address the world's growing demand for new sustainable sources of protein and greater food security. We look forward to working with Mitsui as a strategic partner in marketing and distribution of FeedKind® in important new markets (Asia) and in the expansion of production," added Baruch. "We also welcome the opportunity to establish a significant collaboration in Singapore with Temasek, a leader in supporting innovative technology development."

In November 2016, Calysta and Cargill, along with several third-party investors, announced plans to invest in the creation of the world's largest gas fermentation facility in Memphis, TN, to produce FeedKind protein. Calysta also operates a Market Introduction Facility in the United Kingdom supplying sample quantities of the protein for customers.

Break ground of Memphis feed production facility

NouriTech breaks ground with representatives from Calysta, Cargill, NouriTech and Tennessee and Memphis area officials

In April, Calysta, Cargill officially break ground on NouriTech, a 15 ha Memphis feed production facility. The plant will be home to the world's largest gas fermentation operation that will produce Calysta's FeedKind® protein, a sustainable feed ingredient for fish, livestock and pets, using its proprietary technology. "Today's groundbreaking is an important milestone for this project and our Cargill Memphis campus as it demonstrates our ongoing commitment to Tennessee, Shelby County and Memphis and has expanded our pledge to aquaculture as an increasingly important source of food," said Cargill Managing Director Mike Wagner.

"FeedKind protein is a new sustainable feed ingredient that is critical to helping meet sharply rising global demand for food," said Dr Alan Shaw, Calysta President and CEO. "We are delighted to partner with Cargill and the Memphis community to launch construction at NouriTech of our first commercial scale manufacturing plant. This is the next step in bringing this important product to markets throughout the world."

The first phase of construction is expected to be completed in 2018, with the plant online in 2019, and the second phase of construction completed in 2020. Upon completion, it will feature mainly • A one-story administration building • 20 fermenters where two fermenters are expected to be installed in the first phase of construction and up to an additional 18 in the second phase. • Several dryers, where one dryer will be built and used for the first phase of construction and the remaining dryers will be built in phase two.

NouriTech™, Memphis, Tenn., is a venture formed in 2016 through investments from Cargill, Calysta and several third party institutions. The facility is expected to initially produce up to 20,000 tonnes/year of FeedKind® protein and expand to up to 200,000 tonnes/year at full capacity. More information: www.calysta.com

New feed factory in Australia

During the last few years, the BioMar Group has delivered an increasing volume of feed to the Australian market from factories in Chile and Scotland. Now the company is ready to establish a green field feed factory in Australia with an annual capacity of 110,000 tonnes. The market is evaluated to have a high potential for growth within a broad range of species. The aim is to be able to serve the customers, being locally agile with a solid foundation of global product development and technical experience within species such as salmon, trout and yellowtail kingfish.

"In 2016 we opened a factory in Turkey and this year we will be ready with our second factory in China as well as with expanded capacity in Norway. In 2019, we aim to open a feed factory in Australia supported by our established factories, technical experts and global R&D department. We are as a group dedicated to fulfil the growth ambitions in our strategy being an independent premium feed supplier with a high degree of global cooperation", said Carlos Diaz CEO, BioMar Group.

Carlos Diaz

Through the presence in the market, BioMar Group has obtained a hands-on understanding of the local farming conditions and challenges. It is the expectation that being locally present with commercial staff, technical expertise and production facilities will lead to an even more competitive advantage in the market. The ambition is to support the customers by developing high performance products tailored to local farming conditions with a strong profile with regards to sustainability, feed safety and food quality.

"I am confident that our approach of balancing local agility and global excellence will give us a solid position in Australasia. We have already established very successful cooperation with key customers and we are looking forward to working with a broader base of customers developing the aquaculture industry in Australia and New Zealand. The world around us is changing and there is an increasing need for combining sustainability and efficiency. We clearly see that end-consumers are changing buying patterns towards high quality products with a responsible profile. We firmly believe that working closely together with the value chain can prepare the industry to take a lead in the global food sustainability agenda", added Diaz. More information: www.biomar.com

Joint venture for omega-3 fatty acids from natural marine algae

In March, Royal DSM and Evonik announced their intention to establish a joint venture for omega-3 fatty acid products from natural marine algae for animal nutrition. This breakthrough innovation will, for the first time, enable the production of omega-3 fatty acids for animal nutrition without using fish oil from wild caught fish, a finite resource. Evonik and DSM's alternative omega-3 source is the first to offer both EPA and DHA and will be aimed at initial applications in salmon aquaculture and pet food. The companies will together build a commercial-scale production facility in the US.

