Vol 6 Issue 4 2018

# Hatcheryfeed

*Advances in feeding early life stage and broodstock aquatic species*

## Improving the Supply of Tilapia fingerlings for Rural Farmer in Malawi

## COPEPODS AS LIVE FEED

What's all the fuss about?

## Growth and feed utilization in Cobia early juveniles is affected by water temperature and dietary methionine

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# NEWS REVIEW

HatcheryFeed
The aquatic hatchery resource from Aquafeed.com

## Highlights of recent news from Hatcheryfeed.com

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## Aquagen maps lumpfish genome

The entire DNA sequence encoding the genes (genome) of the lumpfish has now been mapped. This allows all the genes that contribute to traits such as growth, disease resistance and sea lice appetite to be studied with much greater precision than before.

Sequencing of the lumpfish genome can have benefits for both the industry and research institutions for various research purposes, said senior scientist at AquaGen, Tim Martin Knutsen. He has been working on the gene sequence in close collaboration with Tina Graceline and Matthew Kent from CIGENE (NMBU). The genome is open for free use and can be downloaded via the figshare publishing tool (DOI: 10.6084 / m9.figshare.7301546).

"An important milestone of great importance in the breeding program and egg production is that the genes for gender determination seem to have been found. This can help us look at gender differences in growth and lice grazing, something we know very little about today. We can also select female fish for early breeding, and reduce the use of male fish that do not contribute positively to breeding programs or egg production", said senior scientist at AquaGen, Maren Mommens.

The broodstock is to be raised at Namdal Rensefisk, which now, in collaboration with AquaGen, completes a state-of-the-art breeding plant for lumpfish of NOK 80 million in Flatanger, Norway.

AquaGen has also developed a search tool consisting of 70,000 gene markers used to detect differences in DNA encoding important traits. This marker set has a high resolution and is the first to be designed for lumpfish.

"Together with the genome sequence and information about where the different genes are placed in the genome, the marker set enables us to look for important genes with high precision", said Knutsen.

"During winter 2018 we will start a challenge test with the bacterial diseases atypical furunculosis and vibriosis, where we will investigate whether there are genetic differences between individual lumpfish in the resistance to these diseases. We have also studied lumpfish that are kept together with salmon in AquaGen's own seawater facilities. We are counting how many lice each of the lumpfish have eaten while taking a tissue sample for DNA analysis. In this way we can find out if lumpfish with high lice appetite have special genetic variants we can breed for", said Mommens.

Mapping of the lumpfish's genome is part of the research project "New species, new properties, new possibilities" which will run in the period 2017-2019. The project is funded by NMBU, Vaxxinova, AquaGen and the Research Council of Norway.

# Benchmark begins salmon egg production in Salten, Norway

Benchmark has begun production of salmon eggs at its new land based breeding facility in Salten, Norway.

The company said the Salten facility has been built to the highest standards of technology and biosecurity, and will be the most modern salmon egg production site in the world. The increased capacity will allow Benchmark to supply the global market with biosecure eggs year-round, a significant advantage for producers only possible with land based production.

The new facility, the culmination of a two year, £40m investment, will increase Benchmark's in-house capacity by 75% allowing the company to capitalize on its leading market position and the strong growth fundamentals of the industry. Benchmark currently outsources part of its production to meet growing demand for its products. The new facility will enable Benchmark to bring production in-house enhancing profitability.

Sales of fertilized eggs will commence in November 2018 and additional fish will be brought into the facility to ramp up volumes throughout 2019. As anticipated, initial sales will benefit the 2019 financial year, with full production capacity expected by 2021. Salten is located in Northern Norway where the salmon production base is growing fast. The new facility will allow Benchmark to serve this growing region as well as the rest of Norway and international markets.

The fundamentals for salmon farming continue to be very attractive. Global demand for salmon has grown by 6-7% p.a. in recent years and is expected to increase substantially over the next decade from countries including America and China where consumption per capita is low, but growing as a result of increasing health awareness and a growing middle class. This growth and a continuous effort to increase efficiency will continue to drive demand for robust genetics.

# First salmon ova to Atlantic Sapphire delivered from Iceland

Stofnfiskur hf, part of Benchmark Genetics has delivered the first batch of eggs ever to the state-of-the-art land-based facility Atlantic Sapphire in Miami, USA.

The batch of 400,000 eggs were shipped out of Reykjavik on 26th of November and landed safely in Miami the day after. Upon arrival at the site, the eggs were undergoing quality control before they were transferred to the hatching racks.

Johan Andreassen, chief executive of Altantic Sapphire said: “We are very pleased with the quality of the ova we received. These eggs are the starting point of our production in the Miami facility, and we are expecting to harvest the first batches in the fall of 2020.”

StofnFiskur’s production model has some similarities with the Atlantic Sapphire model, holding the broodstock in land-based systems throughout the entire life cycle, and using deep drilled well water, free of any contagious pathogens. The company’s closed compartment system has been approved by MAST in Iceland according to OIE standards, as the only salmon egg producer in Europe.

Andreassen said: “Biosecurity is very important to us, as we are running a full-scale land-based operation based on RAS technology. Knowing that the eggs from Iceland hold the highest biosecurity standards in the industry is an important measure of security to our BluehouseTM technology system.”

Jónas Jónasson, chief executive of StofnFiskur hf said: “We are very pleased to have been chosen as the supplier of the first batch of eggs to Atlantic Sapphire. Through the years, StofnFiskur has developed products specially adapted for land-based systems and we have significant experience in supplying ova across the world. Our breeding operations in Iceland provides eggs every month of the year in order to satisfy the demand by the new and fast developing global land-based salmon industry.”

# Benchmark successfully prosecutes patent infringement

Benchmark Holdings has successfully prosecuted patent infringement in Thailand. The IP&IT court in Thailand ruled that Marine-Tech International (MTI) infringed two of Benchmark's patents related to artemia and hatching enrichment, and the company must cease using the patented technology. The court also awarded damages to Benchmark, which may be subject to appeal.

Benchmark's portfolio includes 221 patents across its three main divisions of genetics, health and advanced nutrition.

"Benchmark robustly protects its intellectual property assets across the world and proactively monitors the market and our competitors for infringement," said Athene Blakeman, group legal counsel. "This intellectual property has been developed through many years of investment in cutting-edge R&D and, while Benchmark strongly supports open and fair competition, we will take all necessary action, including initiating legal procedures as in this case, where we identify unfair infringement of our intellectual property."

# NEW ON THE MARKET

## Dietary support product, EWOS DERMIC™ from EWOS Canada

By Andrew Lawrence, EWOS Canada Ltd., Cargill Aqua Nutrition

Fish husbandry in aquaculture involves activities that require the manual and mechanical handling of fish. During such activities there is inevitably a risk of physical damage, a subsequent loss of growth and condition, and potentially death. Of particular concern, is the significant risk that fish mucous is compromised, scale loss increases, and fish develop open sores and wounds on their flanks.

Unfortunately, that is only half the story. Beyond physical damage from husbandry activities, there are also disease and environmental challenges that result in similar issues, where skin and scale integrity is disrupted. Prime examples are external parasites, ulcerations, and environmental blooms that cause varying degrees of damage and subsequent losses.

Recognizing the challenges and cost impacts associated with such events, EWOS has introduced a new dietary support product, EWOS DERMIC™ to the industry. EWOS DERMIC™ is designed to improve animal health and welfare through skin and scale protection and repair, while increasing the productivity and profitability of our customers.

Through a unique combination of amino acids, an enhanced mineral profile, prebiotics, and vitamins to support skin mucous production and recovery, as well as skin and scale integrity, EWOS DERMIC™ minimizes the impact on performance during stress events, physical handling, treatments and disease.

EWOS DERMIC™ is a dietary support pack that can be added to any EWOS feed and has numerous applications in the Aquaculture industry. Perhaps of most significance to date is its use in combination with mechanical treatments to combat sea lice in the Atlantic salmon industry. “More handling and movement increases the risk of physical damage to the fish, and can result in mortality. For customers using EWOS DERMIC™, there is not only a reduced incidence of physical damage but also a reduction in the requirement to treat for sea lice”, said Gareth Butterfield, Sales Director for EWOS Canada Ltd.

Fig. 1. Atlantic salmon showing significant signs of recovery following severe winter ulcer (*Moritella* sp.) infection having fed EWOS DERMIC™ for a period of 8 weeks.

Gareth continued, "Winter sores in Atlantic salmon is another area we are seeing incredible recovery and repair through the use of EWOS DERMIC™. The incidence and severity of winter sores has increased in recent years across numerous operating regions, but the utilization of EWOS DERMIC™ has shown very promising results to date in wound healing and fish recovery. The most impressive aspect is that the recovery results we are seeing are being replicated across multiple growing regions, building our confidence in this product to provide the benefits in the field that we observed in the research and development phase."

However, the benefits of EWOS DERMIC™ do not end at Atlantic salmon, and EWOS Canada is in various stages of several trials in Pacific salmon species, tilapia, and seriola for various challenges, including:

- Vibriosis sp.
- Flexibacter columnaris
- Flavobacterium sp.
- Ectoparasites
- Enhancement marking; fin clipping

At EWOS Canada, we manufacture feed for 14 species of fish, so it is important we cater not only to the Atlantic salmon industry but also for enhancement aquaculture (Pacific salmon and freshwater species), emerging industries (seriola), and growing sectors (tilapia), among others. To have a product that will facilitate skin and scale support across such a vast array of species and environmental conditions is a huge asset for our customer base. After all, skin, scales and mucous are the first line of defense for disease challenge, osmoregulation and physiological control, so having a product to support all species, before, during and after manual and mechanical handling, disease and environmental challenges is an investment that deserves serious consideration.

EWOS DERMIC™ can be fed strategically to improve resistance and repair in anticipation of and following incidents where the skin and scales are challenged. It can be added to any diet or size, is available across the entire EWOS feed portfolio, and is appropriate for all species of fish.

**More information**

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References available on request.

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# XpertSea launches AI-powered Growth Platform for aquaculture


XpertSea, a Canadian aquaculture technology company, has launched the XpertSea Growth Platform. The platform automates data collection and provides insights so that shrimp farmers can make informed data-driven decisions and maximize farm profitability. The Platform allows farmers to collect animal data easily and often, discover and address problems early, optimize feeding regimes, predict growth, and choose the best time to harvest.

Unlike solutions that require manual data entry, the XpertSea Growth Platform builds on the capabilities of the XperCount, a portable "smart bucket" that uses optics, computer vision and machine learning to count, size, weigh and image aquatic organisms, at the press of a button. The Growth Platform leverages this data to provide actionable business insights, on a web-based dashboard that shrimp farmers can access from any device, anywhere.

The XpertSea Growth Platform tracks growth from Day One in the hatchery through nursery, grow-out and harvesting. Taking no more than a few minutes per day, the XperCount feeds automated organism data such as size and weight to the AI platform, which results in precise data about daily growth rate, feed conversion ratio, stocking density and survival rate, among others. Leveraging deep learning and AI, the Growth Platform predicts future organism size, their weight distribution and pond composition. The harvest optimization tool then calculates factors such as average weight, weekly growth rates, and current market prices so farmers can better plan harvest times. There is also a function to add the cost of staff and feed to get a complete profit forecast for the season. This results in a data-driven scientific approach to picking the best harvest date based on peak time to sell organisms to obtain maximum revenues, while respecting engagement with food processors and end clients.

"Most importantly, this program provides you and your technicians visibility into the weight distribution that will impact your harvest," said Sim Ing Jye, Senior Manager at Sea Horse, a fully integrated supplier to hatcheries, farms, processors

and international customers. “By understanding this variation earlier, you can focus on adjusting feed parameters to increase profits for each pond, and you will have the peace of mind that there will be fewer surprises at the time of harvest."

XpertSea has accumulated millions of data points on shrimp growth, provided voluntarily by farmers around the world. By benchmarking their growth against this anonymized, aggregated data, producers get a better understanding of what they can change to improve their performance.

”The XpertSea Growth Platform is a new concept in aquaculture that has the potential to unlock significant yields for farmers,” said Valerie Robitaille, CEO and Co-Founder of XpertSea. “It replaces manual data entry with smart aquaculture equipment, artificial intelligence, and industry benchmarks. Many farmers are still using their ‘best guess’ to decide when to harvest. With Growth Platform they can use reliable data and growth predictions to plan the best harvest date and maximize revenues. ”

The XpertSea Growth Platform is available for farms and hatcheries for both shrimp and fish. It’s also configured for health, feed and genetics companies that wish to gain insights on their product efficiency at the field level. The platform is currently deployed successfully in more than 250 sites in Ecuador, Mexico, the United Kingdom and Vietnam, among others.

## Skretting prepares to launch new RAS concept: RecircReady

Skretting is preparing to launch its new and improved integrated concept for recirculating aquaculture systems: RecircReady. The concept takes into account growth and waste prediction models, nutrient recycling, fish and system health monitoring in addition to tailored feed solutions and their impact on the systems themselves.

