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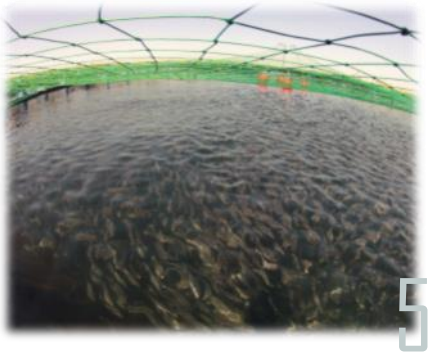

**Cover story Barramundi larvae. Photo: Valentin Thépot, MBD Energy, Australia.*

HATCHERYFEED 2017

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From the Publisher

"Today knowledge has power. It controls access to opportunity and advancement"

We've all heard those words by business guru, Peter F. Drucker — or words like them, but in a specialized field like hatchery feed and nutrition, it isn't that simple: there is information to be had—but it's not always easy to find. Hatcheryfeed.com is changing that. This is the first of our magazines for 2017. We've increased frequency to four issues a year and it's now freely available in digital and PDF format, (and for purchase if you like to get your hands on old fashioned paper and print). We've also completely updated and redesigned the Hatcheryfeed.com website and are constantly adding to the already rich collection of resources available.

Aquafeed.com is all about empowering stakeholders throughout the aquafeed sector by the transfer of information, an essential tool for the successful functioning of an industry value chain. Hatchery feed and nutrition is so specialized it needs and deserves its own channel and that is why we created Hatcheryfeed.com: we are happy to welcome you to our global community of industry professionals.

Suzi Dominy, Editor & Publisher

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Meeting growth potential of fish larvae: microdiet formulations and technology

By Luis Conceição*, Wilson Pinto, SPAROS Lda, Olhão, Portugal

Microdiets for early weaning of marine fish larvae: there is room for improvement

Replacement of live feeds early in development has been a priority in academic and industrial marine fish larval research since the 1990s. Progress has been considerable, with good weaning results being currently delivered by several commercial microdiets, in particular for major cultivated species such as European seabass and gilthead seabream in Europe and red seabream and olive flounder in Asia. Recently, significant progress on weaning has also been achieved for some candidate species for the expansion of the aquaculture industry in Southern Europe, such as Senegalese sole (Canada et al., 2016; Engrola et al., 2016; Pinto et al., 2015, 2016) and greater amberjack (Conceição et al., 2016a). Still, there is plenty of room for improvement in microdiets for marine fish larvae, in particular for the very early stages.

Even if we have a reasonable understanding of what fish larvae roughly require in their diets: high levels of protein, essential fatty acids, and micronutrients, provided by highly digestible ingredients, the exact nutritional requirements are poorly understood (Hamre et al. 2013). Nutrition is important in terms of survival and growth performance, but also for a healthy immune system or a normal skeleton formation. This is true for the more traditional cultured species such as European seabass, gilthead seabream, red seabream and olive flounder, and certainly also for the emerging species.

Microencapsulation and binding technologies are to improve microdiets

Conceiving an ideal microdiet for fish larvae is only possible through a holistic approach. Although its nutritional adequacy to the requirements of a given species is the first factor to be considered, the technological process involved in microdiet production must also be taken into account. Technology largely influences the physical properties of the microdiet in water, affecting ingestion, nutrient loss to the surrounding water (leaching) and digestion (Khater et al., 2014). Optimal physical properties such as floatability, sinking speed, dispersion both in tank surface and water column will ensure a higher ingestion by fish larvae, ultimately determining the success of weaning and to what extent growth potential is realized. In addition, the high surface-to-volume ratio of microdiet particles makes them prone to leaching of water soluble nutrients, particularly in smaller sizes (< 0.5 mm). This loss may compromise larval growth by reducing the nutrient input to larval bodies, as well as lead to degradation of the rearing water quality.

Most commercial microdiets for fish larvae are produced by extrusion, a cost-effective technological process where a

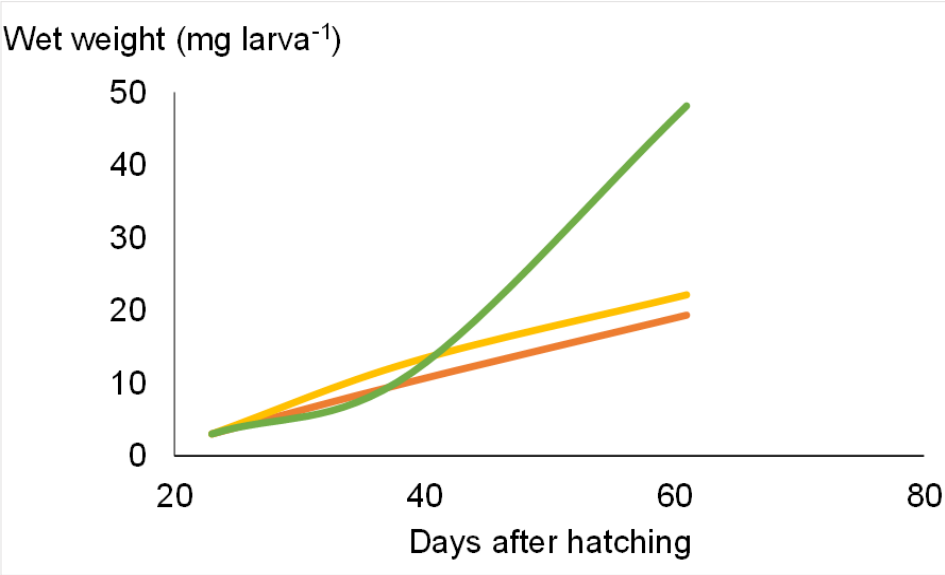

Fig. 1. Growth trajectories (wet weight, mg) of Senegalese sole larvae fed experimental microdiets consisting on the same ingredient formulation, but produced with different technological processes. Orange – Double encapsulated particles (internal encapsulation of water soluble nutrients and outer layer of polymeric binder); yellow – Single encapsulated particles (outer layer consisting of polymeric binder); Green – microparticles produced by low-shear extrusion.

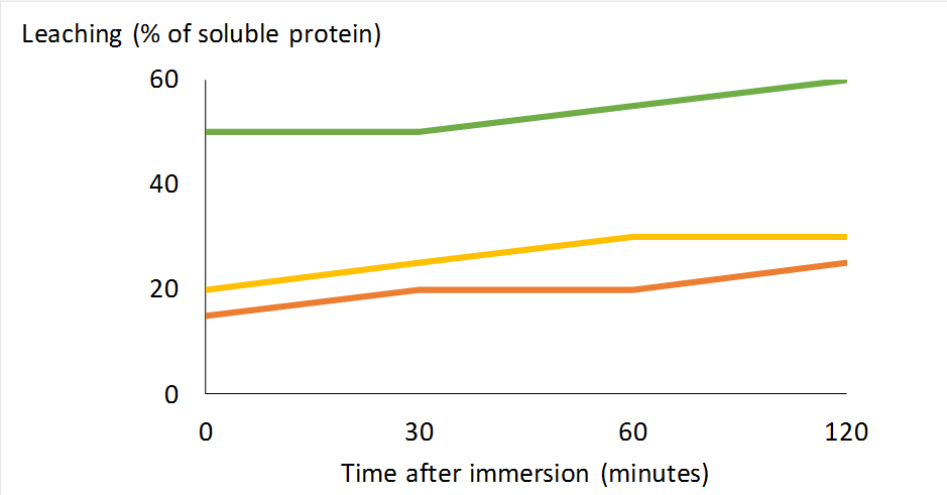

Fig. 2. Leaching pattern (seawater) of soluble protein in different experimental microdiets with a similar ingredient composition, but differing in the technological production process. Orange – Double encapsulated particles (internal encapsulation of water soluble nutrients and outer layer of polymeric binder); yellow – Single encapsulated particles (outer layer consisting of polymeric binder); Green – microparticles produced by low-shear extrusion.

mixture of ingredients including a binder is pushed through a die of a desired cross -section. The resulting pellets are subsequently dried, crumbled and sieved to desired particle sizes. However, crumbling often disrupts the outer layer of the microparticles binder, easing nutrient leaching after water immersion. Arising as an alternative to extrusion, microencapsulation gathers a set of technologies gaining importance over the last decades with potential for nutrient delivery (Vehring et al., 2007; Chiellini et al., 2008). In microencapsulation, the ingredient mixture is entrapped into a matrix-like particle (microparticle) or a reservoir-type particle (microcapsule), implying its protection by an outer layer or a continuous matrix, instead of being directly exposed to the environment. Several microencapsulation techniques can be employed in microdiet production (e.g., Langdon, 2003), and several commercial diets found in the market include microencapsulation as partial or full technological process. Figure 1 depicts results from an experimental trial where Senegalese sole larvae were fed microdiets consisting of the same ingredients but produced either by extrusion or microencapsulation processes. Results showed that although effective in reducing leaching of water soluble nutrients (Fig. 2), microencapsulation may also affect microdiet digestibility. Therefore, microencapsulation will only be an alternative to extrusion if the correct balance between these two factors is achieved (Yúfera et al., 2002; Kvåle et al., 2006).

A focused R&D effort pays-off: development of a high performance diet for sole

Over the last 7 years, SPAROS Lda in collaboration with CCMAR / University of Algarve conducted a strong research effort to develop a microdiet able to sustain growth and development of Senegalese sole larvae from an early developmental stage. This effort, supported by projects MICALA (Project 13380; FEDER/PO Algarve21/QREN 2007-2013/EU) and SOLEAWIN (Project 310305/FEP/71; PROMAR and FEDER),

Sole at hatchery in Portugal

focused on three main areas: larval nutrition, microdiet technology and rearing protocols. In these projects, adequacy of different sources and levels of both macro (protein and lipids) and micronutrients (vitamins, minerals), as well as production processes as extrusion or microencapsulation have been extensively studied, resulting in the recent launching of a novel microdiet – WINFLAT.

Along with significant improvements made on larval zootechnology during the pelagic phase (until 15 days after hatching), the WINFLAT microdiet for flatfish has strongly contributed for a significant reduction of the age of full weaning in Senegalese sole larvae. While in 2010 a full weaning would only be feasible at 40 DAH, it is nowadays possible to achieve survival over 90 % and growth rates above 10 %/day with a full *Artemia* replacement at 25 DAH (Engrola et al., 2016). However, this success story does not seem to be yet finished, whereas recent trials show that with a feeding protocol starting at 15 DAH and consisting of an 80 % replacement of live-feed by WINFLAT have achieved excellent growth results (Fig. 3), indicating that in a near future it will be possible to fully wean Senegalese sole at the very start of the benthonic phase (15 DAH). Interestingly enough, when this

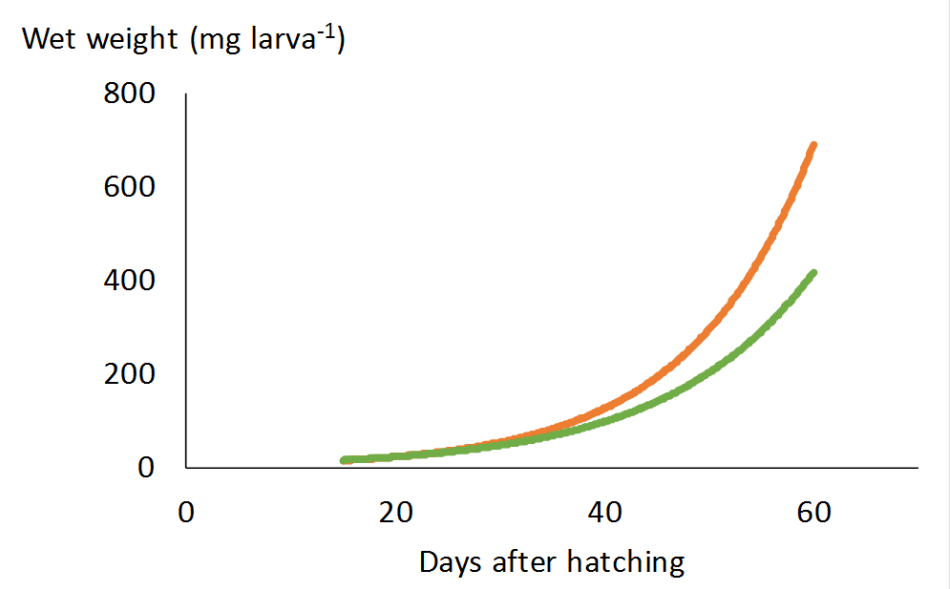

Fig. 3. Growth trajectories (wet weight, mg) of Senegalese sole larvae fed on live-prey until 25 days after hatching and subsequently weaned with WINFLAT (green line) or fed 80% WINFLAT and 20 % live-prey from 15 to 23 DAH and WINFLAT only onwards (orange line).