DSM Nutritional Products and Evonik Nutrition & Care will each hold a 50% share in the joint venture and co-own the production facility, which will be built at an existing site of Evonik and is expected to come on stream in 2019. The joint venture plans to invest around USD 200 million in the facility (USD 100 million by each party over circa 2 years). The initial annual production capacity will meet roughly 15% of the total current annual demand for EPA and DHA by the salmon aquaculture industry. The set-up of the joint venture, to be named Veramaris and headquartered in The Netherlands, will be finalized subject to regulatory approvals and other customary closing conditions.

The joint venture follows the joint development agreement, signed in July 2015 where Evonik and DSM have jointly worked on the development of products and the manufacturing process and explored opportunities for commercialization. Both companies achieved positive results in the development of the product while extensively working with the entire value chain, including fish feed producers, fish farmers and retailers. DSM and Evonik have successfully produced pilot-scale quantities of the algal oil at DSM's production facility in Kingstree, South Carolina (United States). Customers will be able to receive sizeable quantities of the product for market development while the construction of the new manufacturing plant is underway.

The successful product and process development was only possible thanks to the complementary competencies that Evonik and DSM bring to the collaboration: DSM has expertise in the cultivation of marine organisms including algae and long-established biotechnology capabilities in development and operations, whilst Evonik's focus has been on developing industrial biotechnology processes and operating competitively large-scale manufacturing sites for fermentative amino acids.

Innovation breakthrough for aquaculture, pet food and beyond

The algal oil from DSM and Evonik means that the vision of salmon farming without using fish-based resources is – for the first time – becoming realistic. By replacing fish oil in salmon feed with this EPA and DHA rich alternative, the fish-in-fish-out ratio could be reduced significantly. This alternative will enable the aquaculture industry to continue to grow sustainably. Currently, the industry uses about 75% of the annual production of fish oil. DSM and Evonik are also pursuing applications of their algal oil for other aquatic and terrestrial animal species. More information: www.dsm.com/www.evonik.com

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Danish aqua feed producer enters the African market

Visualisation of the finished factory in Zambia - © Aller Aqua Group A/S

Denmark's Aller Aqua is entering the African market from several strategic positions. Aller Aqua Zambia's new factory, with a production capacity of 50,000 tonnes of fish feed/year is under construction in Siavonga. It will be the most technically advanced fish feed factory in Southern Africa.

Aller Aqua Zambia has made the first sales agreement with one of the largest tilapia producers in the World-Yalelo Limited. Yalelo has plans to grow its production of tilapia to 30,000 tonnes in Zambia within the next few years. This rapid expansion will help secure Aller Aqua Zambia's success in the African country.

"The Aller Aqua Group is in rapid expansion. Since the company began producing fish feed for aquaculture more than 50 years ago it has achieved constant growth. In addition to the factory in Denmark, the company has built factories in Poland in 2001, Germany in 2007 and Egypt in 2015. Currently, the company is building in both Zambia and China, and has just extended the capacity in Egypt with a third production line. This has increased the capacity in Egypt substantially. Both of the new factories are expected to be inaugurated in 2017. In Zambia we are investing a total of USD 10 million, as well as a significant amount in Egypt," said Henrik Halken, Group Vice President, Aller Aqua.

"With the investment in Zambia, we will be the market leaders in Africa in terms of modern and environmentally friendly fish feeds for aquaculture. This will enable us to expand our sales not only in Zambia but also to the surrounding countries. The African market will, without a doubt, grow significantly in the coming years. Its population is rising and will require high protein foods. Fish farming for a local fish supply is part of the solution. Fish farming can further help people obtain a livelihood and get out of poverty. In Zambia approximately 95% of the raw materials we will use comes from the local market, which is a great advantage.

"The construction of the factory in Zambia is on schedule. Obviously, there are many challenges when building in Zambia compared to Denmark. But we have a fantastic management team to ensure that we succeed and overcome these challenges," added Halken.