The technology incorporated into RAS allows for close supervision of waste and effluents, while tighter control over water quality and isolation from the external environment can help avoid biological risks. At the same time, RAS provides the opportunity to greatly enhance feed management and scope to facilitate consistent growth rates throughout the production cycle.

Developed by the Skretting Aquaculture Research Centre (ARC) through extensive trials at its research facilities in Norway and Italy, Skretting’s dedicated feeds incorporate specific patented functional ingredients that bind fecal matter. In RAS this means it is easier to filter and remove solid waste particles, resulting in cleaner water and a healthier system.

“Skretting continues to lead advancements in this space,” said Dr. Ingunn Stubhaug, Researcher at Skretting ARC.” Our primary aim is to help farmers produce more fish in a more cost-effective and sustainable manner.”

As recently reported, Skretting’s RAS capabilities are also now supported by a new state-of-the-art recirculation hall at Skretting ARC’s Lerang Research Station in Norway. Comprising 12 independent systems, predominantly conducting trials for salmon product development, this facility is used to investigate the impact of feeds and formulations on the biological filters in RAS.

# SCP product counters EMS in PL shrimp


The Center for Aquaculture Technologies in Canada (CATC) has demonstrated the potential benefit of ProTyton, a single-cell protein (SCP) from White Dog Labs, to shrimp farming. Initial studies demonstrated that inclusion of ProTyton into a CATC reference diet reduces mortality of whiteleg shrimp compared to a commercial diet when challenged by Vibrio *parahaemolyticus* (Vpa) – the aetiological agent of Acute Hepatopancreatic Necrosis Disease (AHPND), and commonly referred to as EMS.

"We are happy to announce these exciting preliminary results, which expand upon our previous studies with the CATC in Atlantic salmon and whiteleg shrimp," said WDL's CEO, Dr. Bryan Tracy.

"As reported earlier, ProTyton inclusion in Atlantic salmon feed has the potential to reduce the overall cost of diets while maintaining high amino acid digestibility values," said Dr. André Dumas, Director of Fish Nutrition at CATC. He added, "we then tested ProTyton in post larval shrimp diets. ProTyton inclusion (with a single replicate per treatment) doubled survival to over 80% and increased weight gain by 50% compared to the CATC diet." Dumas commented, "Given these encouraging results we recommended to perform an AHPND challenge."

The AHPND challenge was carried out by Dr. Mark Braceland, Director of Fish Health at CATC. Braceland said, "we acclimated shrimp to various diets over three weeks, then challenged with Vpa via per os (oral challenge), and then monitored survival over the course of a week." Tested diets included a commercial diet that was optimized for shrimp disease resistance, a CATC reference diet and four test diets with up to 20% inclusion of ProTyton in the CATC diet. Mortality rates were 33 and 55% for the commercial and the CATC diets respectively, while the ProTyton test diets performed equal or better than the commercial diet.

Braceland commented "It is exciting to observe in this preliminary work that ProTyton addition to the CATC diet results in equal or better performance than the commercial diet for mortality. Moreover, three of the four ProTyton diets performed better than the commercial diet, and in two cases reduced mortality to a third that of the commercial diet. Further work is now planned to reconfirm and scale up ProTyton analysis, particularly in a model that is similar to field outbreaks."

"We believe these health benefits are due to the anaerobic nature of ProTyton," explained Tracy. He added, "It is known that anaerobic SCP can also contain immunostimulating secondary metabolites and nucleotides. Moreover, our ProTyton SCP also contains low levels of butyrate, a short chain fatty acid commonly used as a terrestrial feed additive to support gut

health and reduce antibiotic use."

ProTyton is currently being produced using a 5000-gallon fermenter at WDL's Delaware pilot facility and is being evaluated by major aquafeed companies.

WDL has developed and scaled up ProTyton, which exhibits upwards of 85wt% crude protein and over 40wt% essential amino acids. The product is highly digestible, performs well in multiple aquaculture diets.

White Dog Labs (WDL) has signed a collaboration agreement with Midwest Renewable Energy (MRE) and will locate its first ProTyton plant within MRE's ethanol plant in Sutherland NE. The ProTyton plant will initially produce 3,000 metric tons/year of ProTyton with shipments expected in Q4 2019. The plant will expand to 30,000 tons/year as early as 2021.

"Having demonstrated ProTyton benefits, we are now responding to customer requests and accelerating our time to market via the collaboration with MRE." said WDL's CEO, Dr. Bryan Tracy.

## INVE Aquaculture launches Sanocare® FIT for shrimp hatcheries

INVE Aquaculture has launched its latest development: a plant-based water conditioner that protects shrimp larvae and post-larvae against stress and health threats.

The company said that (post-)larval quality and robustness lie at the core of successful shrimp hatcheries worldwide. With the support of Benchmark, INVE Aquaculture continuously strives towards development of effective products that tackle the daily challenges encountered in shrimp culture.

The new product, Sanocare® FIT, is a phytochemical mixture that has been engineered to enhance (post)-larval robustness during culture, and to suppress Vibrio levels during transportation of post-larvae from the hatchery to the nursery or farm.

As health booster during the hatchery cycle, Sanocare® FIT stimulates the production of heat shock proteins in *L.vannamei* post-larvae. These proteins act as a first line of defense mechanism and constitute one of the most important survival strategies of cold blooded animals when they are exposed to abiotic stress and pathogenic micro-organisms. Proof of increased robustness comes from extensive stress tests where considerable higher survival of *L. vannamei* post-larvae was observed when using Sanocare® FIT during the culture.

"The application of Sanocare® FIT during hatchery trials at Fitmar resulted in remarkably higher survival and growth at the end of the grow-out cycle.

This first experience convinced me to incorporate Sanocare® FIT in Fitmar's standard hatchery protocol," Fernando Marino Pinzón Miranda, Proveedora de Larvas, S.A. De C.V. Mexico said.

As a Vibrio suppressor during transportation, application of Sanocare® FIT in the transportation water notably controls the Vibrio load in the water and in L. vannamei post-larvae. The use of Sanocare® FIT during transport results in a 100-time lower *V. parahaemolyticus* count in shrimp post-larvae as compared to transport without Sanocare® FIT.

"The application of Sanocare® FIT during transport prevents Vibrio-induced stress in shrimp post-larvae and thus, gives them the best start upon stocking in the ponds for further growth", Eddy Naessens, Product Manager Shrimp Hatcheries explained.

"Sanocare® FIT can be used directly in the culture water during the hatchery cycle of shrimp, thereby increasing the robustness of the animals. Furthermore, Sanocare® FIT can be added directly to the transportation water to suppress the Vibrio levels during transfer of post-larvae from the hatchery to the nursery or farm. The availability of the product will be different per region, depending on the registrations. We currently have the product available in Mexico and Thailand", he said.

# Copepods as live feed, what is all the fuss about?

By Associate Professor Per M. Jepsen, Ph.D, Per M. Jepsen, Ph.D., Hans van Somere Gréve, Ph.D., Bolette Lykke Holm Nielsen, M.Sc. and Professor Benni Winding Hansen, Ph.D., Roskilde University, Denmark.

*The Roskilde University live feed research team has worked with copepods as live feed since the '90s. In this article they share their opinion on the present status and lack of a major breakthrough for copepods as live feed for marine aquaculture.*

For the last 40 years copepods have been lauded as the next game changer within live feed for marine fish larvae, substituting or even replacing rotifers and the brine shrimp *Artemia*. Today, rotifers and *Artemia* are still the predominant and preferred live feed in marine hatcheries, so what is all the fuss with copepods about?

Here, we give our opinion on the present status on the "copepod" research and industry, what has been achieved and what are the major bottlenecks for a successful launch of copepods as live feed.

In the ocean, copepods represent one of the largest biomasses, leaving them as one of the most numerous and abundant animals on our blue planet. Such a large biomass is not unnoticed by predators, and therefore numerous marine fish and almost all marine fish larvae have included copepods in their natural diets. Within aquaculture, copepods were established early on as a biochemically superior live feed with high content of both essential amino- and fatty acids, especially when compared to rotifers (*Brachionus* spp.) and *Artemia*. Copepods have the advantage that they do not need enrichment products to be nutritionally valuable, since copepods are fed live algae. As long as the algae contain the desired nutritional components, this will be reflected in the copepods' biochemical profile. Therefore, the majority of copepods simply are what they eat. However, this dependency on live algae cultures has actually been one of the major constrains of copepod cultivation, since this implies a marine hatchery has to culture both algae and copepods, which is a relatively complex process and requires high investment costs in equipment and human resources. Both rotifers and *Artemia* are easier to culture since they can be fed inert food or algae paste. The problem with feeding copepod with inert food is that it does not trigger a feeding response in the copepods, hence they starve. Recent research has showed that for a short period of time some copepod species can be sustained with algae paste, but the copepods will eventually die. This relates back to the fact that the "go to" algae pastes within aquaculture consist of the species *Tetraselmis* or *Isochrysis* that both lack an essential omega-3 fatty acid. A simple solution could be to create a paste from algae with a more ideal biochemical profile. The issue is that more biochemically rich algae, e.g. *Rhodomonas*, have a short shelf life once concentrated into a paste. One creative way our laboratory has tried to solve this problem is by microencapsulating individual cells from both *Rhodomonas* paste and live *Rhodomonas* in silica-like structures, thereby mimicking diatoms. We have promising results with encapsulating live *Rhodomonas.* However, still we are not fully

satisfied with the product and are tackling the use of copepods in aquaculture from several different angles.

Firstly, we have used an interesting trait regarding calanoid copepods: their eggs can be provoked into a resting stage, where the egg can be stored for up to nine months, similar to *Artemia* cysts. The viable eggs can be hatched and the high nutritional quality nauplii larvae can be fed to marine fish larvae. We have investigated most aspects of this concept, and now have a finished long lasting product. This concept opens up the possibility of centrally produced copepod resting eggs that can be distributed to marine fish larvae hatcheries, a similar concept to battery hen produced eggs. Thereby we close the gap for the local fish farmers by not needing to invest in algae and copepods production. Instead, they receive a "tin" of resting eggs, hatch them and feed them out to their marine fish larvae. It has actually been so successful that companies are now supplying copepod eggs based on our and others' basic research within this field. Despite the success of these companies, they still cannot meet the total demand and are mostly supplying locally in Nordic countries, which is probably also the most ideal market for this product. However, this leaves a huge gap for the use of copepods as live feed in tropical marine farms that produce, for example, shrimp larvae such as the giant tiger prawn *(Peneaus monodon*).

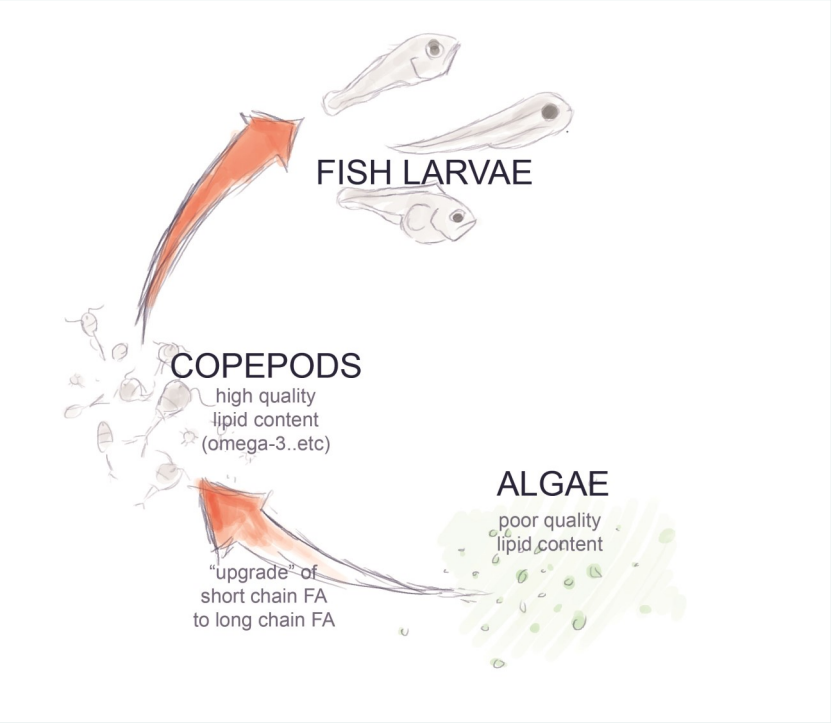


Fig.1. In marine ecosystems, essential fatty acids are generally produced by algae and transferred to higher trophic levels. However, some tropical copepods species are able to "biosynthesize" these fatty acids themselves and thus can feed on algae of low nutritional value.