Gilthead seabream cage farm in Portugal

diet was used on gilthead seabream larvae results were not as positive: a lower growth was observed compared to other microdiets.

High performance larvae require specific diets

Several commercial inert microdiets provide good results in terms of growth and survival, in particular for species of medium growth potential and optimal temperatures around 18-22°C, such as European seabass, gilthead seabream, red seabream and olive flounder. However, faster growing larvae of species such as tuna, amberjack, yellowtail, groupers, cobia and meagre,

are likely to have particularly high requirements in amino acids, fatty acids and other nutrients, considering their tremendous growth rates and higher optimal temperatures. Therefore, specific microdiets are likely required.

Cannibalism problems are also commonly observed in larvae of Bluefin tuna, greater amberjack (Conceição et al. 2016a), meagre (Vallés and Estévez 2015; Saavedra et al. 2016) and other fast-growing fish species. These cannibalism problems are certainly exacerbated if nutrition is not optimal. Conceição et al. (2016a) have shown that greater amberjack (*Seriola dumerili*) larvae fed on a novel microdiet developed for very fast growing larvae led to a 40% higher growth, and reduced cannibalism compared to a control commercial microdiet (Fig. 4), in a R&D project in collaboration with FUTUNA Blue España and ICMAN-CSIC (Spain).

This microdiet (WINFAST), using the same production technology of WINFLAT, was tested with meagre and gilthead seabream larvae at IPMA – EPPO (Olhão, Portugal) in Spring 2016 (Conceição et al. 2016b), using two different lipid levels (16 and 22% crude lipid) and compared to a current premium microdiet (COMM) for marine fish larvae (17% crude lipid).

Diet	Weight (g, 65 DAH)	Size dispersion	Age of full weaning	Cannibalism	Acceptance
FAST	9,85 (40 % higher)	+	34	+	Very good
COMM	5,85	+++	42	+++	Difficult on first days

Fig. 4. Farm scale trial with amberjack larvae reared at 25°C fed a commercial microdiet (COMM) or a novel microdiet developed for FAST growing larvae. Adapted from Conceição et al. (2016a).

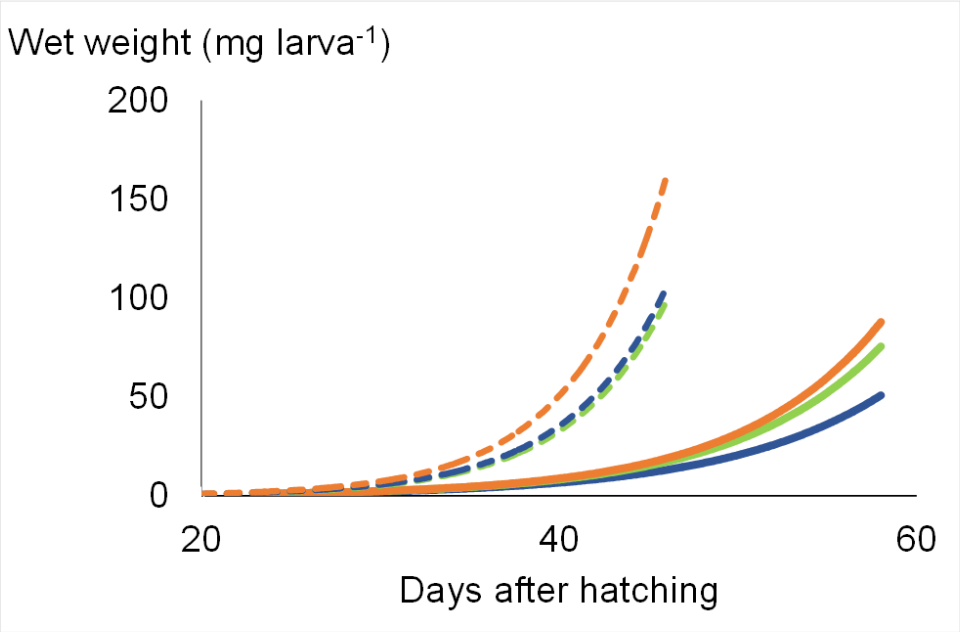

Fig. 5. Growth trajectories (wet weight, mg) of meagre and gilthead seabream larvae fed a commercial diet (blue lines) or diets with two different lipid levels (16 – green line; 22 – orange line). Semi-continuos lines refer to the trial conducted with meagre, while continuous lines refer to the trial conducted with seabream. Adapted from Conceição et al.

Meagre weaning started at 20 days after hatching and growth over a period of 26 days (Fig. 5) was around 20 % higher for the high lipid diet (FAST61/22) compared

to the other 2 diets, while the survival rate with FAST61/22 and FAST64/16 was 92% and 51% higher than the COMM diet, respectively. Therefore, meagre larvae have higher nutritional requirements compared to slower growing species, and require microdiets rich in both protein and lipids. For gilthead seabream, after a 36 days trial, survival rates were considerably better for both FAST diets, while growth for FAST61/22 and FAST64/16 was 42 % and 31 % higher than the COMM diet, respectively (Fig. 5). Gilthead seabream also require microdiets with high lipid content, what is surprising considering its lower growth potential compared to meagre and amberjack (Conceição et al. 2016b).

Live feed replacement will be increasingly a reality, leading to many species start feeding exclusively (or almost) on high quality, inert microdiets.

Future of microdiets for marine fish

As knowledge on larval nutritional requirements progresses and newer technologies become available, we will have better performing microdiets for marine fish. This will mean faster growing larvae, with higher survival rates, and leading to better quality juveniles. Live feed replacement will be increasingly a reality, leading to many species start feeding exclusively (or almost) on high quality, inert microdiets. The future starts today!

ΩHF

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References

A good start is the key to successful fry production

By Peter Jessen, Technical Support Manager, Aller Aqua

A good start is key to achieving healthy fish throughout the production process and therefore for success in fish farming. Good water environment, high hygiene standards and optimal care are all important criteria. Also feed plays an essential role in fry production.

Granulates distribute on the water surface and sink slowly Photo © Aller Aqua

The feed must cover all the quickly growing fry's needs, and must:

- contain the appropriate nutrients
- be easily digestible
- stimulate appetite for quick growth and minimum waste of feed

Physically the feed must be:

- dust free
- quickly and easily digestible
- easy to use with a minimum of waste
- available in sizes which allow fry of any size to eat

Aller Aqua, one of the world's most experienced producers of high quality extruded fish feed for aquaculture, offer a series of products adjusted to the aforementioned requirements; Aller Aqua Hatchery Pack™.

Raw materials of the highest quality

The hatchery pack products have been continuously developed and are characterized by a high degree of stability, where the quality of the raw materials is more important than the cost. The formulations have evolved based on demands for a high and stable quality of the feed, and the fluctuating prices of raw materials does not influence this. Fry feed is typically based on a high content of marine raw materials, including krill meal.

Krill

Krill is a crustacean, living in the Antarctic Ocean. It is said to constitute the largest living biomass on earth and is estimated

at 400 million tonnes. Due to fresh krill's limited durability and the large distances in the Antarctic Ocean, krill meal is prepared on factory boats, where the freshly caught krill is taken directly from catch to processing. Meal from krill is therefore very fresh and known for its attractive taste, which stimulates the appetite of farmed fish.

Krill meal contains a minimum of 56% protein and 20-30% fat, as well as approximately 130 ppm of natural astaxanthin, which besides being a colorant is also a very effective antioxidant. Approximately 15% of the fat in krill meal is the two important omega -3 fatty acids, EPA and DHA, but it is just as important that more than 40% of the fat is made up by phospholipids.

Live tissue consists of cells, enclosed by cell walls. Fry grows fast compared to their size, and thus create a lot of cells. Phospholipids are considered the building blocks of cell walls and thus it is important for the development of healthy, flexible and functional cells that the fry are well supplied with phospholipids.

Production of Hatchery Pack

The products are warm-extruded. In this process the products are subjected to pressure cooking, which combined with mechanical processing, activates the feed's content of starch. During the drying and cooling stages of production the starch solidifies and forms a lattice structure, which is what gives the finished product its robust yet open structure, where both pills and granulates can be sifted to dust free products.

The extrusion process results in an increased digestibility of certain nutrients, but equally important, the process further leads to feed being stable in water, and thus does not dissolve until eaten. Any wasted feed will sink to the bottom of the basin and be flushed away by water flow or otherwise removed.

Trout fry © Aller Aqua

Hatchery Pack – both minipellets and granulates

Ten years ago minipellets for fry entered the market. The series of minipellets included the smallest pellet on the market – just 0.2 mm. This small pellet was succeeded by four pellets covering the interval from 0.4 mm up to 1.3 mm. The minipellets were a big step in the direction of dust free feed, and quickly gained widespread recognition.

However, feeding with minipellets can be a challenge as the more compact structure has the effect that it is difficult to use the pellets without waste, in terms of feed that sinks to the bottom of the basins quicker than the fish can eat it. Many fish farmers have thus decided to continue using granulates and the interest in granulates is currently on the rise.

Granulates

Granulates are the original form of industrially processed starter feed. The production of granulates begins by producing a larger pellet. The pellets are then cut, and subsequently sifted and divided into the desired sizes.

The advantages of granulates are many, but most importantly they:

- float easily on the water surface and spread over a large area regardless of feeding technology
- sink slowly and allow the fish a natural eating pattern in all depths of the water
- have a size distribution which satisfies the natural spread in fish sizes of ungraded fry
- have an open structure, allowing the digestive juices of the fish fast and effective access to the nutrients in the feed, which is of great importance in the fry's short digestive system.

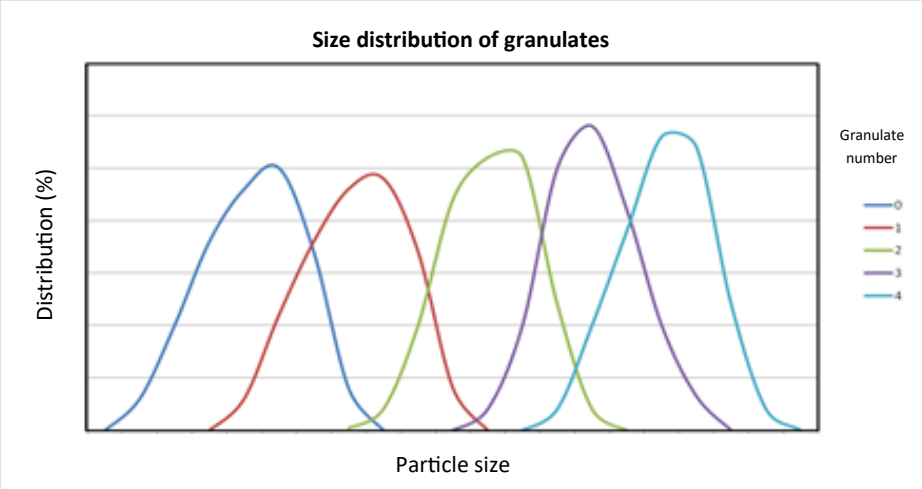
Floating and slow sinking speed

Granulates have a large surface area and a low density. It is therefore easy to get the granulates to float, before they slowly sink. An effective feeding, which ensures the fry the possibility of eating all of the feed, is attainable with all the most common feeding technologies. It is unnecessary to fit the feeding systems as close to the surface as possible, heightening the risk of splashing water. It is therefore easier to keep the feeding system dry, clean and hygienic.