With the increased activity in the African countries, in January 2016 Aller Aqua has appointed Niels Lundgaard as Commercial Director of Africa. Lundgaard will focus entirely on expanding the business in the Sub-Saharan countries. He has helped Aller Aqua Group start sales companies in both Nigeria, Ghana and Kenya in recent times.

"With the subsidiaries in Nigeria, Ghana and Kenya we have strong bases for the rest of the region. Recently a distributor agreement was signed in Rwanda, and there are Aller Aqua agents in both Benin, Tanzania, Cameroon and Senegal. In countries such as Uganda and Madagascar, Aller Aqua sells feed directly from its German factory. This gives us a wide reach in the area. We have highly skilled teams in place. We enter the markets with our usual approach; we want to grow with the customers and help them increase the output of their fish farms. We do this by providing extruded fish feed, advice and training. Furthermore, we hold seminars and participate in local events and exhibitions," said Lundgaard.

As a result of Aller Aqua's growth in the markets in Sub-Sahara, the company will participate in World Aquaculture 2017 as Gold Sponsor.

"We have a solid set-up in Europe. Here in Sub-Saharan Africa, we see that we have a big impact now. The rising incomes and developing economies in countries like Nigeria, Kenya and Ghana support this potential, and has had the effect that we have opened subsidiaries in all three countries. This, combined with our operations in Egypt and Zambia, made it an obvious choice to support the World Aquaculture 2017 event, which takes place for the first time in Africa", said Hans Erik Bylling, CEO and owner of Aller Aqua.

Aller Aqua will be present at booths 1+2. The company hopes to meet current and potential customers, collaboration partners and suppliers at their booths at the Cape Town International Convention Centre from June 26-29, 2017.
More information: www.aller-aqua.com; email: info@aller-aqua.com

Group R&D Director Dr Hanno Slawski, a customer, Commercial Director of Africa Niels Lundgaard and Country Manager for Nigeria, Lasisi Nurudeen talk aquaculture - © Aller Aqua Group A/S

The Zambian factory under construction, May 2017 - © Aller Aqua Group A/S

Launch of FVG Select 2017 and FVG Asia 2018

In March, Victam International B.V. in South East Asia held a press conference to introduce innovations at Victam International. It was led by Erik Heemskerk, the new General Manager, Victam International BV and his team. The event was attended by Pornsil Patcharintanakul, President Thai Feed Milling Association, a supporter of the biannual event in Bangkok, Thailand.

FVG Select 2017

In his introduction, Heemskerk said, "Feed requires technology and is only one part of the food chain. Moving with the times, there is FVG Select. This not just a new concept, but an opportunity to bring together the suppliers to the feed, grain and biomass industry sectors with the senior executives within these industries. The aim is to become the world leading networking event for the global feed industry once every 4 years.

"This is a focused event with a small select expo (55 exhibitors), hospitality suites and 1,000 delegates or visitors. There will be matchmaking program and a news room. This is not just an exhibition but to share ideas," added Heemskerk. The first FVG Select 2017 will be held from June 13 -14, 2017 in Cologne, Germany and will include matchmaking through Jublia Match. FVG Select 2017 will have six technical conferences and for the aquafeed industry, Aquafeed Horizons. The news room will have facilities for the media to conduct interviews with speakers and exhibitors.

New website

A sneak preview of the website was given by Catelijne de Gooijer, Marketing Communications Manager. This is a modern and easy to navigate website. There will be information on program and speakers. "We have recently added 'the find your route feature' which helps visitors to find their way around the event hall using their smart phone without having to download an app. Visitors can easily search for a stand and see the shortest route from their computer, mobile or tablet. Visitors can also plan their day at the event by easily searching for exhibitors using the filters and adding to their plans. They can also save the plan to come back to this later or share with a friend."

Alltech Feed Survey

Guest speaker, Steve Elliot, Global Minerals Director, Alltech gave an overview on the findings of the Alltech 2017 feed survey conducted annually. "We are fortunately that we work well with industry and have been able to get the information. Year by year, we are getting better at doing this." Elliot showed that feed production increased 1.6% to reach just over 1 billion tonnes in 2016. Asia Pacific dominated production and led by China which grew by 5%. Growth of aqua feed production was lower due to disease challenges.