## The challenges of tropical copepod production

Most tropical copepods are egg carriers, and the few free egg spawners do not have a resting egg stage, preventing the storage of eggs after collection, as we can do for certain Nordic species. In tropical aquaculture systems, the present copepods are challenged and adapted to rapidly fluctuating temperatures, salinity, pH and food quality. This harsh environment has resulted in only the same 3-5 copepod species being present in all aquaculture ponds across the tropic and sub-tropical region, primarily because these species are the only ones that can survive in these ponds. This practical selection for "resilient" copepods is a huge advantage when taking copepods into culture. We have worked in Taiwan and have isolated and brought into culture two species namely, *Apocyclops royi* and *Pseudodiaptomus annandalei.* These species were the two most abundant species in the aquaculture ponds in Tungkang, in the southern part of Taiwan. However, why look to Taiwan? Taiwan is interesting since in the '60s and way into the '80s they were the world leaders in marine finfish propagation, reporting the first successful larval rearing of flathead grey mullet (*Mugil cephalus*), various species of grouper larvae, sea bream (*Epinephelus malabaricus*) and milk

fish (*Acanthopagrus schlegeli*). An advantage for the Taiwanese rearing success of marine fish larval was the use of copepods. Never-the-less, in recent years the use of copepods in Taiwan has been completely or partly substituted by rotifers and *Artemia*, even though copepods are a cheaper alternative that the latter. This replacement is founded in copepods from outdoor systems being excellent intermediate hosts for various parasites, gill flukes and transmitters of viral nervous necrosis.

We believe that the path to prevent diseases and vector born parasites with copepods as intermediate hosts is by isolation, creating disease free cultures. We initially thought that by doing so, the investment cost and culturing both algae and copepods would again create a bottleneck. However, both *P. annandalei* and *A. royi* have proven us wrong. Both species are relatively easy to culture since, as we expected, their requirements regarding the abiotic environment is very low. However, what surprised us most is that one can feed them very low quality food. We have successfully reared both species on both *Tetraselmis* and *Isocrysis,* but also *Dunaliella tertiolecta* which is infamously known for not containing any long chained or essential fatty acids. Further brand new research has shown that we can successfully rear the copepods by feeding them just baker's yeast. Sustaining tropical copepods on these low quality diets is possible because these copepods themselves are able to convert fatty acids in a process called "elongation and desaturation" of fatty acids. The copepods' ability to do so not only makes them easy to rear, but also makes the copepods themselves a desirable live feed with ideal fatty acids profiles readily available for marine fish larvae.

Therefore, we sincerely believe that we now have solutions and products suitable for both Northern and tropical aquaculture: so, the last barrier to overcome is convincing farmers about the wonders of copepods, but that is a complete other story.

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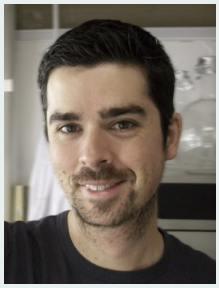
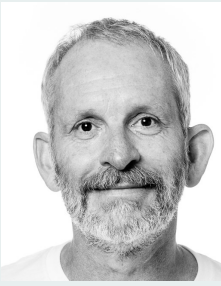
**About the Authors**



Associate Professor Per Meyer Jepsen has been working with copepods for the last 15 years as a part of Professor Benni Winding Hansen´s Live feed Research group. Postdoc Hans van Someren Gréve and Research assistant Bolette Lykke Holm Nielsen has joined the team within recent years and has been deeply involved in working experimentally with tropical copepods. Professor Benni W. Hansen has during his 30 years of experience with copepods worked with copepods in semi-intensive outdoor copepod production and in intensive production worked with optimization of phytoplankton production in bioreactors for use in recirculating copepod production.

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# Tissue distribution and excretion of deoxynivalenol in rainbow trout

By Rui A. Gonçalves MSc, Scientist - Aquaculture, BIOMIN.

*Fusarium* mycotoxins are the most common mycotoxins found in aquafeeds, reflecting the type and inclusion levels of plant meals used in these diets. Deoxynivalenol (DON) is a metabolite produced by the genus *Fusarium* and the main mycotoxin found in small grain cereals.

The kinetics of DON absorption, distribution, metabolism and elimination (ADME) must be understood before it can be tackled in aquatic species. The toxic effects and toxicokinetics of DON have been comprehensively described in terrestrial farmed animals, but less is known in aquatic animals. As ADME mechanisms differ between animal species, the mechanisms specific to aquatic species should be studied. An experiment was therefore devised to assess the toxicokinetics of radiolabeled DON ([$^3$H]-DON) in rainbow trout (*Oncorhynchus mykiss)*, focusing on tissue distribution and excretion (Gonçalves *et al*., 2018).

## Methodology

Juvenile rainbow trout (*Oncorhynchus mykiss*) with a mean initial body weight of 7.72 ± 1.42 g were acclimatized in 40-liter cylindrical/conical fiberglass tanks for three weeks. During the acclimatization period, the fish were fed a mycotoxin-free diet at 1.5% of their body weight, four times a day by automatic feeders. Fish were kept in a freshwater recirculating system at 15 ± 1.0°C, with a 12 h light: 12 h dark photoperiod.

Each feed pellet was labeled with 31.25 ng of the tracer, [$^3$H]-DON

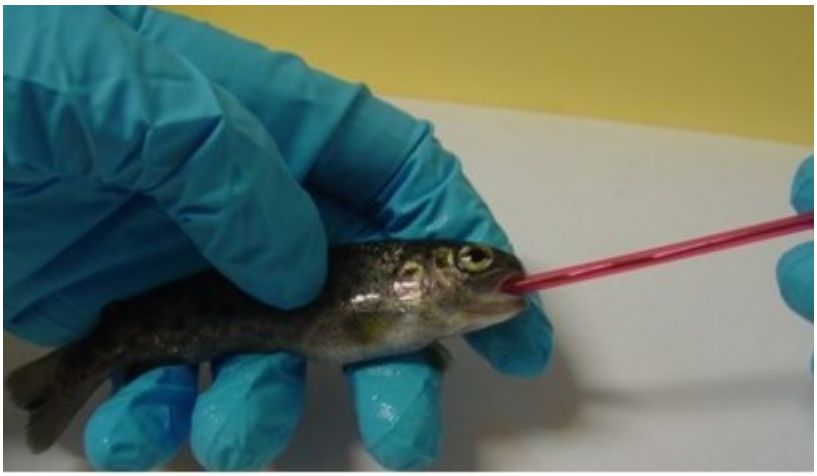

Fig. 1. Hollow plastic tube used for tube-feeding.
*Photo: Sofia Engrola.*

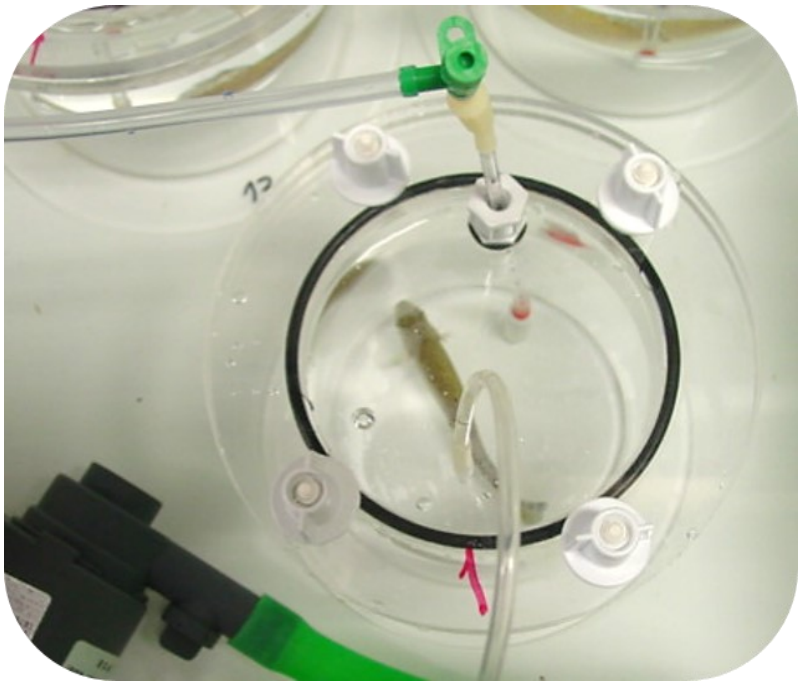

Fig. 2.Hermetically sealed incubation chambers for individual trout.

(3.7 MBq; American Radiolabeled Chemicals Inc., the Netherlands). After labeling, the pellets were dried at 50°C for 30 minutes and stored at 8°C for subsequent tube-feeding procedure. After acclimatization, rainbow trout juveniles were tube-fed with pellets containing the radiolabeled DON. Randomly selected fish (n = 6 for each sampling time point) were transferred to the laboratory after being fasted for 18 hours. Fish were anesthetized (using ethyl 3-aminobenzoate (MS-222), Sigma-Aldrich) and tube-fed using a hollow plastic tube with an inner diameter of 1.5 mm and a smaller, solid plunger (Figure 1). The diameter and length of the plastic tubing was tested prior to use to prevent injury to the esophagus of the juvenile fish. Each fish was given four pellets of the diet (corresponding to 0.13% of their body weight and a total of 125 ± 0.019 ng of [$^3$H]-DON). Tube-fed fish were allowed to recover for 10 minutes in clean, fresh water to eliminate any residual anesthetic from the skin and gills, and monitored for possible pellet regurgitation. The fish were then transferred to an incubator at 15°C, where they were placed in individual chambers. Each of the six 2-liter chambers was hermetically sealed and supplied with a gentle flow of oxygen (Figure 2). After the incubation period (1 h, 3 h, 6 h, 12 h or 24 h), oxygen flow was discontinued and the fish were euthanized inside the chambers using a lethal dose of the anesthetic used previously.

The fish were then removed and 5 ml water was collected from each chamber to measure radioactivity and determine the quantity of mycotoxin excreted by the fish. Fish were individually weighed, and muscle (without skin), skin, liver, kidney and gastrointestinal tract (GIT) samples were taken. Radioactivity in the tissue samples, water samples and pellets (n = 50 to confirm effective labeling) was quantified using a Tri-Carb 2910TR low activity liquid scintillation counter (PerkinElmer, USA) after

addition of Ultima Gold XR scintillation cocktail (PerkinElmer, USA).

## Results and Discussion

The quantity of DON distributed throughout the fish tissues and in the water at each sampling point, and the percentage of DON in the tissues (sum of tissues at each sampling point) or in the water relative to the tube-fed amount (125 ± 0.019 ng DON) is shown in Table 1.

One hour after tube-feeding, [$^3$H]-DON was mainly detected in the GIT (20.56 ± 8.30 ng), with low levels in the liver (1.44 ± 0.67 ng) and kidneys (0.23 ± 0.13 ng). Muscle and skin were not sampled at one hour post feeding. The detection of DON in the fish liver and kidneys indicates that DON is absorbed relatively fast in juvenile rainbow trout. The fact that most of the DON was detected in the GIT was expected, but 6.19 ± 0.83 ng [$^3$H]-DON was already detected in the water at the 1 h sampling point (Table 1). This represented 4.94 ± 0.66% of the ingested [$^3$H]-DON. This result was surprising, as we would expect DON to be excreted in the feces. Regurgitation was ruled out by visual confirmation, so all [$^3$H]-DON detected in the water must have been excreted, and not vomited or leached from the pellets (which were deposited in the stomach). Dänicke *et al*. (2004)

Table 1: Distribution of deoxynivalenol (DON) in fish tissue (gastrointestinal tract, liver, kidney, muscle and skin) and in water at each sampling point (1 to 24 hours) after tube-feeding pellets radiolabeled with [$^3$H]-DON, and the percentage of DON in tissues (sum of tissues at each sampling point) or in water relative to the tube-fed amount (125 ± 0.019 ng DON).

| | **Sampling point** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 h | | 3 h | | 6 h | | 12 h | | 24 h | |
| **Water/ tissue** | DON (ng) | % DON relative to ingested DON | DON (ng) | % DON relative to ingested DON | DON (ng) | % DON relative to ingested DON | DON (ng) | % DON relative to ingested DON | DON (ng) | % DON relative to ingested DON |
| **Water** | 6.19 ± 0.83$^{c}$ | 4.94 ± 0.66$^{a}$ | 20.81 ± 16.04$^{bc}$ | 16.62 ± 12.80$^{a}$ | 16.58 ± 3.93$^{c}$ | 11.03 ± 6.09$^{a}$ | 63.50 ± 27.76$^{b}$ | 50.71 ± 22.17$^{b}$ | 77.84 ± 44.54$^{a}$ | 62.15 ± 35.56$^{b}$ |
| **GIT** | 20.56 ± 8.30 | 17.74 ± 6.71$^{b}$ | 18.27 ± 1.88 | 22.30 ± 3.48$^{b}$ | 21.79 ± 7.95 | 28.80 ± 8.54$^{b}$ | 13.14 ± 6.14 | 19.15 ± 7.70$^{a}$ | 10.02 ± 10.45 | 13.07 ± 11.54$^{a}$ |
| **Liver** | 1.44 ± 0.67 | | 0.93 ± 0.17 | | 1.24 ± 0.54 | | 1.14 ± 0.55 | | 0.87 ± 0.85 | |
| **Muscle** | n.s. | | 6.14 ± 2.48$^{ab}$ | | 8.89 ± 4.00$^{a}$ | | 6.67 ± 2.30$^{ab}$ | | 3.61 ± 2.84$^{b}$ | |
| **Kidneys** | 0.23 ± 0.13 | | 0.30 ± 0.20 | | 0.52 ± 0.41 | | 0.31 ± 0.08 | | 0.57 ± 0.46 | |
| **Skin** | n.s. | | 2.44 ± 1.35 | | 3.62 ± 2.30 | | 2.78 ± 1.14 | | 1.58 ± 1.57 | |
| **[$^3$H]-DON Recovery** | - | 22.68% | - | 38.92% | - | 39.83% | - | 69.86% | - | 75.22% |

Values are means ± SD for each tissue and water sample. Different letters indicate statistically significant differences ($p < 0.05$, one-way ANOVA) between time points for tissues and water. There was no significant difference between the kidneys, liver, GIT and skin during the 24-hour period. For the percentage of DON relative to ingested DON, different letters indicate statistically significant differences ($p < 0.05$, one-way ANOVA) between water and the sum of the tissues at the same sampling time point. n.s. = not sampled.