All fry are able to eat

Newly hatched fry are not a homogenous group. Some fry hatch earlier than others and are thus more developed when the farmers begins to feed with fry feed. When the fry starts eating, not all of them have equal appetite and the fry grow at different paces. Granulates accommodate these variations. When the original pellet is cut, a natural variation in size occurs. The subsequent sifting process divides the granulates into groups relating to the corresponding granulate sizes. The graph visualizes how the granulate sizes overlap.

The overlap can also be illustrated differently. The picture above gives an impression of the overlap in sizes. The result is that all fry, regardless of size, are able to eat and grow.



Dust is no longer a problem

Previously granulates have been known to contain an amount of fine particles/ dust that could cause a higher level of nutrients in the water, and often caused problems with infections in the gills of the fry. The picture above shows the variation in granulate size, but also the fact that there is no dust in the products.

The use of warm extrusion for the processing of granulates, combined with modern technology for sifting of the products, results in modern granulates being dust free.

Efficient uptake of nutrients

Fry grow fast and thus need to absorb relatively large amounts of nutrients. This is why fry are often fed throughout the day or even around the clock, in an attempt at getting the fish to eat several times.

Fish, and in particular fry, have a very short digestive system and the intensive feeding regime only allows limited time for the digestive system of the fish to absorb the nutrients from the feed. It is therefore important that the feed is both easily digestible and at the same time has a shape that allows the fry to quickly utilize it.

By contrast to the more compact minipellets, the structure of the granulates is open and nutrients easily accessible. This gives the gastro-intestinal digestive juices optimum possibility of entering the feed particle and processing it via the very large surface.

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Granulate surface versus pellet © Aller Aqua

More information

Peter Jessen, Technical Support Manager, Aller Aqua

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Improved growth, faster development and enhanced stress resistance in barramundi (*Lates calcarifer*) larvae fed mixed algal diet enriched rotifers

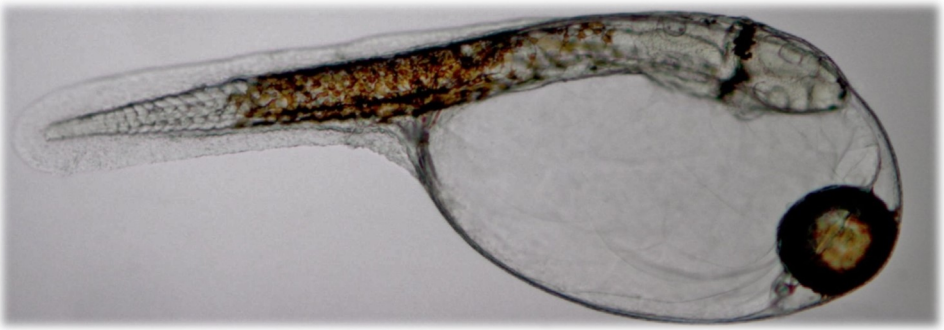
By Valentin Thépot, Senior Research Assistant at MBD Energy, Townsville, Australia.

The high production cost of live feeds has led to significant investments in research to reduce or even replace their use in marine finfish aquaculture. The aim of this study was to test if the quality and performance of barramundi larvae could be improved by feeding rotifers enriched with microalgae blends.

The primary goal of marine fish hatcheries worldwide is to produce more and better quality seedlings at a minimized cost. However, very little remains known regarding the nutritional requirements of marine fish larvae compared to freshwater fish. While most freshwater fish larvae can be fed formulated diets from the start of exogenous feeding, marine fish larvae have to first be offered live feed. Common live feeds in commercial marine fish hatcheries include rotifers (*Brachionus sp*.) and brine shrimp (*Artemia sp*.) which are respectively fed to larvae at early (2-30 dph) and later (8-40 dph) larval development stages.

Because of the high production cost of live feed, significant research has been allocated to reducing or even replacing the use of live feed but to this day, live feed reduction and alternatives have been met with limited success.

Live feed alone are of poor nutritional quality and are generally enriched with



Bottlenecks still remain at the larval stage of barramundi rearing.

microalgae or oil emulsions prior to be fed to the fish larvae. There is however a high cost associated with the production of live microalgae therefore cost effective, off the shelf options such as microalgal pastes are utilized. Commercially available microalgae include *Nannochloropsis oculata* and *Chlorella vulgaris* and in addition to enriching the live feed, they are also used to dose the larval tanks to promote "green water". The green water technique both maintains the nutritional quality of rotifers as a feed and provides the fish larvae with a more shaded environment, resulting in improved feed ingestion, survival and growth.

Although barramundi has been cultured for over 30 years in South East Asia and Australia, bottlenecks still remain for the larval phase. Slow growth, low survival, deformities and high sensitivity to stress are only a few of the symptoms affecting barramundi larvae, especially at critical times in their development such as metamorphosis. These issues have been mainly associated with deficiencies in essential fatty acids (EFA), in particular the long chain highly unsaturated fatty acids (omega-3s) such as docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA) and arachidonic acid (ARA). Early larval rearing of barramundi in Australia relies on two microalgae for the rotifer feeding period: (1) *N. oculata* or (2) DHA enriched *C. vulgaris*. The first is rich in EPA, has moderate amount of ARA and no DHA while the latter is low in EPA, has no ARA but is high in DHA. Looking at the complementary fatty acid profile of the two pastes, researchers at James Cook University (Townsville, Australia) investigated different proportional blends of the two to enrich rotifers for the feeding of 2-13 days old barramundi larvae. The aim of the study was to test if

the quality and performance of barramundi larvae (growth, stress resistance and development) could be improved by feeding the larvae rotifers enriched with microalgae blends (*C. vulgaris* and *N. oculata*) in comparison to a traditional monospecific diet.

Experimental set up

Twelve 100L tanks were stocked with 2 days post hatch (dph) barramundi larvae at a density of 260 ind/L and were offered enriched rotifers straight after stocking. The four treatments feeding each three 100L tanks were rotifers enriched with either *N. oculata, C. vulgaris*, 50:50 or 75:25 blend of the two respectively (based on dry weight). The fatty acid composition of the algal paste, enriched rotifers and larvae was used to track the retention of the EFA. The four groups of larvae were measured at 2, 6, 10 and 13 dph for total length, eye diameter and tail height at the anal vent to keep track of their growth. The larvae were also inspected for the percentage undergoing flexion, the developmental change characterized by the upward flexion of the notochord. Flexion is a nutritionally demanding process and if the nutritional requirements are not met it leads to deformities and poor survival. Finally, at completion of the experiment, 100 13 dph larvae from each group were tested for stress resistance by exposing them to the air on a 250 µm net for three minutes and then returning them to a 1-l aerated beaker. After seven minutes, the numbers of dead and live larvae were recorded. This test was designed to mimic grading which is required for barramundi as early as 13 dph due to their cannibalistic nature.

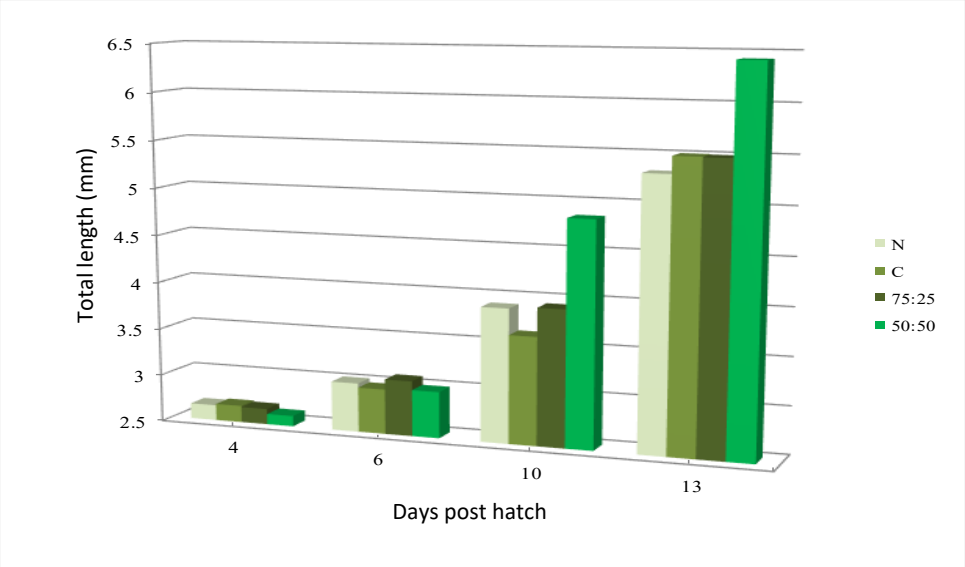


Figure 1. Total length of the 4, 6, 10 and 13 dph barramundi larvae fed one of four diets where: N =*N. oculata*; C = *C. vulgaris*; 50:50 and 75:25 = proportional blends of *N. oculata* and *C. vulgaris* respectively (mean ± SD; n = 150). Different letters denote significant differences (P < 0.05).

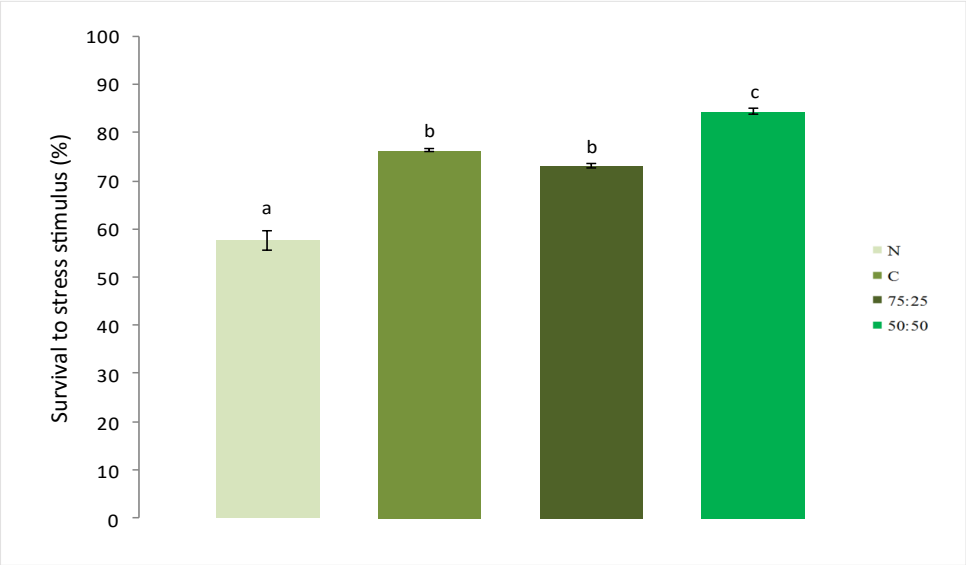


Figure 2. Percentage of 13 dph larvae fed the four diets which survived the stress stimulus where: N =*N. oculata*; C = *C. vulgaris*; 50:50 and 75:25 = proportional blends of *N. oculata* and *C. vulgaris* respectively (mean ± SD; n = 300). Different letters denote significant differences (P < 0.05).