FIAAP/VICTAM/GRAPAS 2016

This was an astounding success. Over the last twenty years each show has grown significantly. It was the largest event in Asia so far. As in 2014 the 2016 show was completely sold out. There were 223 exhibitors and they came from 28 different countries; the net exhibition floor area was 11% larger than the 2014 show. There were more exhibiting companies than in 2014. More than 55% of visitors expressed interest in feed technology, 47.6% in production technology and 30.2% in aqua feed ingredients and technology.

Erik Heemskerk, third from right with his team after signing agreement with Expolink Global Network. From right, Patricia Heimgartner, Event Manager; Catelijnede Gooijer, and Bep Spruijt, Finance & Administration Manager (left).

Since 2014, Victam Foundation sponsored and the Thai Feed Mill Manufacturers Association hosted the ASEAN Feed Summit. During the second summit in 2016, which was a closed session, Pornsil Patchrintanakul, President of the Thai Feed Mill Manufacturers Association was the chair. The next ASEAN Feed & Rice Symposia will be held during FVG Asia 2018 from March 27–29, 2018.

FVG Asia 2018

"Victam International has to be part of a changing feed industry. We need to keep modernizing event organization," said Heemsker. He then announced the dates for the 2018 edition of the biannual feed industry trade show and conference. The exhibitions will have the same industry profiles – feed ingredients, feed production and rice & grain processing. However, the event will now be called FVG Asia 2018 which is an abbreviation of FIAAP/VICTAM/GRAPAS.

Heemsker said that at FVG Asia 2018 next March, visitors and exhibitors will find a lot of changes at the BITEC exhibition center as it has undergone major improvements. FIAAP profiles the ingredients and additives that are used within the formulation of safe and cost effective animal feeds. VICTAM is the premier event for technology required in the processing and manufacture for animal feeds. The show also covers the important and very necessary ancillary equipment and systems that are utilised in a feed mill, rice mill and flour mill. VICTAM is also the industry showpiece event for biomass pelleting technology. GRAPAS is for specialist systems and technology used within rice & flour mills, together with additional exhibits for grain storage, preservation and transportation.

FVG 2018 will be held from March27 – 29, 2018 at the Bangkok International Trade & Exhibition Centre or BITEC. Once again there will be a series of conferences to complement the three shows, these will be: • The FIAAP Conference 2018 • Petfood Forum Asia 2018 • Aquafeed Horizons Asia 2018 • Global Milling Conference with GRAPAS Asia 2018 • ASEAN Feed & Rice Symposia 2018. Exhibitors will also be given the opportunity to give technical seminars. Timings and topics will be subject to change.

More detailed information about the 2018 conferences will be available shortly on the website and in the Autumn/Fall edition of Showtime. More information: www.fvg-asia.com

THE AQUACULTURE ROUNDTABLESERIES® 2017
A shared vision for aquaculture in Asia
August 16-17 2017, Conrad Bali, Indonesia

Finfish Aquaculture: Strategies for Growth

Growth Strategies for Asia's Finfish Aquaculture

The **Aquaculture Roundtable Series (TARS) 2017** will address *Finfish Aquaculture: Strategies for Growth*. This is the second time this series of roundtables, initiated in 2011 is focusing on the finfish aquaculture industry. The meeting taking place in Bali, Indonesia from August 16-17 will explore the growth potential of Asia's finfish aquaculture industry, with a view towards developing a strategic approach towards market-driven production.

"Asia's finfish producers realise the need to be consumer-friendly fish providers, as the focus is on food safety. The industry must also address several challenges holding back its progress as a trusted and responsible fish supplier, including image and credibility issues," says Dr Zuridah Merican, editor of Aqua Culture Asia Pacific, and chairperson of TARS 2017.

TARS 2017 will start with the plenary session featuring state-of-the-industry and science presentations by invited local and international industry experts. It will be followed by a dialogue with three finfish farmers, group participation at breakout roundtable sessions and a final report session. The two-day meeting aims to promote positive image building and improve relationships and communication among the key players in the finfish sector, namely CEOs, technical managers, integrators, feed producers, farm, hatchery and technologists, investors, seafood marketers, as well as governments, NGOs, scientists and researchers, and other stakeholders.