Source: Gonçalves *et al*. (2018)

actually observed that DON leached from pellets into the liquids in the pig stomach, and was emptied with the liquid chyme more rapidly than the solid chyme (Bucking and Wood, 2006). Although the rapid excretion of DON may prevent the immediate negative effects of DON in the diet on the trout GIT, its high solubility and stability in water may lead to re-ingestion by the fish and accumulation in the tank (depending on its hydrodynamics).

Levels of [$^3$H]-DON in the kidneys, liver and skin of the juvenile trout remained relatively low for the remainder of the trial (24 hours). [$^3$H]-DON was relatively constant in the GIT for the first six hours, before decreasing to 10.02 ±10.45 ng at 24 hours. The level of DON in the water, as a percentage of the total tube-fed DON (125 ± 0.019 ng), was significantly higher ($p = 0.001$) after 12 hours (63.50 ± 27.76%) and 24 hours (62.15 ± 35.56%) than at the previous sampling points (1 h = 4.94 ± 0.66%, 3 h = 16.62 ± 12.80% and 6 h = 11.03 ± 6.09%). Total [$^3$H]-DON recovered also increased significantly at the 12 and 24 h sampling points (69.86 and 75.22%, respectively). At the end of the trial period (24 h after tube-feeding), traces of [$^3$H]-DON were still found in the tissues (GIT 10.02 ± 10.45 ng; liver 0.87 ± 0.85 ng; muscle 3.61 ± 2.84 ng; kidney 0.57 ± 0.46 ng; and skin 1.58 ± 1.57 ng), but most of the [$^3$H]-DON was found in the water (77.84 ± 44.54 ng, or 62.15 ± 35.56% of the initial tube-fed DON). The period between 6 and 12 hours after tube-feeding seems to be the turning point where more [$^3$H]-DON is excreted into the water than retained in the fish. After 24 hours, the sum of the [$^3$H]-DON in all the tissue samples was 16.37 ± 14.46 ng, compared to 77.84 ± 44.54 ng excreted into the water.

The [$^3$H]-DON recovered, especially at the first three sampling time points (1, 3 and 6 h) was relatively low (22.68%, 38.92% and 39.83%, respectively). Although the metabolic chambers were a closed system, some losses were expected due to sampling limitations. For instance, residues of DON in the head and skeleton were not analyzed, and residues in the blood could not be analyzed due to the coagulation caused by the anesthetic overdose used to euthanize the fish. This inevitably contributed to [$^3$H]-DON losses. The most important factor contributing to the poor recovery of [$^3$H]-DON was probably the loss of material from the GIT during sampling: most of the solid chyme and the feces remained in the GIT during tissues sampling, but some fluid chyme was probably lost during the sampling procedure. Consequently, the loss of DON in the fluid phase may have contributed to the constantly low levels of [$^3$H]-DON recovered from the GIT at the first two sampling points (1 h and 6 h). [$^3$H]-DON recovery was higher at 12 and 24 hours, at 69.86% and 75.22%, respectively. At these time points, recovery was probably most affected by the tissues that were not collected (head, blood, and skeleton with muscle attached) as digestion had already finished.

## Conclusions

Despite some limitations in trial procedures we conclude that [$^3$H]-DON can be detected in samples of fish liver and kidney one hour after tube-feeding, indicating rapid absorption of DON. 20.56 ± 8.30 ng [$^3$H]-DON was detected in the GIT at the first sampling point at 1 h, but 6.19 ± 0.83 ng was also detected in the water at this same point. The rapid excretion of [$^3$H]-DON (faster than the average gastric emptying time in trout) suggests that DON, which is a water-soluble compound, is excreted in the liquid phase of the chyme. Levels of [$^3$H]-DON in the GIT were stable for the first six hours and this long residence time in the GIT may compromise GIT health and increase absorption. Our results suggest that an effective method of neutralizing DON and protect fish from its negative impact should act in six hours or less. Most of the excretion can be expected to occur after six hours, so the method should be irreversible in the conditions found in the GIT.

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# Implementation of new hatchery technologies to improve the supply of tilapia fingerlings for rural farmer in Malawi

## A contribution of the R&D project "Improving Community Health-Nutrition Linkages through Solar Energy Based Fish and Crop Integrated Value Chains (Acronym "ICH LIEBE FISCH"), a cooperation between Germany and Malawi.

By Dr. Bernd Ueberschär, Gesellschaft für marine Aquakultur (GMA), Büsum, Germany

### Introduction

Research or development conducted during developmental aid projects in rural areas of Sub-Saharan Africa, especially in smaller communities, can only be of benefit for a very limited time Mostly, projects are focused on one or few specific aspects, such as improving water quality, providing novel gear or implementing new technologies. These, on their own, do not take into account the value chain, which is important for the development of a sustainable local economy. A project considering the value chain of sustainable integrated agriculture (crops and plants) and aquaculture of endemic freshwater finfish production in rural areas would have the

### Background

The project is being accomplished under the umbrella of the German research cooperation for global food security and diversified agriculture for a balanced nutrition in Sub-Saharan Africa. The project is financially supported by the German Federal Ministry of Food and Agriculture (BMEL) through the Federal Office for Agriculture and Food (BLE). The project has mainly two German partners (Fraunhofer Research Institution for Marine Biotechnology and Cell Technology, EMB and the Association for Marine Aquaculture, GMA) and five Malawian partners and NGOs with the Lilongwe University of Agriculture & Natural Resources, Aquaculture and Fisheries Science Department (LUANAR-AQF) being the Malawian coordinator in the project.

potential to overcome this bottleneck in sustainability. Thus, the project "Ich liebe Fisch" (I love fish) focuses on research and linking of several aspects along the value chain of sustainable aquaculture of endemic tilapia species, a favored and high-quality source of protein for human nutrition. In this context, an innovative linkage of fish and crop production in integrated aquatic systems (traditional integrated agriculture-aquaculture systems, IAA, and aquaponics) will allow enhanced productivity and thus an optimized nutritional and socio-economic status of smallholder farmers in rural areas of Malawi adopting these techniques.

Malawi is a landlocked country in south-eastern Africa, bordered by Zambia to the northwest, Tanzania to the northeast and Mozambique to the south, southwest and southeast. Malawi is among the world's least-developed countries. The economy is heavily based in agriculture, with around 85% of the population living in rural areas. Over 80% of the population is engaged in subsistence farming.

The project aims to improve the supply of tilapia as food fish specifically in rural communities and to advance crop production by introducing small-scale aquaponic facilities and enhancing pond-based integrated aquaculture-agriculture (IAA) approaches. The project has a quite diverse agenda; briefly, the specific goals of this project are:

- to enhance the production of endemic fish species by selective breeding and hybridization
- to establish a specialized solar powered hatchery and to optimize rearing protocols of the most desired tilapia species in Malawi, specifically the Chambo (*Oreochromis karongae*), in order to improve the sustainable supply of fingerlings of this species for on-growing farms,
- to use an IAA system approach to integrate nutrient fluxes between animal and crop production,
- to implement training courses for local communities and smallholder farmers, thus ensuring capacity development and
- to monitor the changes in health status and food habits of local families - especially children and elderly people—after implementation of the project measures, to ensure a benefit for the whole community and
- to facilitate establishment of a community agriculture-nutrition-health linkage innovation platform and networking with relevant institutions to ensure sustainability beyond the project´s life cycle.

This article focuses mainly on the aspect of the implementation of innovative hatchery technologies that aim to shift the production of tilapia fingerlings in Malawi to the next level.

In combination with the introduction of aquaponics and efficient application of integrated agricul-

Children are the special focus of the project "Ich liebe Fisch", which aims to improve the nutritional condition of Malawian folk in rural areas. These children are just undertaking a "taste test" of porridge with fish.

ture-aquaculture (IAA) the goal to have more fish and vegetables available as a healthy enrichment of the popular maize dishes can become a reality.

## Rationale

Traditionally, Malawi is a fish-eating nation. However, what is left on the table is mainly maize mush, traditionally called Nsima.

Daily dish in the countryside: Nsima, the traditional maize mush, enriched with some small freshwater sardines from Lake Malawi.

Although Malawi is blessed with the ninth largest lake in the world and the third largest and second deepest lake in Africa, overfishing has resulted in the collapse of the tilapia fishery in the lake since the beginning of the '90s. Tilapia-like species, specifically *Oreochromis karongae*, known locally as chambo, is the country's favorite fish. Owing to the Chambo scarcity on the market, its wholesale price has risen from 2.5 Malawian kwacha per kilo in the early 1990s to 130 Malawian kwacha per kilo in 2002. Today, the price has reached more than 3000 – 6000 Malawian kwacha (approximately US$ 4-8) per kilo which is hardly affordable for most Malawian people. The historical yields of 70% of Chambo (*Oreochromis karongae*) in the nets has turned into only 3–5% Chambo today, with small fish called Usipa (Lake Malawi sardine, *Engraulicypris sardella*) being the most prominent fish in the catches from Lake Malawi, at present providing 70% of the yield.

Under these circumstances, aquaculture is being considered as one of the measures to provide more Chambo on the table and for the market, however, the production in the country is still small and in general not efficient. Aquaculture has a tradition of about 100 years in Malawi, introduced while England was ruling Malawi, taking off with about 60 ponds in the 1950s and is represented today by about 6,000 active fish farmers. At present, about 3,600 tonnes of tilapia-like species are being produced annually by the rural farmer. One of the major bottlenecks for smallholder farmers to improve their yield is the scarcity and unreliable of sufficient viable fingerlings, specifically from Chambo.

Propagation and production of fingerlings is usually conducted in ponds with all generations of tilapia. This implies, however, an unfavorable environment for fingerling production, including predation (predatory tadpoles from frogs are a huge problem in open ponds), cannibalism, feed competition and environmental impact. Thus, the number of offspring that can be expected from the farmer in a breeding season is unknown.

## Innovative hatchery technology for Malawi

Thus, one of the major goals of the project ¨Ich liebe Fisch "was to establish technologies which improve significantly the stable supply of viable fingerlings to farmers who want to grow fish for food and for the market. To achieve this goal, the project has provided a solar powered indoor hatchery which is designed to support intensive production of tilapia fingerlings, specifically from Chambo.

The hatchery is based on a design which has proven its usefulness in fish larval rearing for more than 25 years. The design was adapted to the specific needs under the conditions in Malawi and the kind of species which will be reared in this facility. The main elements of the hatchery are two large fiberglass tanks with smaller tanks hanging inside of the big tanks (Figure 1). The advantage of this compact design is obvious. The water conditioning can be

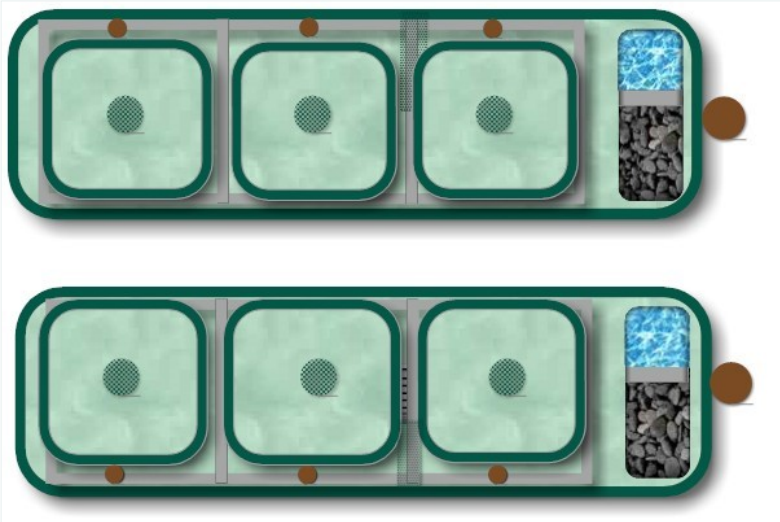


Fig.1. The hatcheries main elements are two identical units; each unit has a large fiberglass tank with three smaller tanks inside. Dimensions of the large tanks about 6.0 x 1.9 x 1.1 m (L x W x H). Dimensions of the smaller tanks are about 1.3 x 1.2 x 0.7 mm. Each unit has the same equipment and can be operated independently from each other, which allows, for example, rearing trials with different water temperatures.

accomplished in the big tank (heating, aeration, filtering etc.) without having any mechanical impact on the larvae inside the small tanks. On the other hand, the larvae inside of the small tanks are practically swimming in about 12 $m^3$ of water. The water in the big tank keeps the water temperature constant for all smaller tanks, which is a huge advantage if research trials are conducted in this facility.