Results

The barramundi larvae fed with the 50:50 enriched rotifer diet outperformed the other three treatments, having significantly greater length, eye diameter and body depth at 13 dph. These trends were already detectable as early as 10 dph. Larvae fed the 50:50 enriched rotifer diet also achieved the highest flexion percentage at 10 dph and recorded the highest survival (85%) to the stress-test at the end of the experiment. On the other hand, the *N. oculata* treatment resulted in the lowest survival rate for the stress test and

Table 1. Fatty acid content (mg/g DW) of 2 and 13 dph barramundi larvae fed the four enriched rotifer diets. Mean values (mean ± SD; n = 3) within rows with different superscript letters are significantly different (P < 0.05).

	2 dph				13 dph			
Fatty acid	***N. oculata***	**75:25**	**50:50**	**C. vulgaris**	***N. oculata***	**75:25**	**50:50**	***C. vulgaris***
C14:0	1.4 ± 0.0^{a}	1.5 ± 0.1^{a}	1.4 ± 0.0^{a}	1.2 ± 0.1^{b}	1.9 ± 0.1^{a}	1.2 ± 0.3^{b}	0.8 ± 0.1^{c}	0.3 ± 0.0^{d}
C15:0	1.3 ± 0.0^{a}	1.1 ± 0.1^{a}	1.1 ± 0.0^{a}	1.1 ± 0.1^{a}	0.5 ± 0.0^{a}	0.4 ± 0.0^{a}	0.3 ± 0.0^{a}	0.3 ± 0.0^{a}
C16:0 (PAL)	17.7 ± 0.5^{a}	17.9 ± 0.6^{a}	16.9 ± 0.7^{b}	16.7 ± 0.6^{b}	21.1 ± 0.5^{a}	19.2 ± 1.2^{b}	17.6 ± 1^{c}	15.8 ± 0.8^{d}
C16:1n-9	0.5 ± 0.1^{a}	0.6 ± 0.0^{a}	0.5 ± 0.0^{a}	0.6 ± 0.0^{a}	0.5 ± 0.1^{a}	0.5 ± 0.1^{a}	0.5 ± 0.1^{b}	0.7 ± 0.1^{c}
C16:1n-7 (POA)	3.8 ± 0.2^{a}	3.6 ± 0.3^{a}	3.5 ± 0.3^{a}	2.7 ± 0.1^{b}	7.3 ± 0.2^{a}	4.8 ± 0.7^{b}	3.1 ± 0.3^{c}	0.5 ± 0.0^{d}
C16:2n-6	0.8 ± 0.0^{a}	0.8 ± 0.3^{a}	0.4 ± 0.0^{b}	0.7 ± 0.0^{a}	0.3 ± 0.0^{a}	0.5 ± 0.1^{b}	0.7 ± 0.1^{c}	1.4 ± 0.2^{d}
C16:2n-4	8.7 ± 0.8^{a}	8.3 ± 0.7^{a}	8.0 ± 0.2^{a}	7.8 ± 0.5^{a}	0.5 ± 0.0^{a}	0.5 ± 0.0^{a}	0.5 ± 0.0^{a}	0.6 ± 0.0^{a}
C16:3n-3	0.4 ± 0.0^{a}	0.4 ± 0.0^{a}	0.4 ± 0.1^{b}	0.4 ± 0.0^{b}	0.3 ± 0.0^{a}	0.3 ± 0.0^{a}	0.2 ± 0.0^{a}	0.2 ± 0.0^{b}
C18:0	8.9 ± 0.2^{a}	8.7 ± 0.1^{a}	8.2 ± 0.3^{b}	8.5 ± 0.2^{b}	7.9 ± 0.3^{a}	8.7 ± 0.2^{b}	8.5 ± 0.4^{c}	9.3 ± 0.3^{d}
C18:1n-9 (OLA)	17.7 ± 0.5^{a}	17.1 ± 0.4^{a}	16.3 ± 0.5^{b}	16.4 ± 0.6^{b}	5.7 ± 0.2^{a}	5.1 ± 0.2^{b}	4.5 ± 0.4^{c}	4.0 ± 0.1^{d}
C18:1n-7	3.9 ± 0.1^{a}	3.9 ± 0.1^{a}	3.7 ± 0.1^{b}	3.5 ± 0.1^{b}	3.6 ± 0.1^{a}	2.9 ± 0.2^{b}	2.2 ± 0.2^{c}	0.8 ± 0.0^{d}
C18:2n-6 (LOA)	7.6 ± 0.2^{a}	8.6 ± 0.2^{a}	7.5 ± 0.4^{a}	9.1 ± 0.6^{b}	4.1 ± 0.0^{a}	5.5 ± 0.5^{b}	7.5 ± 0.7^{c}	12.4 ± 1.0^{d}
C18:3n-6	4.3 ± 0.3^{a}	4.0 ± 0.3^{b}	4.0 ± 0.2^{b}	3.9 ± 0.3^{b}	0.5 ± 0.0^{a}	0.5 ± 0.1^{a}	0.5 ± 0.0^{a}	0.6 ± 0.0^{b}
C18:3n-3 (αLNA)	2.9 ± 0.2^{a}	3.0 ± 0.0^{b}	2.7 ± 0.1^{a}	3.1 ± 0.2^{b}	0.8 ± 0.0^{a}	1.1 ± 0.1^{b}	1.5 ± 0.2^{c}	2.3 ± 0.3^{d}
C18:4n-3	0.6 ± 0.0^{a}	0.6 ± 0.0^{a}	0.6 ± 0.0^{a}	0.6 ± 0.0^{a}	-	0.2 ± 0.0^{a}	0.2 ± 0.0^{a}	0.2 ± 0.0^{b}
C20:0	1.2 ± 0.0^{a}	1.2 ± 0.0^{a}	1.1 ± 0.0^{a}	1.2 ± 0.1^{a}	0.9 ± 0.1^{a}	0.7 ± 0.1^{a}	0.6 ± 0.1^{b}	0.7 ± 0^{b}
C20:2n-6	-	-	-	-	-	0.8 ± 0.1^{a}	1.1 ± 0.1^{b}	2.0 ± 0.1^{c}
C20:4n-6 (ARA)	3.0 ± 0.1^{a}	2.9 ± 0.2^{a}	2.8 ± 0.1^{a}	2.4 ± 0.1^{b}	7.1 ± 0.1^{a}	5.2 ± 0.1^{b}	3.8 ± 0.1^{c}	0.8 ± 0^{d}
C20:5n-3 (EPA)	6.0 ± 0.2^{a}	6.1 ± 0.6^{a}	5.8 ± 0.5^{a}	4.8 ± 0.2^{b}	15.1 ± 0.0^{a}	9.3 ± 0.9^{b}	6.8 ± 0.6^{c}	3.9 ± 0.3^{d}
C23:0	0.3 ± 0.0^{a}	0.3 ± 0.0^{a}	0.2 ± 0.0^{a}	0.4 ± 0.0^{a}	-	0.3 ± 0.1^{a}	0.4 ± 0.1^{a}	0.6 ± 0.1^{b}
C22:5n-6 (DPA)	3.3 ± 0.1^{a}	3.2 ± 0.3^{a}	3.1 ± 0.1^{a}	3.1 ± 0.2^{a}	13.1 ± 0.6^{a}	10 ± 0.4^{b}	7.0 ± 0.6^{c}	4.7 ± 0.4^{d}
C22:6n-3 (DHA)	28.4 ± 1.0^{a}	28 ± 0.7^{a}	26.6 ± 0.7^{b}	28.5 ± 1.3^{a}	1.1 ± 0.1^{a}	4.2 ± 0.2^{b}	8.9 ± 0.3^{c}	15.6 ± 0.8^{d}
EPA/ARA	1.9 ± 0.0^{a}	2.1 ± 0.0^{a}	2.0 ± 0.0^{a}	1.9 ± 0.0^{a}	2.1 ± 0.0^{a}	1.7 ± 0.1^{b}	1.7 ± 0.0^{b}	5.0 ± 0.0^{c}
DHA/EPA	4.7 ± 0.0^{a}	4.6 ± 0.0^{a}	4.6 ± 0.2^{a}	5.9 ± 0.2^{b}	-	1.3 ± 0.0^{a}	0.4 ± 0.0^{b}	3.9 ± 0.0^{c}
DHA/EPA/ARA	-	4.6/2.1/1.0	4.6/2.0/1.0	5.9/1.9/1.0	-	1.3/1.7/1.0	0.4/1.7/1.0	3.9/5.0/1.0
∑ n - 3	38.3 ± 1.2^{a}	38.2 ± 0.4^{a}	36.1 ± 1.1^{b}	37.3 ± 1.7^{a}	17.3 ± 0.1^{a}	15.1 ± 0.9^{b}	17.6 ± 1.2^{a}	22.2 ± 1.4^{c}
∑ n - 6	19.0 ± 0.7^{a}	19.3 ± 0.8^{a}	17.7 ± 0.5^{b}	19.2 ± 0.9^{a}	25.1 ± 0.7^{a}	22.4 ± 1.2^{b}	20.5 ± 1.5^{c}	21.9 ± 1.7^{b}
n - 3/n - 6	2.0 ± 0.4^{a}	2.0 ± 0.2^{a}	2.0 ± 0.3^{a}	1.94 ± 0.6^{a}	0.7 ± 0.2^{a}	0.7 ± 0.4^{a}	0.9 ± 0.6^{b}	1.0 ± 0.6^{c}
∑SFA	30.7 ± 0.8^{a}	30.7 ± 0.8^{a}	28.9 ± 1.0^{b}	29 ± 1.0^{b}	32.2 ± 0.8^{a}	30.5 ± 1.5^{b}	28.3 ± 1.5^{c}	27.1 ± 1.2^{d}
MUFA	25.9 ± 0.9^{a}	25.1 ± 0.4^{a}	24 ± 0.7^{b}	23.2 ± 0.8^{b}	17.1 ± 0.4^{a}	13.2 ± 1.1^{b}	10.3 ± 0.8^{c}	6.0 ± 0.3^{d}
PUFA	66.0 ± 2.6^{a}	65.8 ± 1.1^{a}	61.9 ± 1.8^{b}	64.2 ± 3.1^{a}	42.9 ± 0.7^{a}	38 ± 2.2^{b}	38.6 ± 2.7^{b}	44.6 ± 3.1^{c}
Total fatty acid	122.6 ± 4.2^{a}	121.6 ± 1.8^{a}	114.8 ± 3.4^{b}	116.5 ± 4.8^{c}	92.1 ± 1.7^{a}	81.7 ± 4.7^{b}	77.2 ± 5.0^{c}	77.7 ± 4.5^{c}
Total lipid (% DW)	29.7 ± 0.3^{a}	29.5 ± 0.2^{a}	29.9 ± 0.3^{a}	29.6 ± 0.3^{a}	17.7 ± 0.2^{a}	16.8 ± 0.4^{b}	16.3 ± 0.3^{b}	17.7 ± 0.2^{a}

The barramundi larvae fed with the 50:50 enriched rotifer diet outperformed the other three treatments, having significantly greater length, eye diameter and body depth at 13 dph.

similarly to the *C. vulgaris* diet fed larvae, it induced slower larval development when compared to the tow mixed diets.

Although an important fatty acid, DHA, the best performing diet (50:50) had the second highest dietary level of the fatty acid, which suggests that while DHA is an essential fatty acid for barramundi larvae it is likely that its interactions with other EFA's and monounsaturated fatty acids also play a critical role in larval development. While the only qualitative trait tested in the four diets was fatty acid composition other nutrients (vitamins, amino acids, pigments, enzymes etc.) might have contributed to the observed results.

As for mollusc hatcheries, which use blends of microalgae to minimize shortfall in dietary requirement of the culture species, using blends of microalgae rather than single species for enriching live feeds can improved the balance of dietary fatty acids for barramundi larvae, leading to better growth, faster development and higher stress resistance.