REGISTRATION IS LIMITED TO 200 PARTICIPANTS.
Early bird registration ends on **June 19**. Walk-ins are not encouraged.
For more information and updates, go to www.tarsaquaculture.com • Email: conference@tarsaquaculture.com

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INTERACTIVE BREAKOUT ROUNDTABLE SESSIONS

"Strategies for Growth"

The plenary presentations sets the tone for the 3 interactive breakout roundtable sessions. Led by a group leader, participants will break into groups of 10 delegates/table to discuss issues and challenges impacting Asia's finfish aquaculture industry; identify opportunities; and recommend strategic approaches towards market-driven production. Leaders from each group will present a summary of the output at the Report Session.

Hard Talk with Finfish Farmers
A dialogue session with hard hitting questions on farming models, challenges and success to overcome diseases in farms.

Speaker highlights (at press time)

Session 1: State of Industry and Challenges

State of Industry on Finfish Farming in Asia

"We review health challenges, good quality juveniles, breeding, nutrition, sustainability, and responsible sourcing. I will illustrate how sustainability and reputation management have improved through organizing stakeholder and keystone players, as individual companies do not have the size and legitimacy to succeed..."
- ***Einar Wathne***, *Cargill Aqua Nutrition, Norway*

Growing Finfish in Indonesia

"The country's finfish farming industry is currently facing many challenges. On the other hand, there is a growing momentum to learn from the past, educate farmers and influence market demand..."
- ***Erwin Suwendi***, *PT Suri Tani Pemuka, Indonesia*

Session 2: New Realm of Asian White Fish

Lessons from the Mediterranean: Strategies with Competition

"The increase in the production of farmed fish induced a strong decrease of ex-farm prices that obliged the industry to rationalize the fixed costs. Certification is a strong asset to remain competitive..."
- ***Hervé Lucien-Brun***, *France*

Increasing Value Through Technology

"Tilapia, with its low cost and ease of production is viewed as a great source of protein. A holistic management plan for on-growing, will allow farmers to cost-efficiently produce fish that is recognized for its quality, and can be certified..."
- ***Oliver DeCamp***, *INVE Aquaculture, Thailand*

Session 3: Production, Health and Environment

Palatability Drivers in Fish Diets

"We can clearly show that different processes of production applied to the same raw material will yield different palatability performances..."
- ***Philippe Sourd***, *SPF-Diana Aquativ, France*

Parasite Prevention in Fish Farming

"The traditional approach to combat fish parasites is increasingly hampered... There are a number of strategies to control parasitic diseases, both established as well as innovative, based on particular traits of the different parasite types affecting different fish species..."
- ***Francisco E Montero***, *University of Valencia, Spain*

Session 4: Performance Feeds & Cost Efficiency

Nutrition, Feed Formulation and the Commercial Field Realities

"Important commercial field production issues such as diseases, environmental and technological limitations, and low profitability, create additional challenges that aquaculture feed producers cannot ignore..."
- ***Dominique Bureau***, *University of Guelph, Canada*

Early Weaning with High Performance Larval Feeds

"The important question is whether we need matching larval feeds for individual species, or if one diet fits all (or several) species..."
- ***Luís Conceição***, *SPAROS Lda, Portugal*

New Tendencies and Challenges in Aquafeed Formulation

"...plant ingredients may help to reduce the costs of feed production, but they expose producers to new challenges, higher inclusion rates, lower palatability, anti-nutritional factors and mycotoxins..."
- ***Michele Muccio***, *BIOMIN Holding GmbH, Austria*

Session 5: New Frontiers in Finfish Farming

A Future with Fishmeal-Free Diets

"... the availability of feed additives and novel ingredients have made the reduction or elimination of fish meal use in feeds for finfish a reality..."
- ***Anant S Bharadwaj***, *Integrated Aquaculture International, USA*

Benchmarking: The Salmon Model

"Present day high tech production focuses on intensive farming, sustainability, profitability and consumer perception. I will highlight subjects and technologies from the salmon industry of direct relevance and inspiration for warm water aquaculture..."
- ***Bent Pedersen***, *DSM Nutritional Products A/S, Denmark*