The equipment used and the water flow is depicted and annotated in Figure 2. Each unit has a two-way circulation and can be operated in a batch mode, which means that a certain volume of water, based on the current water condition, is

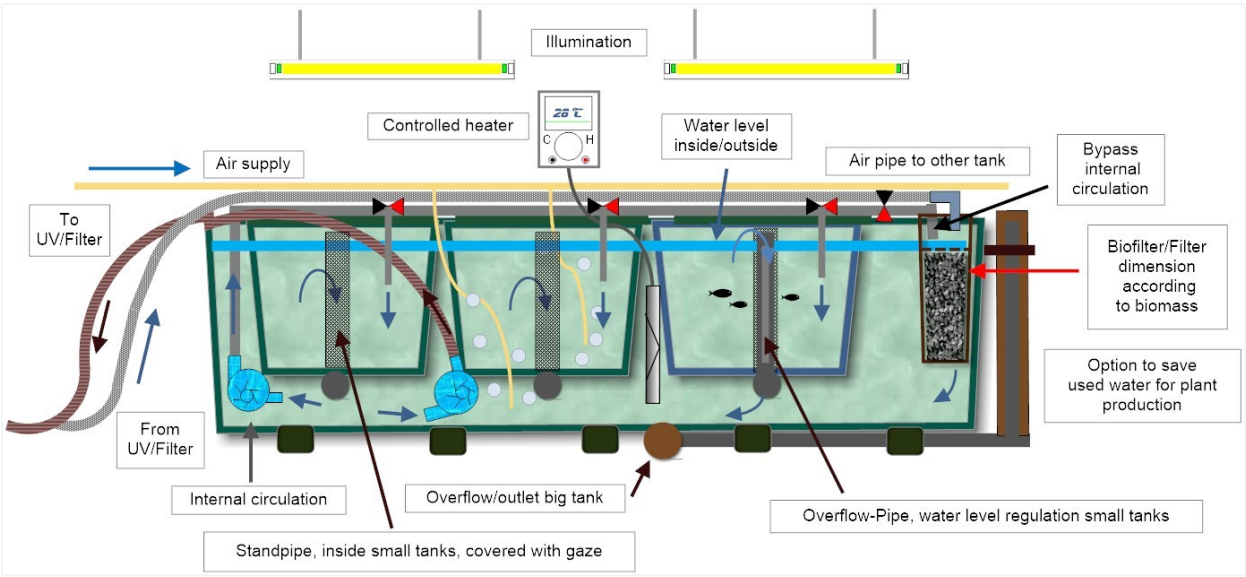



Fig. 2. The sketch depicts schematically the water circulation and the equipment installed in one tank unit. Water from the big tank is pumped through a UV-unit, a filter unit outside which can be equipped with various filter cartouches and goes back to a coarse filter inside of the big tank. Attached to the coarse filter, a biofilter is established which is fed with returning bypass water from the big tank. The other pump circulates the water from the big tank through the small tanks. Heaters are deployed in the water body of the big tanks. Significant aeration is accomplished in the big tanks, inside the small tanks only gentle aeration is applied to keep larvae in the water column. Ball valves at each water inlet into the smaller tanks allow the adjustment of the water current and, depending on the age, to adjust a more or less gentle current, drifting around the larvae so they cannot get stuck in the corners. The tanks can be operated in a batch mode, i.e. a certain water volume can be exchanged on a daily basis if necessary, or the tanks can be operated in a flow-through mode.

The hatchery in operational mode

Incubation unit: McDonald-type hatching jars, stocked with some Chambo eggs.

Tilapia (Chambo) fingerlings.

being exchanged or the system can be operated in a flow-through mode. The second option might be difficult to apply under the conditions in Malawi, since constant water pumping often fails because of frequent failure in grid electricity.

The prototype of the hatchery was set up in March and April 2018 at the farm of the Bunda College in Lilongwe which is part of the Lilongwe University of Agriculture & Natural Resources, Department of Aquaculture and Fisheries (LUANAR) and was ready to operate in the next breeding season, which starts in November and lasts normally until April.

In addition to the main rearing tanks, an egg incubation unit was established inside next to the tanks, based on McDonald-type hatching jars. Since the target species in the project are mainly mouth breeders, the eggs can easily be retrieved from the females. This facility along with the rearing tanks completes the full control over the entire hatching and rearing process, facilitating also the effort of selective breeding, in order to improve the performance of the larvae and to control the results of hybridization experiments (one attempt in the project to produce all-male generations).

## Solar power supply

Grid power in Malawi fails frequently, at present in the mean only six hours of power from the public grid per day can be expected. Since such a hatchery set-up needs constant power supply in order to run pumps, aeration, illumination and heaters without a break, a solar power unit was attached to the hatchery. Gensets as a continuous provider of power is not an option, since fuel and gasoline are very expensive in Malawi. The solar power unit was designed as an island solution and provides sufficient power for the equipment in the hatchery 24h/7days a week. The solar facility provides about 1.7kW in the night which is sufficient to run the most important equipment without a break. The solar power can automatically switch to grid power when available (Figure 3). A diesel genset which automatically starts is

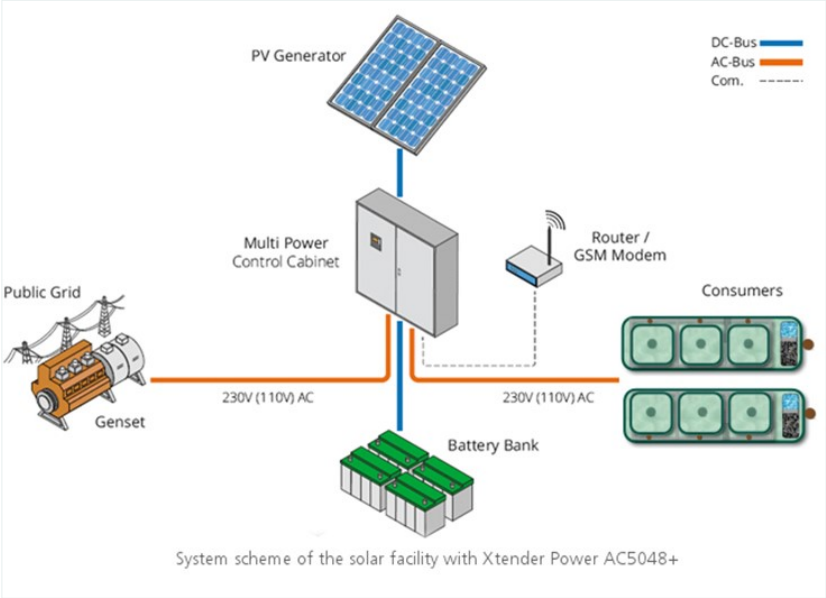



Fig. 3. Schematic sketch of the solar power facility which provides permanent electricity for the hatchery operation. The system has 36 solar panels, each providing about 300 Watt. The battery block has 24 batteries with in total 48 Volt and 1270 Ah per battery. The facility is designed as an island solution; however, grid power can be used when available to increase the batteries' life time. Additionally, a genset is attached as emergency back-up. The system can be remote-controlled through a GPRS modem.

Mounting the 36 solar panels that are the heart of the solar power facility that provides electricity for the hatchery.

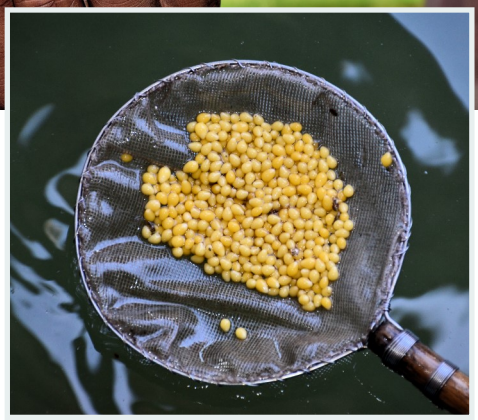
being installed as an emergency back-up when both other sources for electricity fail.

A GPRS modem was connected to the control unit, which allows the remote control of the operating data of the facility through the Internet, which is very useful in the period beyond the first start-up of the system.

## Production and research

The hatchery was mainly designed to produce tilapia fingerlings to support stocking of the ponds of the rural farmers. However, the facility can also be used to do research trials; this is important since a number of optimal biotic and abiotic conditions for e.g. the Chambo are not yet known but can be identified in experiments conducted in the hatchery. In order to increase the number of parameters to test and to be able to achieve viable results with more replicates, small floating buckets can be introduced into the tanks with larvae introduced into the buckets.

The capacity per rearing trial is about 50.000 tilapia larvae per unit. One trial in the indoor hatchery takes about 4 weeks, subsequently the post larvae are introduced into hapas in the ponds of the farm where they are able to adapt to pond conditions in a protected environment, and are raised until they have reached the right size to be disseminated to the farmer (about 5-10 g). In a breeding season, about 5 trials can be conducted, which can provide about 0.5 million fry per breeding season, assuming, there are sufficient brooders available. This capacity is good for stocking the



Above: Endemic Tilapia species *Oreochromis karongae*, the Chambo. Right: Eggs from Chambo, taken from the female and ready to incubate in the hatchery.

ponds of 5-10 fish farming communities, depending on the number and size of the ponds they are managing.

## Conclusions and outlook

To some extent, it might appear to be very ambitious to establish this hatchery level 2.0 in one of the poorest countries on the globe. However, it has to be taken into account that the location where the solar powered hatchery was established is at the farm of the Bunda College, which is part of LUANAR, and which was approved by the World Bank in 2016 as a Centre of Excellence in Aquaculture and Fisheries Sciences in Africa.

Thus, with the excellent infrastruc-

A fish club harvests a pond. A fish club can be a couple of people working together, or even a whole village who operate and manages farmland and ponds together.

ture at the Bunda Farm with its many ponds and safe water supply, it was considered a proper environment to shift the production of tilapia fingerlings to the next level in Malawi. Since the hatchery is being operated by the excellent and knowledgeable staff of LUANAR, who were thoroughly trained by the German partner, there are no doubts that this facility will be able to contribute significantly to improve the tilapia production of the rural fish farmer on the long-term scale in Malawi.

## Feed is still a major bottleneck

There is, however, one major bottleneck for the rural fish farmer in Malawi. Even with the supply of sufficient viable fingerlings, the on-growing conditions are still very weak, concerning the feed available to the farmer. Malawi has no production of commercial fish feed, and rural farmer cannot afford to import pelleted fish feed from e.g. Zambia. Thus, the farmers are using homemade feed, which is mainly remnants from maize processing (maize bran) and which has very little value as fish feed and does not come close to making use of the growth potential of the tilapia species. This situation can actually jeopardize the effort to improve the yields which can be achieved with the availability of significantly more fingerlings. Thus, to facilitate the production of high-quality fish feed inside Malawi, the project aims to establish a pilot plant to demonstrate the production of maggots of the black soldier fly under local conditions and eventually meal from insect proteins which can be used to produce a protein rich feed which will help to utilize the growth potential of the fish in the farmers ponds.

*Malawi has no production of commercial fish feed, and rural farmer cannot afford to import pelleted fish feed ... thus farmers are using homemade feed.*

ΩHF

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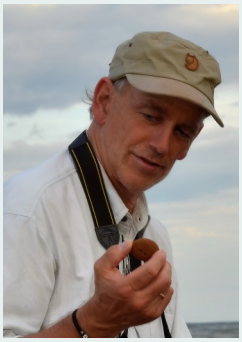

# Growth and feed utilization in Cobia early juveniles is affected by water temperature and dietary methionine

By Luís Conceição[a*], Minh Van Nguyen[b], Manuel Yúfera[c], Minh Hoang Le[b], Sofia Engrola[d], Marit Espe[e], Ann-Elise Jordal and Ivar Rønnestad[f].

[a] Sparos Lda, Olhão, Portugal; [b]Institute of Aquaculture, Nha Trang University, Vietnam; [c]Instituto de Ciencias Marinas de Andalucía (ICMAN-CSIC), Puerto Real, Spain; [d] Centre of Marine Sciences of Algarve (CCMAR), Universidade do Algarve, Faro, Portugal; [e]Institute of Marine Research, Bergen, Norway; [f]Department of Biological Sciences, University of Bergen, Bergen, Norway.