In conclusion, depending on the microalgae species and their cost, the productivity, profitability, and risks associated with variable production in barramundi hatcheries could be improved by opting for a mix rather than a monospiecific diet to enrich rotifers.

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Publication

Small feed production

Pelleted and crumbled, micro-bound, sphere-ized, micro-coated, and micro-encapsulated - the range of feeds is wide and sometimes confusing. Dana Nelson, Business Development - Aquaculture Specialist, at Extru-Tech Inc., gives an insight into the manufacturing considerations and the solutions available to hatcheries.

Over the last several decades, tremendous efforts have been made in the advancement and development of aquaculture. Aquaculture's role as a source of food, nutrition, and income for hundreds of millions of people around the globe has been discussed and estimated at length. Few, if any, experts question the importance of aquaculture in addressing the challenge of feeding the world's population, which will equal more than 9 billion people by 2050.

Fish nutrition and feed technology have always played a vital role in the maturation of species development and the struggle for economic viability. In fact, the collaborative dance between researchers, growers, and feed producers has been critical to much of the success. The application of innovative technology and practical solutions to feed problems has resulted in feed quality that could only have been dreamed about a few years ago. Much of the recent progress relative to feeds and their position in future sustainability can be directly attributed to lessons learned from the struggles of the past. New technologies are being applied to many aspects of feed manufacturing. Modern cooking extrusion equipment offers flexibility and capability that is needed to permit a significant shift toward modern formulations that would have once been very problematic.

It may be even more interesting to note that this dance is not over. Feed quality is an area of serious concern and focus for emerging species and feed continues to be the primary cost in most farming operations. Feed issues and cost are factors inhibiting growth in even well-understood species in many markets. Although the challenges are varied, some of the most obvious revolve around the acceptance and performance of hatchery feeds.

Any discussion about aquafeed should begin with a clarification. The diversity of feeds being used globally is incredibly varied. Which physical attributes are deemed most important and which raw materials are considered cost effective vary not only from species to species but from market to market. In one part of the world, locally developed and prepared feeds are basic and shortcomings are considered acceptable. Waste is valued as nutrient to a non-intensive system. In another, feeds are examined

on a highly detailed level. Successful entrepreneurs recently met in Silicon Valley to discuss feed technology and its role in pushing aquaculture to new heights of sustainability, practicality, and promise. This brief discussion about the production of small feeds deals with just a sliver of this diverse landscape.

Extrusion technology

Most advanced aquafeeds today are produced using cooking extrusion. This process has been refined to provide flexibility to suit a wide range of different feed characteristics and raw materials. Floating feed, sinking feed, and feeds with specific attention to cell structure for water stability and/or the ability to carry high levels of fat have become expected feed qualities. These extrusion systems have significantly contributed to the economic progress of aquaculture; however, the methods used to produce these dry, durable particles become problematic when applied to small feeds.

There is a long list of reasons explaining why dry extruded feeds have not replaced live feeds. The chemical and physical properties of extruded nutrients that perform well in adult feeds are not ideal for all stages of development. Attraction, palatability, leaching, ingestion, and digestion issues have been examined for many species. Although not all interactions are fully understood, it is clear that dry extruded feeds have limitations. Exotic micro-bound, sphereized (MEM and PARA), micro-coated, and micro-encapsulated diets all offer physical characteristics that have repeatedly demonstrated better performance in the live feed replacement, weaning, and early rearing stages of many species. However, it is equally clear that properly prepared and extruded fry, fingerling, and other small feeds have their place and are being extensively used when the advantages outweigh the disadvantages.

Crumbled pellets

A huge percentage of the steam-pelleted and extruded feeds smaller than 1.5 mm being fed around the world are crumbled pellets. The difficulties associated with compressing or forming rations through small holes are so great that feed manufacturers have resorted to breaking larger pellets into pieces and physically screening them into groups of "crumbles" in a desired size range.

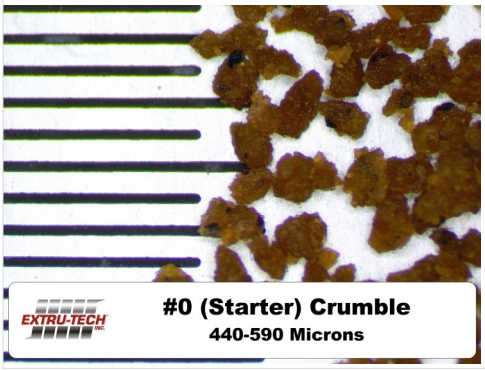
It is not my intention to examine or critique the use of crumbled feeds in this article. Similarly, it is not my goal to promote micro-pellets. It is, however, my intention to discuss several details of these feeds that are not always well understood. I would also like to introduce certain problem solving practices that aquafeed manufacturers are currently implementing in order to successfully extrude smaller sized pellets. My hope is that a better general understanding of the issues will lead to more cooperation and a greater implementation of novel ideas to improve these small feeds.

Although steam pelleting systems exist for feeds smaller than 2.5 mm, these systems are not widely accepted and are not being extensively used in aquafeed production. Cooking extrusion equipment, on the other hand, is being successfully used in many places around the world to produce feeds as small as 1.0 mm. Producing feeds using small

... properly prepared and extruded fry, fingerling, and other small feeds have their place and are being extensively used when the advantages outweigh the disadvantages.

extrusion dies is a challenge. Maintaining stable extrusion parameters with intermittent and unexpected flow problems at the die is the primary problem. Although, grinder performance is the key priority, other factors contribute to die fouling and process problems as well . As manufacturers attempt to push sizes smaller than 1.0 mm, these problems become exponentially more difficult.

Because of these difficulties, crumbled feeds are quite often the best solution. Crumbled particles perform well in many cases despite their rough texture. In fact, although the sharp edges and shapes of these feeds cause acceptability problems, these same characteristics create at least one advantage. The varied, irregular, and high surface area of these particles allows them to use water surface tension to gain buoyancy. Anyone who has fed these feeds knows the surprising range of their reactions to water. Effective feeding practices have evolved alongside awareness about the uncontrolled, yet important, sequencing that occurs as these particles sink. Feed trials evaluating the performance of more acceptable and palatable particles



are likely to be compromised if practices are not modified in keeping with this phenomenon. It should also be noted that many have theorized that the wide range of individual particles also offers some advantages.

From a manufacturer's perspective, the primary disadvantage of crumbling feed is yield. By far, the costliest element of aquafeed production is the ingredients themselves. The practice of crumbling larger pellets into smaller particles was originally developed for animal feeds. These feeds were steam-pelleted and although the process was time consuming, the yield was high. Crumbles are produced by pinching pellets between two precisely engineered rolls. The gap between the rolls, the speeds at which they turn, and the texture or surface are all controlled in order to break the pellets in a way that dictates their size. Ideally, a very high percentage of the pellets are broken into the correct size. Any particles that are too large are returned to the rolls to be broken again. Any particles or dust that is too small is routed back to the pellet mill and reformed to be broken again. Because pellet mills primarily use compression and low levels of heat and moisture to bind the ingredients together, the raw materials react well to this recycling. In some cases, the crumble quality improves with multiple passes through the pelleting process. Eventually, almost all the initial raw materials batched are formed into the desired size.

Creating crumbles made from pellets formed using cooking extrusion equipment is much less efficient because cooking extrusion operates at high moisture and heat levels, meaning that the opportunity to bind raw materials together only presents itself once. Any attempt to route undersized feed directly back into the extruder results in pellet quality that is unfit for re-crumbling. Well engineered and designed systems are only capable of forming 60% of the initial batch into correctly sized particles. Most systems in operation around the world are even less efficient. Fortunately, the raw materials are not lost. They can be collected and re-used in future production at an inclusion rate of up to 25%, but the energy invested in forming and drying will be wasted. Vitamin degradation will also occur as a result of processing. Additional nutrients will need to be supplemented to compensate for what is lost during processing. Finally, additional energy will be needed to grind the particles into similar sizes with the other ingredients to ensure a stable and predictable process.

Extruded micropellets

The production of extruded pellets smaller than 1.0 mm is slowly becoming more common, whereas the physical limitations of steam-pelleted crumbles are becoming more obvious. The inefficiencies of extruded crumbles are also better understood. These factors, combined with the use of more expensive and exotic ingredients that are vulnerable to damage from unnecessary processing, have pushed manufactures to re-examine their ability to extrude micro-pellets.

The use of cooking extrusion to make small pellets is not a mystery. All the same principles apply and all the steps in the process are similar or the same as the others. Unfortunately, extruding formulations through small holes makes matters more difficult because of one key factor: the die. The die on cooking extruders have two functions. The first is to restrict flow. Raw materials back up in the process and are subjected to friction from the screws. As temperatures rise from this friction, the dough becomes less viscous and flows more easily through the die. As these raw materials flow through the holes in the die, the second purpose of the die is realized as the ingredients are formed into pellets of a specific size.

Controlling the process

Cooking extrusion on either twin screw or single screw systems requires the stable control of process variables. Although the analogy is not a perfect one, raw materials traveling through an extrusion system are like automobiles on a crowded freeway or street. Surges, or unpredicted events, are like accidents. A

stable and predictable flow needs to be maintained at the die to ensure consistent pellet size, durability, and density. If individual particles, groups of agglomerated particles, and/or the viscosity of the dough are not controlled sufficiently, the die becomes blocked. The flow halts and the process must be shut down and the equipment cleaned to begin again.

Maintaining system hygiene and grinding equipment that ensures that there are no particles to foul or plug the die is no small task. The mixing and wetting of ingredients that is acceptable in larger feeds is insufficient for micro-pellets. Variations in the dry feed rate, added water, steam, or oils that are easily dampened during normal extrusion are often unacceptable in micropellet production. In many cases, the best solutions are specialty production lines dedicated to small feeds. Capital requirements and the feed volume to justify these lines is an obvious challenge.

Greater demands for food safety have led extrusion equipment manufacturers to improve their attention to detail. Clean in place and sanitary construction features have resolved many problem areas that were present in past designs. Precision milling and machine work coupled with exotic metals and heat treatments once reserved for high tech industries are now being applied to aquafeed production. Engineers can now afford to design and build die and knife systems that are much larger and have sufficient surface area to allow for more small holes. Extrusion systems are now available that control restriction and mechanical energy in ways unrelated to the die. Modifications and improvements to grinding and screening systems ensure that raw materials are ready to be processed in ways that were either unavailable or too costly for aquafeed only a few years ago.

The continued application of these technologies is likely to refine and encourage practical solutions and lead to further improvements. Extruded pellets smaller than 1.0 mm are likely to become more common. The production efficiency gains, and control over attributes like density, texture, and other physical characteristics, could provide much-needed value and performance to growers. It is also reasonable to expect that the lessons learned will be applied to create greater efficiencies and improve the performance of production size feeds as well.

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About the Author

With more than 30 years of experience in the aquaculture feed manufacturing industry, Dana Nelson recently joined Extru-Tech, Inc. as an Aquaculture Specialist based in Salt Lake City, Utah, USA. He is one of three former-owner partners in Nelson & Son's, Inc., the original developers and producers of Silver Cup Feeds. After selling the company to Skretting USA in 2008, Nelson continued to work for Skretting for the next five years as production manager and, ultimately, project manager, before retiring from the company in 2012.

After joining his family in the feed mill business, by 1992, Nelson had expanded the company vision and begun building a new facility outside Salt Lake City with new extrusion lines dedicated specifically to aquafeed production. Shortly thereafter, Dana and his cousins, Richard and Chris Nelson, who had also been involved in their family's feed milling business, acquired the company from their parents and developed Silver Cup feeds.

Dana was responsible for production and most of the operational activities. In a tribute to the Nelsons and Silver Cup in a 2012 issue of The Fish Line, a publication of the Colorado Aquaculture Association, Rick Barrows, USDA Agricultural Research Service, stated, "Dana's ability to tweak and reconfigure equipment to make it perform beyond specifications is what has made the Silver Cup products look good, perform well and help stabilise costs to the customers."