Critical Success Factors for Marine Fish Farming

"With this comes a permanent fight against existing and emerging pathogens. My mantra: follow the scientific way to try and transform doubts in approaching the comprehension of reality..."
- ***Alain Michel***, *France*

Refer to www.tarsaquaculture.com for full program details

24th Annual Practical Short Course on Aquaculture Feed Extrusion, Nutrition and Feed Management

August 20-25, 2017

This is a one-week practical short course on Aquaculture Feed Extrusion, Nutrition and Feed Management. It will be presented on August 20-25, 2017 at Texas A&M University by staff, industry representative and consultants. This program will cover information on designing new feed mills and selecting conveying, drying, grinding, conditioning and feed mixing equipment. Current practices for preparing full-fat soy meal processing; recycling fisheries by-products, raw animal products, and secondary resources; raw material, extrusion of floating, sinking, and high fat feeds; spraying and coating fats, digests and preservatives; use of encapsulated ingredients and preparation of premixes, nutritional requirements of warn water fish and shrimp, feed managements and least cost formulation will be reviewed. It will also include practical demonstration of sinking, floating, and high fat aqua feed, on four major types of extruders (dry, interrupted flights, single and twin screw), using various shaping dies. Other demonstrations include: vacuum coating and laboratory analysis of the raw material for extrusion.

Reservations are accepted on a first-come basis. For more information, programs and application forms, contact: Dr. Mian N. Riaz, 2476 TAMU; Food Protein R&D Center, Texas A&M University; College Station, TX 77843-2476. Email: mnriaz@tamu.edu; Web: http://foodprotein.tamu.edu/extrusion

2017

Details on the events below are available online at **http://www.aquaasiapac.com/news.php**
To have your event included in this section, email details to **zuridah@aquaasiapac.com**

May 31- June 4
5th International Trade Exhibition for the Seafood Industry in Asia
Bangkok, Thailand
Web: www.worldofseafood.com

June 1-4
Asia-Pacific Aquaculture Expo 2017
Fuzhou City, China
Web: www.apaexpo.com.cn

June 14
10th Aquafeed Horizons conference
Cologne, Germany
Web: feedconferences.com

June 26-30
World Aquaculture 2017
Cape Town, South Africa
Web: www.was.org

July 10-13
Practical Short Course on Extruded Pet Foods and Treats
Texas A&M University, USA
Email: mnriaz@tamu.edu
Web: www.foodprotein.tamu.edu/extrusion

July 24-27
Asia Pacific Aquaculture 2017
Kuala Lumpur, Malaysia
Web: www.was.org

August 2-4
Aqua Fisheries Cambodia 2017
Phnom Penh
Web: www.myanmar-aquafisheries.com

August 16-17
TARS 2017: Finfish Aquaculture
Bali, Indonesia
Email: conference@tarsaquaculture.com
Web: www.tarsaquaculture.com

August 20-25
24th Annual Practical Short Course on Aquaculture Feed Extrusion, Nutrition and Feed Management
Texas A&M, USA
Email: mnriaz@tamu.edu
Web: http://foodprotein.tamu.edu/extrusion

August 29-31
Vietfish 2017
Ho Chin Minh City, Vietnam
Email: namphuong@vasep.com.vn
Web: www.en.vietfish.com.vn

August 28-September 1
10th Symposium on Diseases in Asian Aquaculture
Bali, Indonesia
Web:www.fhs-afs.net/www.daa10.org

September 27-29
Aqua Fisheries Myanmar 2017
Yangon
Email: marketing.dept@veas.com.vn
Web: www.myanmar-aquafisheries.com

October 17-20
Aquaculture Europe 17
Dubrovnik, Croatia
Email: ae2017@aquaeas.eu
Web: www.aquaeas.eu

October 26-29
The 7 th International Conference of Aquaculture Indonesia 2017 (ICAI 2017)
Solo, Indonesia
Email: icai.mai.ias@gmail.com
Web: icai.aquaculture-mai.org

November 1-2
China Fisheries and Seafood Expo
Qingdao, China
Web: chinaseafoodexpo.com

November 9-11
Taiwan International Fisheries and Seafood Show 2017 (TIFSS)
Kaohsiung, Taiwan
Email: stenly_yonardi@myexhibition.com.tw
Web: www.taiwanfishery.com

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