## Introduction

Cobia (*Rachycentron canadum*), is a fast-growing warm waters fish with a broad distribution in tropical and subtropical areas of the Pacific, Indic and Atlantic oceans. This high-valued species has been profiled for marine aquaculture in many countries and may reach up to 6 kg in one year. The annual world production of cobia has reached over 40.000 tons in recent years (FAO, 2018), and is produced mainly in South-East Asia, but also in the Gulf of Mexico. It is one of the main marine fish farmed in Vietnam (Nhu et al., 2011). In Southern Vietnam and other regions where the species is farmed, water temperature in cages and tanks normally is from 27 - 30°C, but may reach up to 36°C during the warmer season. In hatcheries water temperature may be partially controlled depending on the technical solutions in the facility.

Successful production of high quality cobia from early juvenile stage to when the fish is stocked into cages depends on availability of good quality and cost-effective feeds that meet the nutritional requirements of this fast growing fish. Fast growing fish have typically high protein needs, and methionine tends to be the first limiting amino acid in protein synthesis. Since protein, and methionine in particular is costly, its dietary levels need to be optimized. Moreover, feed intake,

Feeding Cobia juveniles at Nha Trang University .

digestion and nutritional requirements, and thereby feed utilization and growth are well known to be affected by water temperature in fish. Therefore, it is important to know how temperature affects cobia metabolism in order to identify diet formulations that allow to optimize growth.

In a study conducted under the EU project WISEFEED we have evaluated the impact of water temperature and dietary methionine levels on digestion, feed conversion and growth of cobia. Two temperatures, 30 and 34°C, and three methionine levels in feed were studied. The results are further explored in two peer-reviewed papers (Nguyen et al., 2019; Yúfera et al., 2019).

Cobia tanks at Nha Trang University fish facility.

Cobia juveniles with empty (above) and full (below) stomachs.

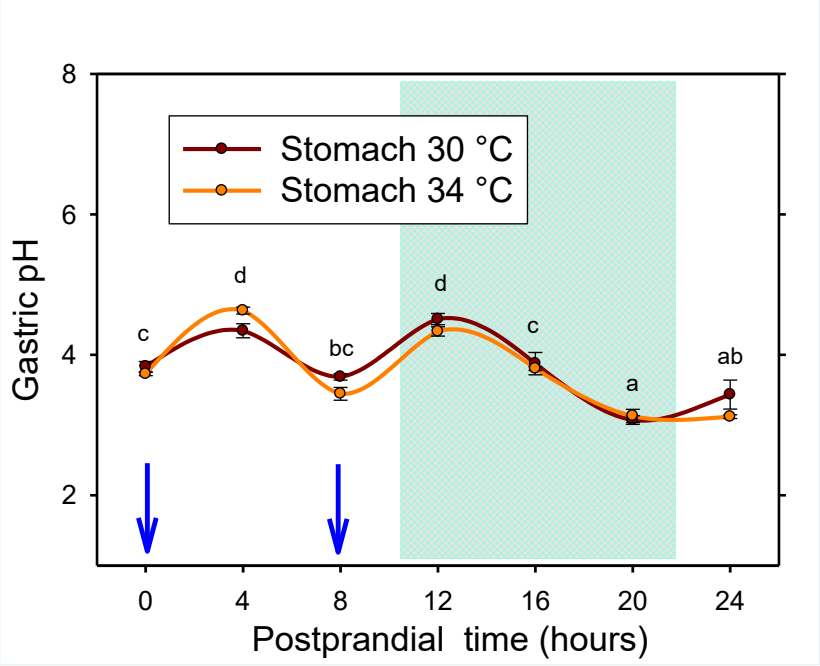


Fig. 1. Stomach pH in cobia early juveniles during a 24 h period and when fed two meals (blue arrows). Blue shaded area stand for the night time.

## Temperature affects cobia digestion

Digestion is a complex process, involving mechanical and enzymatic actions, and activity of digestive enzymes controlled by acidity (pH). An efficient digestion normally requires an acidic environment in the stomach and an alkaline one in the intestine. Stomach pH of early juvenile cobia fed two meals a day was permanently acidic and always below pH 5 (see fig. 1). However, pH increased along the intestine, with mean pH values of 6.1 in anterior intestine to 7.7 in the distal intestine. The stomach pH was unaffected by temperature, while in the intestine a slightly higher acidity was induced at 34°C, compared to 30°C (see Yúfera et. al. 2019 for more details and for digestive enzyme activities). The continuous acidity in cobia juveniles stomach, even in the absence of feed, parallels what is observed in mammals and birds, and differs from most studied fish, which maintain a neutral pH in the lumen of the stomach between meals and with a decline only after the ingestion of feeds. This contributes to explain the very fast growth of early juvenile cobia.

The transfer of partly digested feed (transit rate) from the stomach was higher during the first 4 h after the first meal in the morning and decreased progressively along the rest of the 24 h cycle at both temperatures. However, the transit rate was notably faster at 34°C, and in particular during the first 8 h

after feeding. The intestine transit rate was more constant and similar at both temperatures during 12 h after the first meal, and remained low for the following 12 h. A faster stomach transit time has been associated in previous studies with a lower feed conversion ratio, as dietary proteins are available for digestion for a shorter time.

## High temperatures affect negatively feed conversion and growth in cobia

Cobia reared at 30°C grew faster and had a better feed conversion ratio (FCR) than those at 34°C (fig. 2). At both temperatures the feed intake of cobia was very impressive, as can be observed in the photo. However, at the higher temperature (34°C) the digestion efficiency and feed intake decreased which lead to a lower growth (Nguyen et al. 2019). The growth rate of around 6%/day observed in early juvenile cobia, up to 60 g, is amongst the highest observed in the fish, being comparable to those recorded for blue fin tuna, greater amberjack and Arapaima. Based on our results 30 °C is a more appropriate temperature compared to 34 °C for rearing early juvenile cobia.

## Methionine deficiency or excess affects negatively cobia performance

Growth, feed conversion rate (Figure 2) and protein utilization were better at the intermediate methionine level (1.2% of dry diet) compared to fish fed a low dietary (0.9% of dry diet) or high (1.6% of dry diet) methionine level. Based on this, early juvenile cobia seem to require 1.2 % of methionine in dry diet for optimal growth. Protein utilization was better in the fish fed the intermediate methionine level, what is in line to what observed in other fish species.

Importantly, we also observed that high dietary levels of methionine partially recovered the performance of cobia reared at elevated water temperature, meaning that the requirement of methionine is higher under temperature stress.

## Conclusion

Cobia at early juvenile stage have a very impressive high growth rate, based on a particular digestive capacity, but the growth is affected both by dietary (e.g., methionine) imbalances and sub-optimal environmental factors (e.g., high temperature). Long-term effects of such sub-optimal conditions remain to be studied. Therefore, cobia farming in nurseries should be done under optimal nutritional and environmental conditions. An important finding is that the dietary methionine levels should be higher at elevated temperatures to sustain high growth rates and probably fish heath and welfare.

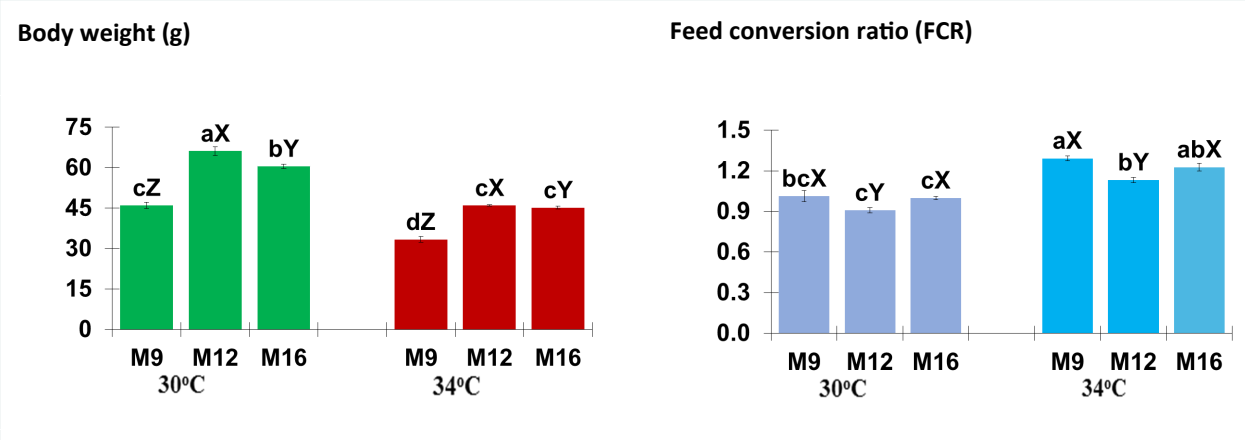


Fig. 2. Weight gain and Feed conversion ratio (FCR) in cobia early juveniles at 30 and 34°C, and fed diets with three different methionine levels (0.9, 1.2 and 1.6 % in dry feed).

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Nguyen, M.V., Espe, M., Conceição, L.E.C., Le, M.H., Yúfera M., Engrola, S., Jordal, A-E.O., Rønnestad, I. 2018. The role of dietary methionine concentrations on growth, metabolism and N-retention in cobia (*Rachycentron canadum*) at elevated water temperatures. *Aquaculture Nutrition. 2018;1–12* (in press). DOI: 10.1111/anu.12875.

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Acknowledgements: The project WISEFEED received funding by the European Union's H2020 programme (Marie Skłodowska-Curie grant No 691150). The study received additional funding from EFISHDIGEST AGL2014-52888 (MINECO, Spain + FEDER/ERDF contribution), Portuguese national funds from FCT - Foundation for Science and Technology through project UDI/Multi/04326/2016 and Norwegian Agency for Development Cooperation NORHED, No. QZA-0485 SRV-13/0010. S.E. acknowledges a Foundation for Science and Technology of Portugal (FCT) investigator grant IF/00482/2014/CP1217/CT0005 funded by the European Social Fund, the Operational Programme Human Potential and FCT.

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# Brazilian hatcheries hold the key



By Bernard Devresse

The Brazilian shrimp industry is facing difficult times. 2017 production reached 40,967 tons for 30,000 ha of pond approximately (Jomar Carvalho Filho, 2018). This is 21% lower that than 2016 and a mere 45% of its peak production in 2003 (90,190 tons). In reality, Brazilian shrimp aquaculture has been struggling with disease and structural problems for 15 years and there are no fundamental changes in sight that could justify a reversal in this trend in the near future.

This is in stark contrast with other Latin American and South East Asian countries such as India, which will reach and pass 600,000 tons in 2018, having managed to overcome most of their disease outbreaks, including EMS, and experienced impressive growth during the last 5 years.

Brazil is plagued by only four diseases (IHHNV, NHP, WSSV and IMNV) compared with 13 known diseases in Ecuador. So why does Brazil experience so many problems in managing and solving its problems? As always, such a complex situation will have many reasons or causes and everyone will have an opinion on the subject. I want to focus here on one important aspect: broodstock and post-larvae health status.

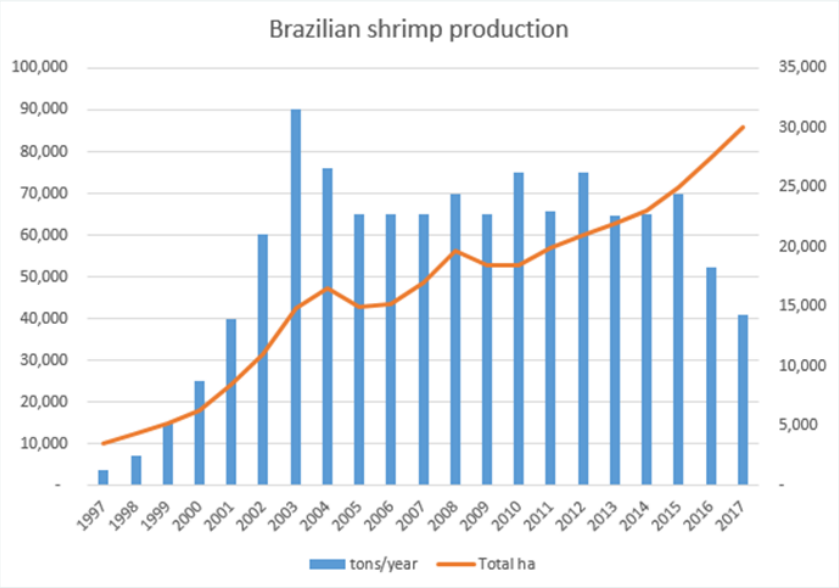


Fig. 1. Brazilian shrimp production fell by 21% in 2017 from previous year.

It is very interesting to point out how South-East Asia managed to solved their problems with WSSV and EMS, thanks to massive importation of "clean" high performing shrimp from professional genetic selection programs. India alone imported more than 150,000 broodstock in 2017, approximately 20-25% of the world SPF *vannamei* broodstock export market. In many South-East Asian countries, the use of clean post-larvae is now accepted as a necessary condition for successful aquaculture. Not in Brazil, however.