Now, Dana Nelson brings that same kind of passion and commitment to Extru-Tech, where he will assist customers with the use of Extru-Tech equipment in the production of a wide variety of aquatic feeds.

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Necton, 20 years producing and selling microalgae: ups and downs

After several years of research and development in the Portuguese Catholic University, Necton was established in 1997. As microalgae need sunlight and temperate climates, the company was set on an ideal location to grow those organisms, the South of Portugal. In 1998, Necton set up its first photobioreactor, shown in the Future Pavilion at International Exhibition EXPO98 held in Lisbon.

By Victoria del Pino, Microalgae Business Manager, Necton S.A.

Since its establishment, Necton has grown its facilities in a 23 ha salt marsh in the Natural Park of Ria Formosa (Algarve). Apart from the microalgae production facility, this fortunate location impelled the start-up of another business in the year 2000. The company begun to exploit the salt marshes to obtain artisanal sea salt and “flor de sal”. At this moment, Necton operates two different business units: Microalgae Business Unit and Salt Business Unit.

Our company has an unique and distinctive experience in designing and operating different microalgae cultivation technologies, both for freshwater and marine microalgae, ranging from open to closed systems. The research and development team has developed an extensive industrial knowledge which allows us to produce more than 10 different types of microalgae.

Necton is specialized in the cultivation and commercialization of microalgae. Our scientific, technological and market knowledge is focused in specialty feeds for live-prey cultivation/enrichment and early stages of larval development of crustaceans and mollusks.

Microalgae play an undoubtful crucial nutritional role for the marine animals, as phytoplankton is the basis of marine food chain, and most marine invertebrates depend on microalgae for their whole life cycle. And since the very beginning, Necton’s vision was to develop a set of specialized microalgae concentrates which aimed to solve hatcheries day-to-day problems.

Downs

- Realizing that hatchery managers did not want to fully replace their phytoplankton cultivation rooms by our products, even though the operation of those systems was costly, they apparently could not rely on an external supplier of microalgae.
- The lack of consistency between strains being cultivated among the hatcheries, on the methodologies used, on the nutritional profile needed and the sense that every hatchery manager had, that their own production system (or strains) was the one producing the best microalgae in the planet!

- The constant need for teaching and learning from each Customer; knowing about their needs and understanding their production cycles, showing them we were specialized in cultivating microalgae and they could rely on our products at least on the most demanding seasons, when everybody is rushing and microalgae cultures quite often crash.

- After the biofuels hype, many projects failed to achieve the unrealistic goals of using microalgae as a source of oils for further transformation into fuels. They turned into the businesses that were already mature, microalgae concentrates for aquaculture, sometimes supplying microalgae with 10 times more heavy metals than allowed in the European Union! Dealing with competitors presenting low prices of poor quality products was definitely a source of frustration.

Ups

- We launched our first microalgae concentrate, "Phytobloom green formula" in 2000. By that time, Necton and Reed Mariculture were the main providers of algae concentrates, and we did collaborate a lot back on that time, learning and sharing knowledge. Both companies are still here and doing well! Many others have bankrupted or changed business strategies.

- Under the main brand of Phytobloom, Necton has been providing 3 ranges of products (liquid formulation, frozen pastes, and freeze-dried powders) for many years. Most of companies copied the success formula, and we are actually proud of being a benchmark.

- After many years of strong effort to show hatchery managers that they could rely on powdered microalgae, we notice that almost all hatchery managers know nowadays the quality differences between spray-dried powders and freeze -dried ones. In the beginning it was difficult to convince them, that freeze

drying is the only process which maintains the morphology and cells unaltered, retaining all the nutritional value. The reason is simple, the process is mainly based in pressure drops, and temperatures will not go higher than 30ºC, compared with high temperatures experienced in spray drying that are well over the boiling point of water. Microalgae freeze-dried powders have an extended shelf life, and are easily re-suspended in water with their natural morphology, size and nutritional value.

- After 20 years talking with different people, we must congratulate hatchery managers - the industry has matured a lot, not only in size but principally in knowledge and technological approaches. Hatchery managers know very well nowadays which questions to ask. A couple of weeks ago, chatting with a French turbot grower, we became very impressed with the technical level of his queries. To sell products to this market, microalgae producers should be prepared to support their claims with real knowledge, regular quality checks, standards, certificates of analysis, product specifications, health certificates and material safety data sheets as any other commercial feed that is used in hatchery environment.

To celebrate our 20th anniversary, we have enlarged our production facilities, we have reduced prices for hatchery supplies, and we provide in a regular basis pure microalgae concentrates of *Nannochloropsis, Isochrysis, Tetraselmis,* and *Phaeodactylum.*

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Microbiome manipulation in shrimp: Fact or Fiction?

Stephen G. Newman Ph.D., President and CEO Aquaintech Inc.

Life depends on microbes (this includes fungi, bacteria, viruses, archaebacteria, etc.). Science is just beginning to unravel how complex this relationship is. Among the discoveries is the observation that more than 80% of bacteria cannot be cultured using conventional approaches. Thus many of the conclusions we have drawn from what we thought were well designed experiments are not based on a complete picture, likely leading to misleading conclusions. Using high throughput sequencing technologies we can now gain a much better idea about how complex the microbiome is and what can impact it (1).

It is widely held that the ability to reproducibly manipulate the microbial ecology of the digestive tract will offer some promise in controlling the impact of infectious diseases on animal health, improving stress tolerance as well as digestibility and optimum utility of feed components among many other possible benefits (2). We have only just begun to figure this puzzle out.

Focusing on shrimp farming, perhaps one of the areas of greatest interest involving the use of microbes is the use of what has been coined as probiotics. The widely agreed upon definition of probiotics (3) is "live microorganisms which when administered in adequate amounts confer a health benefit on the host." This fails to recognize that many organisms are immunogenic (whether they are dead or alive) and the term health benefit is vague. Since shrimp constantly forage and bacteria are an important natural component of their diets, this further muddies the applicability of the term for use in shrimp.

This definition requires that the bacteria be alive at the time of application. They must survive ingestion and through any possible unspecified mechanism have an impact on animal health. There are some schools of thought that also believe that the definition should include the ability to colonize the digestive tract in a manner where there is a measurable change in the composition of the bacteria in the gut and a measurable impact on animal health.

The vast majority of products marketed as probiotics into shrimp farming do not fit this definition. In fact, there is little evidence to support that most even act directly on the animal at all. They are in reality tools for bioremediation. Historically most of the bacterial strains in these products were being used to degrade the organic matter in septic tanks. They act on the environment and the impacts that they have on animals are a result of this. The most common organisms used are the gram-positive spore-forming rods, members of the *Bacillus* species. Members of this genus are widely employed for their enzymatic abilities in many commercial processes. They form spores that are shelf and heat stable. Spores, while alive, are not the same as actively metabolizing vegetative cells.

There is little to no evidence to support that idea that the microbiome in farmed shrimp in production environments is stable (4). More than likely it is constantly changing in response to changes in composition that occur

naturally as water quality, population dynamics, pond ecology and feed composition and microbial make up varies.

Even though there is no reason to believe that stable changes in the microbial composition in the guts of shrimp are readily achievable, in our work with bioremediation we have seen meaningful impacts in shrimp hatcheries. One of our products is a tableted blend of *Bacillus* spores (PRO 4000X) that we designed and field-tested more than a decade ago. We have found that this approach has a meaningful and reproducible impact on shrimp when used in hatcheries (Table 1). Among the impacts observed are changes in the composition and levels of vibrios, cleaner tanks, increased survivals and more robust animals. These are widely

Table 1. Impact of PRO4000X on hatchery reared shrimp

Observations	Comment
Control of heterotrophic bacterial loads	Plate counts of production tanks consistently show much lower levels of vibrios and other types of bacteria.
Growth rate is better.	PLs grow faster in tanks treated with PRO4000X tablets and are larger at harvest.
Animals feed more aggressively.	No molting problems in treated tanks contrasted with control tanks.
Fewer mortalities	Higher survivals as a result of lower pathogen loads, less stress and better water quality
Controlled fouling issues	Lower accumulated organics equals less food for bacteria and fungi that cause fouling
Less accumulated organics	The primary benefit from using the product
Very low levels of metabolites	Ammonia and its breakdown products are controlled by the Bacillus species in the product.
No other bacteria added or needed.	Only the use of PRO 4000X is required.

**Personal communication, S. Mathiyalahan, Owner, Aquabios Enterprises, India*

reported for our product and for some others. Unlike approaches that require activation of the bacterial spore mixtures prior to use the tablets dissolve in the tank and the spores germinate through out the tank. There is no requirements for field users to culture before use thus lessening the chances of adding something unwanted that could grow during an extended activation.

By the definition above, microbes that act on the environment and thus impact the health of the shrimp would be considered to be probiotics. Since the coiners of the definition were focused on ingestion (such as Lactobacillus species in yogurt), there likely would not have been any thought that this term would apply to bacteria that impact the environment. Will we be able to feed shrimp bacteria that have the same impact? This will depend on the ability of the material to withstand the rigors of milling into feed or the use of top dressing mechanisms that ensure that sufficient numbers are ingested. Most of the spores will pass through the gut, as the gut transition time is less than the typical spore germination time and enter the environment through the feces. If these are re-ingested as living cells are they a probiotic? It is apparent that regardless of what we call the products, their use can have a positive impact on production in shrimp hatcheries. Maybe someday we will have products that act on the microbiome and we can equate activity with the presence of specific strains. There is much work to do.

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Even though there is no reason to believe that stable changes in the microbial composition in the guts of shrimp are readily achievable, in our work with bioremediation we have seen meaningful impacts in shrimp hatcheries.

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Zooplankton for Larviculture

By Eric Henry, PhD, Research Scientist, Reed Mariculture Inc.

Zooplankton are the minute animals that graze on phytoplankton, the microscopic plants of the sea. Zooplankton can be considered the foundation of fish larviculture, because they have long been the essential feed for larval fishes that require live prey since they cannot survive on formulated feeds. Although protozoa such as ciliates and trochophore larvae of bivalves have occasionally been used on a small scale, *Artemia* (brine shrimp), rotifers, and copepods are by far the most commonly-used zooplankton live feeds.

Brachionus plicatilis rotifer

Artemia

Artemia are in wide use because they are a "convenience food." *Artemia* cysts (resting eggs) are harvested in bulk from the wild and preserved by canning. They therefore have a very long shelf-life, so they may be stored at the hatchery and the cysts are hatched as needed. *Artemia* can also be cultured on a wide variety of feeds. However, *Artemia* have several shortcomings. Before hatching, the cysts should first be "decapsulated" using bleach and sodium hydroxide, both to kill pathogens that may contaminate their surfaces (although endogenous pathogens will not be affected), and to remove the hard shells of the cysts, which can kill larvae if ingested. Even first-stage nauplii are significantly larger than rotifers and so are too large to serve as the first feed for most fish species. Because *Artemia* are wild-harvested from habitats that are dominated by algae with limited nutritional value, the cysts and newly-hatched nauplii have an inferior fatty-acid profile compared to rotifers produced on enrichment feeds. Furthermore, first-stage *Artemia* nauplii are incapable of feeding, so their limited nutritional value rapidly diminishes and they cannot be nutritionally enriched until they molt to the second stage. Another concern is that *Artemia* are harvested from habitats (such as the Great Salt Lake in Utah, USA) that receive runoff and fallout of airborne particulates from nearby urban areas, highways, and farmland, and so may be contaminated with industrial and agricultural chemicals.

Rotifers

The rotifers used in aquaculture are almost invariably saltwater strains of the genus *Brachionus*, most often called *B. plicatilis* (the larger, "L-type") or *B. rotundiformis* (the smaller, "S-type"). They are a suitable size for many fish larvae to consume, and they swim slowly and so are easy for naïve early larvae to capture. Because they tolerate a wide range of conditions (temperature, pH, salinity, oxygen concentration—they even grow in sewage treatment plants!), *Brachionus* cultures are robust, and with due care are not subject to unexplained crashes. They have very high reproductive rates that allow them to more than double in numbers each day, and can achieve very high culture densities (as high as 5-10 million/liter). Such high

culture densities are only possible because rotifers can be grown using commercially-available feeds, which have much higher biomass concentrations than can be achieved in algae cultures. These feeds also free the hatchery from the need to culture microalgae, and the nutritional content of the rotifers can be optimized by choosing appropriate feeds.

Optimized rotifer production protocols

Effective and economical rotifer production is now routine practice thanks to the development of protocols that provide optimal growth conditions for rotifers while making hatchery operations simpler, easier, and more economical. Fluctuations in culture conditions (temperature, pH, feed dosing, harvest rate, etc.) are minimized by employing "continuous" cultures rather than traditional "batch" cultures. Some of the benefits are:

1) The consistent feeding and harvest regimes that prevail in continuous culture promote rotifer health, supporting high productivity and nutritional quality.
2) The rotifers have a younger age distribution due to the high daily harvest rate; younger rotifers feed more actively, are more fecund, and are more vigorous swimmers.
3) Once daily harvesting begins, the culture requires the same feeding and harvest every day, simplifying the management of culture operations and so minimizing the opportunities for costly mistakes.
4) There is no interruption of production while a new culture grows to harvest density.
5) Labor inputs are reduced because culture tanks do not require frequent sanitizing and re-inoculation.

Reed Mariculture maintains mass-cultures of L- and S-type *Brachionus* rotifers and routinely supplies the aquaculture industry with orders of 1 million to 1 billion or more. These rotifers are produced using Reed Mariculture's RotiGrow® liquid algae concentrate feeds, which support high-density cultures of rotifers with nutritional profiles that are optimized for larval fishes.

Copepods

Several species of copepods are used in fish larviculture because their first-stage nauplii are smaller than rotifers, and they are nutritionally superior. But they are much more difficult to culture because they have a much longer life cycle (2-3 weeks, in contrast to 2-3 days for rotifers), maximum culture densities are only a few thousand per liter, and the nauplii must be separated from the rest of the culture for feeding to larvae. Unlike rotifers, which can be produced entirely on commercial feeds, many copepod species require live algae cultured in the hatchery as feed. Because of these difficulties, larvae are often started on copepod nauplii, and as they grow they are transitioned to rotifers, which are much easier to mass-produce.

A new copepod for aquaculture

Reed Mariculture is the only significant commercial supplier of rotifers for aquaculture in North America, and will soon offer cultures of *Apocyclops panamensis*, a Cyclopoid copepod that offers important advantages for aquaculture use compared to many other copepods. *A. panamensis* nauplii have

Female *Apocyclops panamensis*.

Apocyclops panamensis nauplius

been shown to be an excellent first feed for the larvae of Red Snapper (*Lutjanus campechanus)*, and can be produced entirely on Reed Mariculture's microalgae concentrate RotiGrow® enrichment/grow-out feeds, while it effectively suppresses any contamination by ciliates. A copepod with these characteristics has the potential to become a widely-used, mass-produced larval feed, perhaps the "New Rotifer" that aquaculture has been waiting for.

Reed Mariculture has supplied microalgal concentrates to the aquaculture industry for over 20 years, and is likewise dedicated to being the dependable supplier of zooplankton. Hatcheries benefit economically by obtaining zooplankton from the zooplankton specialists at Reed Mariculture as the need arises, rather than having to maintain cultures even when they are not needed. This allows them to devote their resources to the culture of fish, rather than fish feeds, and reduces the need for staffing with algae and zooplankton culture expertise. Hatchery operators also enjoy increased peace-of-mind by knowing that microalgae and zooplankton are readily available in case of culture failures.

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More information

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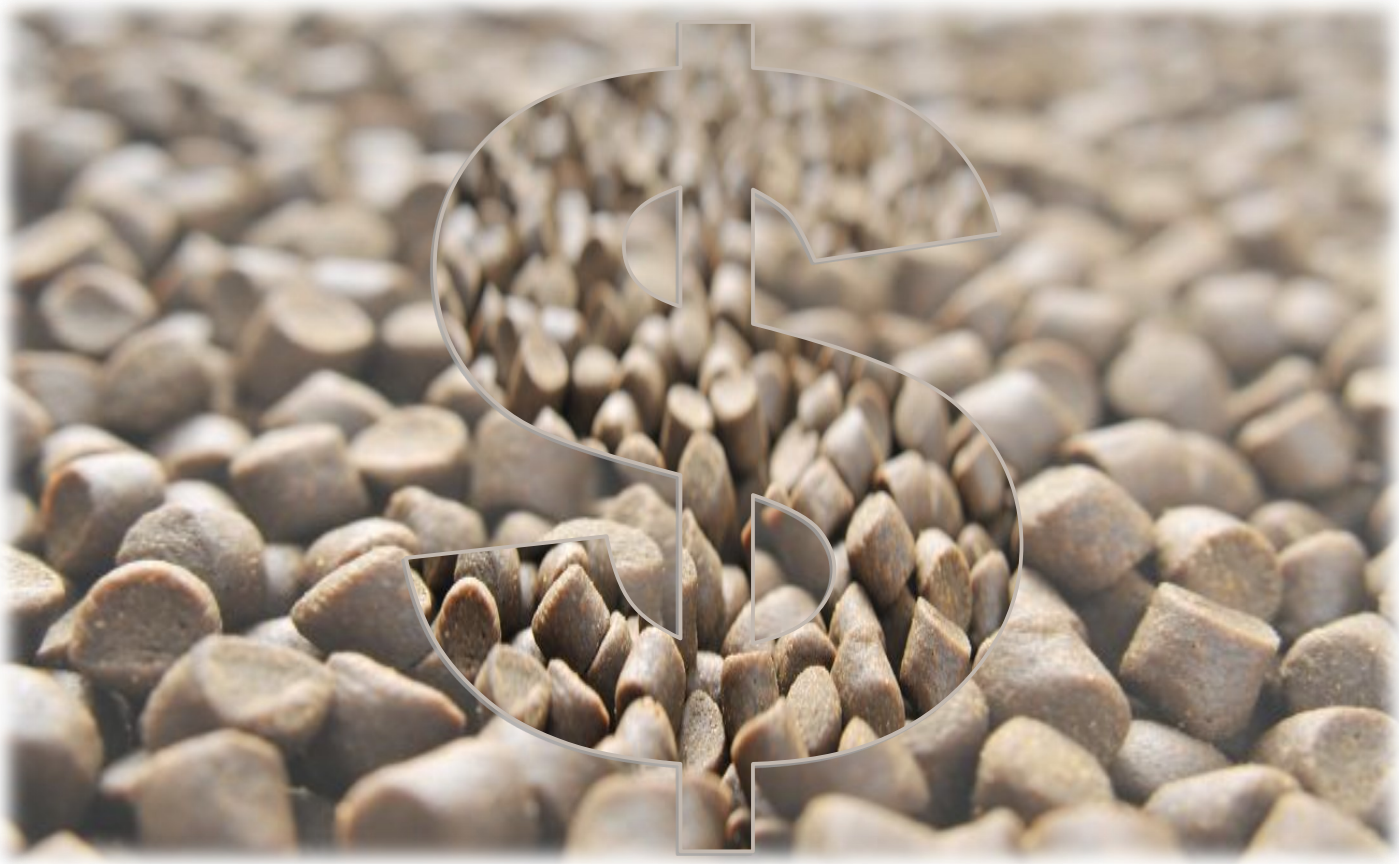
The high cost of feed pricing



Some of the most widely used pricing models for aquaculture feed are outdated and inefficient. If we start thinking about feed cost instead of feed prices, our industry will move efficiently into the future, writes OddGeir Oddsen, C.E.O. of aquaculture feed supplier ProChaete.

Price versus cost

In the global aquaculture feed market, a significant percentage of buyers only consider the price when deciding what feed to buy. And the price is an inaccurate indicator of how good the feed is, not only in terms of nutritional quality, but also in terms of how good it is for business. More specifically, a product's price does not tell us what the product is worth, just what it costs.

This means that it is up to each buyer to define the worth of the feed she or he is buying. Does the price of the feed reflect the health, weight and survival rates of my animals? And so the feed price itself becomes an inaccurate indicator of the feed's value.

Feed cost, on the other hand, is the total cost related to the feed of getting a certain animal to a certain stage in its life cycle. Let us say, for instance, that you are running a shrimp farm that covers the shrimps' whole life cycles. Getting each shrimp to a certain weight more quickly is obviously good for business, because it raises the overall capacity of the farm. Thus switching to a higher quality feed will lower feed cost, provided that the extra money you spend does not exceed what you earn by raising the farm's capacity.

Changing the pricing scheme in the aquaculture feed business not only has the ability to change our industry. It has the potential to change the way we feed the world.

So why are we looking at the price tag?

Now, some of the more advanced areas of the aquaculture industry - salmon farming is one example - have regarded calculating feed cost as a smart way of doing business for many years. The shrimp farming industry seems to be lagging a little behind. Why is that?

Some will argue it has to do with simplicity: Dealing solely with price is less complicated. It may also, at least in some parts of the world, have something to do with tradition: This is the way it's always been done. Why change a winning recipe?

There are also the aquaculture businesses that only constitute small parts of the value chain. If your responsibility is to get your shrimp to PL12 before selling them to another facility that pays by number of shrimp, it doesn't matter if each PL12 shrimp is larger healthier, stronger, or responds better to stress. You don't get paid more if the mortality rate goes down or even if your shrimps are twice the size as that of your competitors, so why waste money on high quality feed? And if your buyer doesn't see the value in buying exceptional PL12 shrimp from your facility, there really is no value in buying a more nutritional shrimp feed. But can there be?

And why is all this so important?

At ProChaete, our mission is to find better, more sustainable ways of producing protein in order to feed the world's growing population. Soon we'll be more than nine billion people on this planet, and feeding all of us will require brains, effort, and science. And it requires consistent small steps in the right direction. Producing nutrient-dense aquaculture feed sustainably will in turn produce larger, healthier shrimp faster. Higher performing feed with higher protein retention makes the industry less wasteful. And when the shrimp farmer who used to sell his shrimps at PL12 is able to sell them at PL10 because they're that much bigger, he will start seeing the value of calculating the feed cost. And as soon as efficient shrimp farming is recognised as being good for business, the world will see an industry that's running cleaner, and producing better food.

Changing the pricing scheme in the aquaculture feed business not only has the ability to change our industry. It has the potential to change the way we feed the world.

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Photo: courtesy of Merlin SEA LIFE Chongqing.

Live nitrifying bacteria improve output and prevents losses in aquaculture and aquarium operations

Researchers have suggested the need for simple, inexpensive, reliable and effective methods for aquaculture professionals to accelerate the establishment of nitrifying bacteria in their zero-exchange nursery systems prior to tank stocking. Accordingly, a recent study completed by Texas A&M's AgriLife Research Mariculture Lab investigated Fritz-Zyme TurboStart 900, a product developed to increase shrimp (Litopenaeus vannamei) production as well as prevent loss of shrimp for aquaculture professionals.

The study demonstrated that the product proved effective at accelerating the development of nitrifying bacteria and limiting the accumulation of ammonia and nitrite to toxic concentrations. According to the study, adding Fritz-Zyme TurboStart to closed culture systems "greatly accelerated AOB (ammonia oxidizing bacteria) and NOB (nitrite-oxidizing bacteria) establishment."