The prevalent thinking among most Brazilian farmers is that seeding a "resistant" shrimp in infected culture ponds is the best strategy.

These robust animals, selected from challenged areas, are in fact known as APE (All Pathogen Exposed) in comparison with SPF (Specific Disease Free) or SPR (Specific Disease Resistant) concepts. In practice, the use of robust APE animals have yielded some positive results when compared to one unique fast growth line produced by a well-known shrimp hatchery located in the state of Rio Grande do Norte. However, the reality is that the industry has not found an acceptable solution with the use of these APE animals. Crop yields per ha have reached a new low with some 1.3 tons/ha per year, stocking can be as low as 5 PL/m², losses are frequent, most shrimp are sold with less than 10-12 g of body weight, shrimp farms are for sales or for rent all over the place. The industry is now quickly integrating horizontally: big farmers are getting bigger, small farmers are progressively quitting the industry.

Table 1 briefly presents the hatchery production in Brazil. From these data, we can see that more than 60% of the total post-larvae production is in the hands of the six largest hatcheries. Most, if not all large and medium hatcheries own their maturation. The reason for this lies in cost saving, the unavailability of commercial nauplii producers and the simplicity of current maturation procedures. In practice, animals originating from the farms are brought in production without much attention to their health status. There are no state regulations established or enforced for quarantine procedure on animals used for reproduction.

Animals that have reached the right size for reproduction are quickly and informally placed in maturation facilities. Most hatcheries are not performing any kind of formal analysis such as PCR or histological diagnostic.

None of those hatcheries deliver post-larvae with a documented health certificate and no PCR analysis is available. Few farmers have implemented a systematic quality control on post-larvae. Moreover, most of them have now abandoned regular use of expensive PCR analysis, since it has not been perceived as a useful tool to manage the results of the farm.

*The Brazilian authorities responsible for the sector would do a great job for the industry by facilitating multiple and regular importation of SPF shrimp animals aimed at reproduction from approved producers and implement some safeguard to prevent the recycling of diseases and pathogens inside the country between farms and hatcheries.*

Table 1: Shrimp hatchery production in Brazil

| | Capacity (PL/month) | Number | Total production (PL/mes) | Maturation | Hatcheries with formal genetic selection program |
|---|---|---|---|---|---|
| **Large Hatcheries** | ‘ > 100 | 6 | 1115 | 6 | 2 (3) |
| **Medium Hatcheries** | 50-100 | 3 | 220 | 2 | - |
| **Small hatcheries** | ‘< 50 | 11 | 340 | 3 | - |
| **Total** | | 19 | 1675* | | |
| **Data collected from producers. Value probably over-estimated by 20-25%* | | | | | |

The Brazilian shrimp industry has therefore no alternative but to buy shrimp post-larvae very likely contaminated by pathogens. As long as broodstock animals are collected from the wild, all pathogens exposed and placed in maturation without a formal quarantine (which can be as long as 24 months to clean the animals from all pathogens), the situation will offer little hope for better days. As the procedures involving the cleansing of all pathogens is a complex and lengthy process, the Brazilian shrimp industry must consider the importation of clean animals selected for growth or robustness. This has shown to be a true game-changer in many countries involved in the shrimp industry in Southeast Asia and Latin America.

The Brazilian authorities responsible for the sector would do a great job for the industry by facilitating multiple and regular importation of SPF shrimp animals aimed at reproduction from approved producers and implement some safeguard to prevent the recycling of diseases and pathogens inside the country between farms and hatcheries.

Reference: Jomar Carvalho Filho (2018). A produção aquícola de 2017. *Panorama da Aqüicultura.* p54-59. Julho-Agosto 2018.

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**About the author**

Bernard Devresse has 30 years of experience in the shrimp and fish feed industry, more specifically in nutrition and feed processing. He is working today both a shrimp farmer and shrimp nutritionist in N-E Brazil.

# Why should you feed your tilapia larvae with high quality micro-extruded feed ?

By By Delphine Weissman, R&D Aquaculture manager – DRDI, Neovia Group.

Intensification of aquaculture and the increasing need in fish coming from aquaculture require high quality fish larvae for an efficient production. A good feeding in early phases will ensure a good production in terms of survival, deformities and growth in the future carrier of the fish.

Tilapia as one of the most farmed species over the world is often fed with crumbled feed during the first feeding days after yolk sac absorption.

The study presented here shows the great technical interest of using high quality micro-extruded feed to feed tilapia fingerlings during the first 28 days after yolk sac absorption. MEM® from BernAqua is a micro-extruded feed that ensures the right size of pellets for the fish. It avoids water pollution due to its good stability in water (see Figure 1) allowed by its unique technology: cold micro-extrusion and marumerization. It permits a good catch-up by the fish thanks to its good dispersion in water and the slow sinking behavior of the pellets. The feed nutritional balance is guaranteed by the high nutrients levels and the noble raw materials used in the formula. All these features lead to good survival rate, twice faster growth and optimal FCR.

In the present study, the objective was also to evaluate a secondary benefit from the use of a high quality micro-extruded feed for tilapia larvae. The objective was to know if the good growth obtained with the use of MEM® could enable farmers to shorten the conventional sex reversal period of 28 days, and thus increase the efficiency in production.

After yolk sac absorption, tilapia larvae were fed with MEM® of appropriate size (200-300µm, 300-500µm or 500-800µm) depending

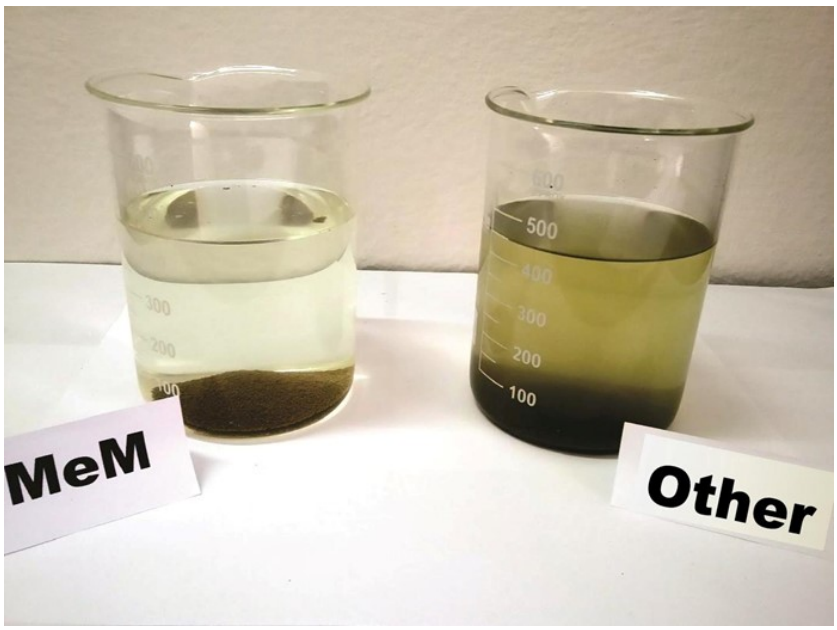


Fig. 1. Illustration of the good water quality allowed by the high stability of MeM in water compared to other products.

on fish age. Feeds were coated with 17 alfa-methyltestosterone during the 21, 25 or 28 first days according to the group (MEM_21, MEM_25 and MEM_28 respectively) and with non-coated MeM until the end of the experiment at 28 days. A fourth group was fed a Brazilian commercial crumbled feed from the market as control. The experiment was conducted at Tilapicultura laboratory in CAUNESP (Centro de Aquicultura da UNESP, Universidade Estadual Paulista, Brazil). Fish were reared in 120L tanks (100L) at 300 fish/tank. Water temperature was 25°C. Feed was offered ad libitum.

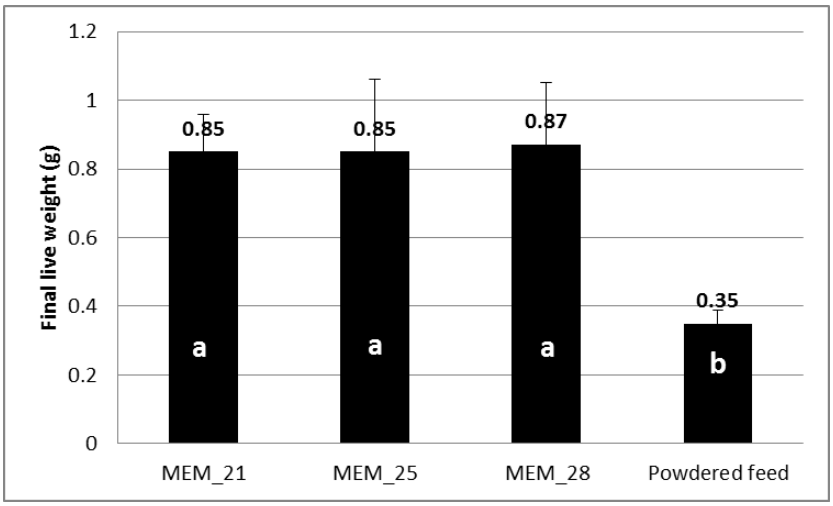


Fig.2. The use of micro-extruded feed improves final live weight of tilapia juveniles by 244% at 28 days after yolk sac absorption in comparison to a standard crumbled feed. Mean±standard deviation of final weight of tilapia juveniles submitted to different feeding programs during 28 days. Means with different letters differ from each other by Tukey test at 5% probability level.

Results showed a clear improvement in growth since live weight 28 days after yolk sac absorption was multiplied by 2.4 when tilapia were fed MEM® compared to crumbled feed. Biomass production per tank was more than doubled with the use of MEM®. In parallel, feed efficiency was significantly improved since the feed conver-

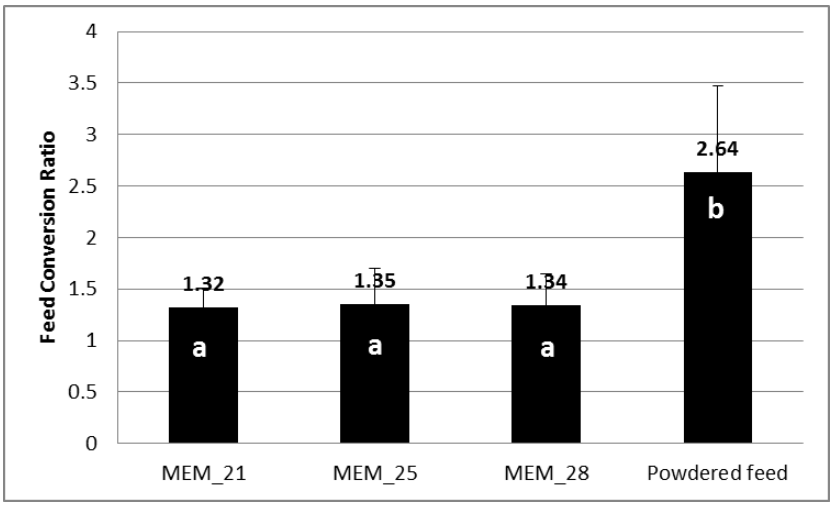


Fig. 3.. The use of micro-extruded feed decreases feed conversion ratio (FCR) of tilapia juveniles by 1.3 during the first 28 days after yolk sac absorption in comparison to a standard crumbled feed. Mean±standard deviation of feed conversion rate of tilapia juveniles submitted to different feeding programs during 28 days. Means with different letters differ from each other by Tukey test at 5% probability level.

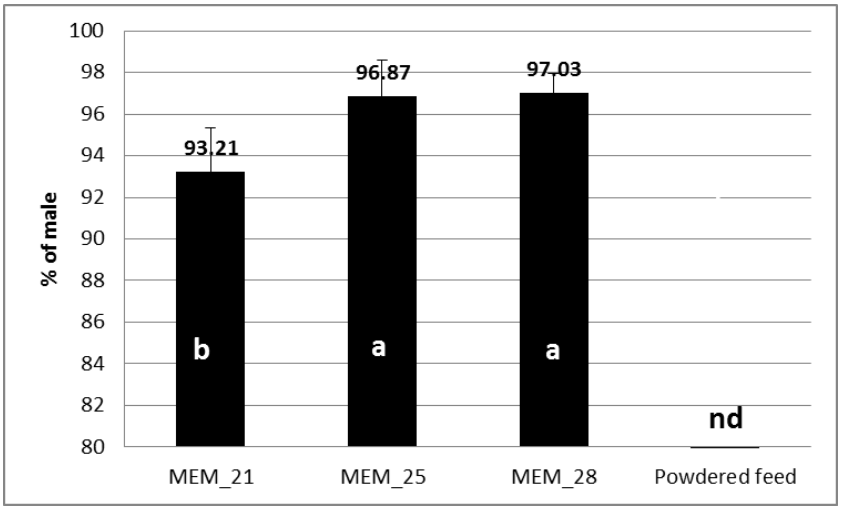


Fig. 4.. The use of micro-extruded feed would allow to shorten sex reversal period by 3 days (at 25°C) without impairing male proportion. Mean±standard deviation of feed conversion rate of tilapia juveniles submitted to different feeding programs during 28 days. Means with different letters differ from each other by Tukey test at 5% probability level.

sion ratio (FCR) was divided by two. It means that eating MEM®, tilapia required half of the time to reach the same live weight and require twice less feed. Tilapia were 2.4 times bigger at the end of the sex reversal period. More, results showed that, at 25°C, the use of MEM® allowed to shorten sex reversal period by 3 days without affecting percentage of males. On survival, results did not show difference (between 57% and 61% without significant difference between groups).

The results obtained in the study confirm past results already observed and published. They demonstrate that feeding tilapia larvae with high quality micro-extruded feed is definitely a good technical strategy to improve fish performances and supply strong larvae at the end of the sex-reversal period. It would also allow farmers to shorten this period, and thus increase productivity through more cycles per year

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# The Importance of dedicated R&D providers in the development of specialized feeds for targeted outcomes

By Jessica Harvey, Aquatic Technician, Pontus Research Ltd., United Kingdom.

Exponential population growth and increased awareness of the health benefits from consuming fish and seafood has seen consumption of these products outpace population growth, and subsequent year-on-year growth of aquaculture production (FAO, 2018). This is accompanied by an increased pressure on the industry to reduce costs, increase yields and improve sustainability (Naylor et al. 2009). Optimizing diets towards improving growth, digestibility and survival, as well as finding low-cost, sustainable alternatives to fishmeal and fish oil will be vital to support future industry growth (Deutsch et al., 2007; Naylor et al., 2009; Alhazzaa et al., 2018). Driving innovation through targeted R&D is at the forefront of finding solutions to these important issues facing this globally significant food production sector.

Whilst many promising novel ingredients for various targeted outcomes are proposed, many fail to reach market due to a lack of time and resources for adequate research and development activities such as in-vivo trialing, amongst other factors (Klinger and Naylor, 2012). Dedicated R&D providers such as Pontus Research, based in the UK, provide essential services to assist companies to overcome these obstacles, through provision of in-vivo trialing, advice and other services.

## Dedicated Facilities

Bespoke facilities, designed especially for the task of working with fish and shrimp of all life stages, will increase capacity and capability to cater for R&D in all areas of the growing aquaculture

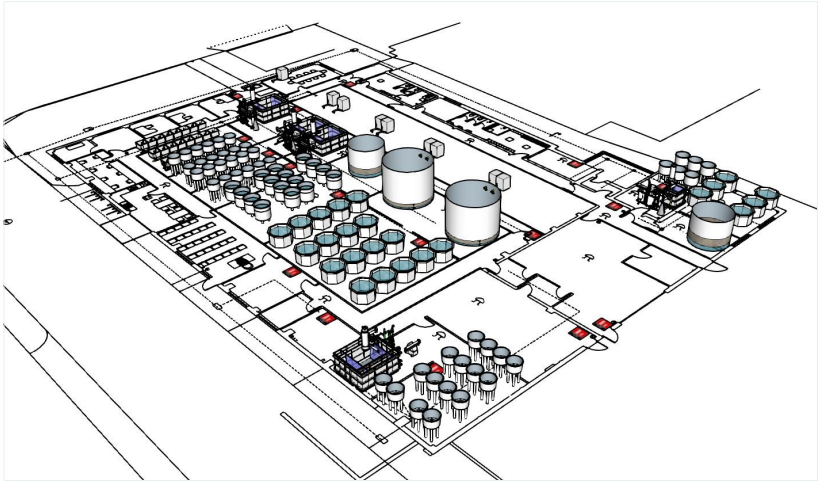

Fig. 1. Pontus Research is expanding their world class R&D facilities in the UK .

industry. In order to cater for the complex needs of the industry, Pontus Research is currently undergoing a major project to expand their world class R&D facilities in the UK (Figure 1). These facilities will be able to facilitate a wide range of trials at different life stages, from larval to broodstock, or life cycle and production cycle studies for both aquaculture and ornamental species (Figure 2).

Recirculating Aquaculture Systems (RAS) when used for R&D allow for fully customizable and precise control of all parameters, including temperature, lighting regimes and salinity (Figure 3). These can be tailored to the species and the trial design to ensure the most accurate, representative and repeatable results, ensuring that scientific integrity is central to the work. Dedicated quarantine systems coupled with total separation of the various research systems enable the highest level of biosecurity, ensuring the wellbeing of the animals and the highest possible quality data.

Trial designs are fully flexible and can include studies investigating multiple treatments or products in a single trial, or dose response studies on single products, among myriad other designs. Such trials can have significant value at all stages of a product's development, from feed formulation for initial testing of novel ingredients or testing existing products for new species, to refinement of the product in the final stages of a product development cycle.

## Nutrition and Growth

Well planned studies when carried out at dedicated and specialized trial facilities allow for a wide range of data to be collected; covering all aspects of performance, including: specific growth rates, feed conversion, feed intake, nutrient digestibility and retention, assessment of micronutrient deposition in muscle, liver and bone, haematocrit, intestinal microbiome and histology, digestive enzyme activity and muscle pigmentation assessment.

Such data can be used to address current industry-wide issues, such as finding cost effective, sustainable fishmeal and fish oil replacements through utilizing by-products from poultry and swine sectors (Campos et al., 2017; Gachango et al., 2017), insect meal (Magalhães et al., 2017; Llaconisi et al., 2018), or microbial products (Kuhn et al., 2009). Whilst much of current movement towards sustainable feeds is targeted at the grow-out stage, increasing costs and demand will drive the need for further R&D for products aimed at broodstock, for example, to improve fecundity through inclusion of pigments (Hansen et al., 2014) and egg quality, in a sector dominated by feeds containing fishmeal and fish oil.

Focused R&D will also continue to play a major role in exploring incorporation of ingredients to improve larval quality and survival, such as β-glucan to promote transferal of maternal immunity (Ghaedi et al., 2015), and new enrichment products to improve live-feed quality (Katagiri et al., 2016; Takaoka et al., 2011), as well as high quality first feeding products based on new and emerging ingredients.

Fig. 2. The new facilities will be able to accommodate a wide range of studies for aquaculture and ornamental species .

## Wellbeing and Health

Targeted R&D also plays an essential role in development of specialised feeds to promote health and wellbeing for different species, at different life-cycle stages. They provide the comprehensive analyses that are required to develop products and provide key data for them to reach the market.

Therefore, the expansion at Pontus Research will also include dedicated world class challenge systems, to be used for studies looking at new or improved vaccines, medicines and nutraceuticals, for example. Fully licensed facilities such as these are vital to test efficacy of and tolerance to products which are becoming increasingly important within the aquaculture industry with the drive to reduce chemical and antibiotic use.

Faruk and Anka (2017) recognize that a major challenge in the industry is the prevention of disease outbreaks, associated with high stocking densities, particularly in the immature immune systems of fish in early developmental stages, emphasizing the importance of prophylactic treatments such as probiotics and phytogenics in larviculture. Studies can allow the discovery and development of a wide range of nutraceutical products in larviculture for targeted outcomes at this vulnerable stage, such as promotion of larval health, disease resilience and immune response.

In R&D, RAS systems allow for fully customizable control of all parameters.

Prevalence of economically devastating diseases such as Rainbow Trout Fry Syndrome (RTFS) and Saprolegniasis with currently inadequate preventions (Chapela et al., 2018; Earle and Hintz, 2014) and Bacillary necrosis in Pangasius (BNP) which is showing resistance to existing treatments (Faruk and Anka, 2017) are driving a need for new treatments and preventions, from the very earliest stages of development.

The growing global aquaculture industry will only continue to be limited by challenges such as brood quality, survival limitations and disease, amongst others. Innovation in feed products towards targeted outcomes to overcome these challenges, and comprehensive trialing and development of novel products at facilities around the world such as those at Pontus Research will be fundamental to facilitate future growth and meet ever-growing consumer demands for more, better quality and more sustainable fish and shrimp products.

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Pontus Research will be attending Aquaculture 2019 in New Orleans, 7-11, March, 2019. (booth 415).

# Industry events

**Send your meeting details to:**
editor@hatcheryfeed.com

## *January*

| | | |
|---|---|---|
| 31 – Feb 2: | Aquaex India 2019, Hyderabad, India | https://www.aquaexindia.com/ |

## *March*

| | | |
|---|---|---|
| 7 -11: | Aquaculture 2019, New Orleans, Louisiana, USA | http://www.marevent.com/AC19_NEWORLEANS.html |
| 11 -13 | 6th Global Feed & Food Congress 2019, Bangkok, Thailand | http://gffc2019.com |
| 18 – 29: | Inclusive aquaculture development, Bonn, Germany | https://www.wur.nl/en/Research-Results/Research-Institutes/centre-for-development-innovation/short-courses/show/CDIcourse_inclusive_aquaculture.htm |

## *April*

| | | |
|---|---|---|
| 28 – May 3: | 23rd International Seaweed Symposium, Jeju, Korea | http://www.iss2019.org/ |
| 29 – 30: | 13th World Congress on Aquaculture & Fisheries, Seoul, Korea | https://aqua.conferenceseries.com/ |
| 11 – 12: | Food and Feed Drying Technology, Europe (Norway), Ås, Norway | https://fie.com.au/events/drying-norway |
| 15 – 17: | Aquafeed Extrusion Technology, Europe (Norway), Ås, Norway | https://fie.com.au/events/aquafeed-extrusion-norway |

## *June*

| | | |
|---|---|---|
| 12 - 14: | VICTAM International, Cologne, Germany | https://victaminternational.com |
| 12 : | 12th Aquafeed Horizons, Cologne, Germany | https://feedconferences.com |
| 18- 20: | Asian Pacific Aquaculture 2019, Chennai, India | www.marevent.com |

## *July*

| | | |
|---|---|---|
| 15 – 17: | Short Course: Applied Food & Feed Extrusion Thailand, Kasetsart University,Bangkok, Thailand | https://fie.com.au/events/applied-food-feed-extrusion-thailand |

# Hatchery Mart

## The virtual marketplace

### COMPLETE FEED —BROODSTOCK



### COMPLETE FEED —LARVAL








### LIVE FEEDS — ALGAE


# Hatchery Mart

## LARVAL FEED —ALGAE



## LARVAL FEED — ZOOPLANKTON


*Visit: hatcheryfeed.com to view online: links are live in digital editions.*

## PROBIOTIS


## PROTEIN


## WATER CONDITIONERS


## FEED EQUIPMENT


### Marketplace Directory

Aliga
http://aliga.dk/

Alltech Coppens
www.alltechcoppens.com

Extru-Tech
www.extru-techinc.com

Inve
www.inveaquaculture.com

Lallemand
www.lallemandanimalnutrition.com

ProCheate
www.prochaete.com

Reed Mariculture
www.reedmariculture.com

Skretting
www.skretting.com

Sparos Lda
http://sparos.pt

Tom Algae
http://www.tomalgae.com

Zeigler
www.zeiglerfeed.com

Hatchery Mart

Let's get your products in Hatchery Mart

sales@aquafeed.com


# THE FUTURE OF FEED & FOOD
# **ARE WE READY?**

## Date & Venue

The 6th Global Feed & Food Congress (GFFC), organized by the International Feed Industry Federation (IFIF) with technical support provided by the Food and Agriculture Organization of the United Nations (FAO) and in collaboration with VIV worldwide will be held at the exclusive Shangri-La Hotel in Bangkok, Thailand, on **11-13 March 2019**.

## Join us

The 6th GFFC is expected to attract executive level delegates from Asia, Europe, Africa and the Americas. Join us and you will:

— Experience exceptional speakers who will share their insights on the future of feed and food.

— Network and discuss strategy with business leaders, senior government officials, experts and policy makers from the feed & food value chain.

— Engage with leading animal nutrition and food companies, food chain partners, international organisations, national authorities and international civil society.

## Theme & Topics

The 6th GFFC theme **'The future of Feed & Food – are we ready?'** links to the global challenge to provide safe, affordable, nutritious and sustainable animal protein sources through innovative solutions to feed 9 billion people by 2050 and reflects our shared vision to achieve this for a growing world population now and for the future.

The 6th GFFC will look ahead at key topics for the feed & food chain, including:

**— Digital Revolution**
**— Sustainability**
**— Feed & Food Safety**
**— Nutritional Innovation**
**— Global Regulations & Policy**
**— Markets & Trade**
**— Future of Farming Systems**

## How to register?

**For more information please visit www.gffc2019.com**

**Organiser** IFIF Feed the world

**Technical Support** Food and Agriculture Organization of the United Nations

**in collaboration with** viv

**Supporting Partner** TFMA สมาคมผู้ผลิตอาหารสัตว์ไทย THAI FEED MILL ASSOCIATION

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