"It is a known fact that shrimp exposed to high ammonia and nitrite concentrations experience stress and significant mortality rates," stated David I. Prangnell, Ph.D., one of the four researchers who completed the study. "The high concentrations in systems operated with no water exchange occur due to the extended period of time required for nitrifying bacteria in general and especially the nitrite-oxidizing bacteria (NOB) to become established in the system naturally. Such nitrite spikes

In China, FritzZyme TurboStart has been instrumental in the successful grand opening preparations for the newest, most advanced public aquarium.

are commonly observed in closed intensive shrimp production systems as culture water matures"

"This trial has demonstrated a viable system for establishing Fritz-Zyme nitrifying bacteria, which can then be transferred to larger closed culture systems used for super-intensive shrimp culture." The study results will be published in a future edition of The Practical, a publication of the Asian Aquaculture Network.

Ornamental applications

Fritz-Zyme TurboStart was developed by Fritz Industries, a Mesquite, Texas-based company that delivers high performance biotech and chemical solutions to companies worldwide. In addition to the aquaculture industry, Fritz Industries Specialty Division offers chemical and biological products used by zoos, public aquariums and home aquarium hobbyists.

In China, FritzZyme TurboStart has been instrumental in the successful grand opening preparations for the newest, most advanced public aquarium. Located in southwest China, SEA LIFE Chongqing is part of a major new tourist destination from Merlin Entertainments, which is well-known for its Madame Tussauds and LEGOLAND attractions. Its SEA LIFE is the world's largest aquarium brand.

SEA LIFE Chongqing has 17 themed areas with hundreds of thousands of marine species from around the world. Its "breeding, rescue and protection" mission provides interactive experiences for guests to learn about natural ocean environments and sea animal survival. It is dedicated to the protection of the Yangtze River Basin aquatic zone and will have a significant impact on public awareness and protection of marine habitats.

Fritz Industries is proud to be part of a project that offers this level of experiential learning and awareness of ocean life to the public, and proud to be part of its success. After successfully shipping the product overseas during the busy holidays, Fritz Industries received word from the project curator that they had received their first fish deliveries with approximately 40 percent biomass and ammonia not exceeding 0.2 mg NH3/4 with 0 nitrite after using FritzZyme.

"I am very pleased with the performance of your bacteria," said Stefan Inselmann, SEA LIFE Global project curator with Merlin Entertainments, "and look forward to future business!"

Fritz Industries is an employee-owned company specializing in applied chemistry and innovative manufacturing. Founded in 1956, it has grown into an international manufacturing company serving hundreds of customers around the world. The oilfield division offers a complete portfolio of oilfield products applied in hydraulic fracturing, drilling, cementing and production enhancement.

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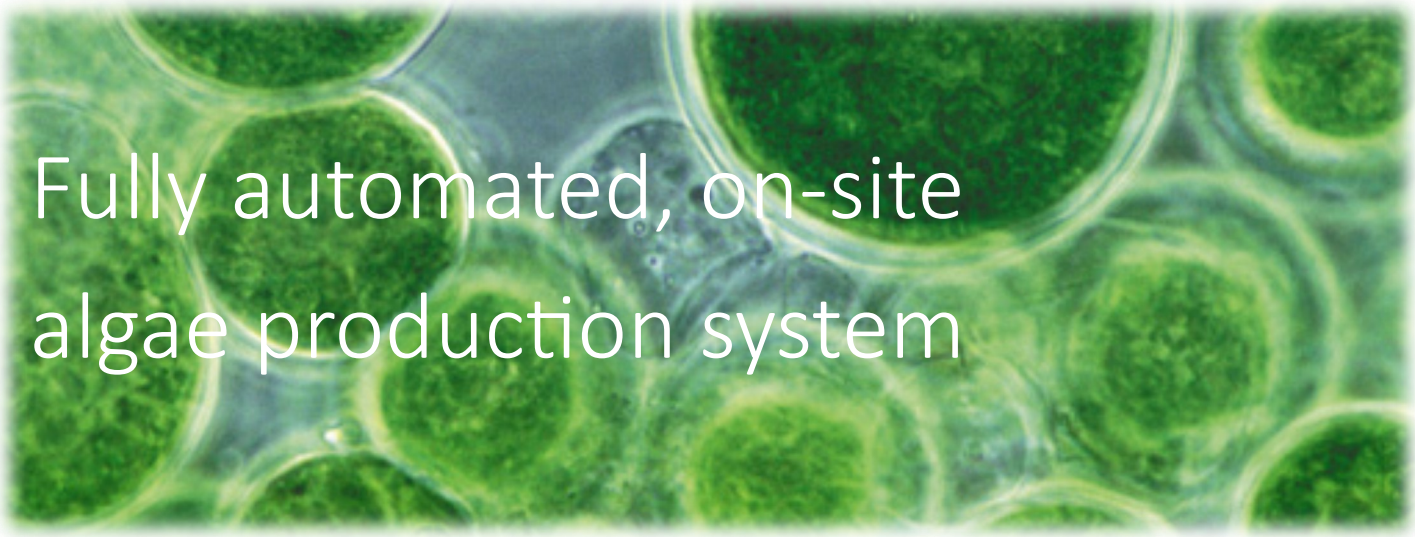

Fully automated, on-site algae production system

By Özgül Boztepe, Subitec GmbH, Germany

According to current industry reports the price for fish oil is projected to rise by 70 percent and even by 90 percent for fishmeal over the next two decades. At the same time consumer awareness and competitive market pressure are driving the aquacultures industry toward higher quality, sustainability, social responsibility and higher efficiency. These are all factors that are likely to increase the input costs of the industry when at the same time market pressure do not allow for an increase in the output costs - the prices of the products that you are selling.

Thus, there is a need to innovate predominant operating models and to introduce new, safer and more efficient technology and ways to operate. Producing fish sustainably at acceptable cost and ensuring biosecurity and quality continues to be the day-to-day challenge that the fish farming industry has to deal with. One of the key factors, with great impact to the quality and sustainability of fish production, is in the management of the food chain. Several studies have shown that the direct or indirect use of microalgae as feed has positively impacted the growth rate, the survival rate and the nutritional quality of fish. Microalgae are an indispensable feed source with high nutritional value and transfer of nutrients through whole food chains. The nutritional properties of microalgae including protein, selected carotenoids, lipids and fatty acids, are essential in the rearing of all stages of breeding in aquaculture.

From what we have observed, on-site cultivation and application of live microalgae for early stage feed is increasing in the industry. On-site production and application of microalgae in closed systems can be cost efficient and is typically a sustainable solution as early stage feed. However, based on feedback that we have received, predominant on-site cultivation methods in open containers are often laborious and prone to contamination resulting in unwanted labor cost and instability in production due to fluctuations in the quality and supply of microalgae.

To solve the predominant issues in on-site cultivation of microalgae and to ensure safe and stable on-site production of microalgae, Subitec has developed a closed, fully automatic cultivation system for the on-site production of microalgae that is used as feed for e.g. copepods and rotifers for fish larvae and shrimp and shellfish larvae. The technology is already proven with the typical algae applied in aquaculture and shown excellent performance in productivity and culture density. The equipment can be cleaned and sterilized in place to uphold high quality standards and minimize contamination risks.

Subitec is an equipment supplier with more than 20 years of experience with microalgae and offers customers the best in expertise and technology.

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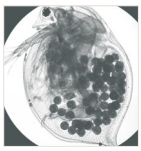
http://subitec.com/_upl/de/_d/sut_flyer_en_web.pdf

Directory of

LIVE FEEDS, WATER CONDITIONERS & ENRICHMENTS



LIVE FEEDS, ENRICHMENTS & SUPPLEMENTS

Links to datasheets available in PDF and digital versions

SUPPLIER	PRODUCT NAME	SPECIES	PRODUCT TYPE	FORM	DESCRIPTION	DATASHEET
Aller Aqua	ALLER ARTEX	Fish	Larvae Fry Nursery	Crumbles	ALLER ARTEX is the best solution for full or partial substitution of live *Artemia* to young fry in the early stages after hatching. A natural feeding solution for fry, the feed has high palatability which is immediately ingested and consequently not polluting the water.	
Aqua-In-Tech	PRO4000X	Fish Shrimp	Water conditioner probiotic for hatchery tanks and ponds	Tablets 1.1,5,10 and 16 grams	Targeted delivery of large number of bacterial spores (>60 billion per tablet) to pond and hatchery tanks. Control ammonia, accumulated organic matter and vibrio loads. Used for bio-augmentation and bio-remediation. Stable field proven bacterial strains are the subject of a US patent for use in catfish ponds. Sludge degradation and ammonia reduction.	DATA SHEET
Aqua-In-Tech	AQUAPRO-EZ	Fish Shrimp	Water conditioner probiotic for hatchery tanks and ponds	Bio-degradable Bags	A mixture of selected bacterial strains and nutrients packaged in a biodegradable bag for direct addition to ponds and tanks. Sludge degradation and ammonia reduction.	DATA SHEET
Aqua-In-Tech	MEGAX	Shrimp & fish broodstock; Shrimp larvae, PL	Bacterial extract	Liquid	A bacterial extract that is a source of nucleotides and nutrients field proven on billions of shrimp to positively impact shrimp production and increase profits and survivals in ponds.	DATA SHEET
Aqua-In-Tech	AQUAPRO F	Shrimp Fish	Water conditioner delivered in the feed	Powder	A blend of *Bacillus* spores designed for delivery to ponds through the feces.	DATA SHEET
Aqua-In-Tech	Custom Blend	Shrimp Fish	Water conditioner probiotic	Powder, bio-degradable bags, tablets, liquid	Custom blends of bacteria and fungi, nutraceuticals, etc.	DATA SHEET

SUPPLIER	PRODUCT NAME	SPECIES	PRODUCT TYPE	FORM	DESCRIPTION	DATASHEET
Aqua-In-Tech	WSSV Lateral flow test kits	Shrimp	Detects WSSV virus using antibodies	Plastic test strips	Rapid pond side detection of WSSV virus. Less than 10 minutes. When it is positive virus is actively growing in the shrimp.	DATA SHEET
BernAqua – *InVivo NSA*	Red Pepper	Fish	Enrichment	Stable Emulsion	Red Pepper is a complete enrichment product for rotifers and *Artemia*. Red Pepper contains, besides essential fatty acids, the most important nutrients. The level of Vitamin C included is unique on the market. Red Pepper is also containing chelated trace minerals and immuno-stimulants. Red Pepper disperses easily. All nutrients are well protected so as not to leach.	DATASHEET
BernAqua – *InVivo NSA*	Olio ω3	Fish	Enrichment	Stable Emulsion	Olioω3 is a stable emulsion based on refined fish oils, stabilized with carefully selected emulsifiers. Olioω3 is also enriched with Vitamins E and C that are acting as anti-oxidants in the body of the fish larvae. Olioω3 is readily forming a uniform and stable emulsion of lipid droplets, filtered efficiently by rotifers or *Artemia*.	DATASHEET
BernAqua – *InVivo NSA*	ω3 Algae	Fish	Micro-algae	Powder	ω3Algae is only composed of a selected blend of Chlorella Algae. The processing ensures the preservation of all nutritional characteristics and the total elimination of all bacteria and viruses. ω3Algae is easy to use, reaching complete cell separation in just a few minutes of blending. The suspension remains remarkably stable in water.	DATASHEET
BernAqua – *InVivo NSA*	ω3Yeast60	Fish	Rotifer Feed	Powder	ω3Yeast60 is a selected yeast-strain, not genetically modified. ω3Yeast60 is presenting the highest levels of protein associated with EFA and vitamin C levels comparable to the highest levels found in live micro algae. No oils are mixed or top coated on the yeast. ω3Yeast60 can support fast growth at high densities for long period of time, without presenting the risk of rotifer degeneration or culture crashes.	DATASHEET
BernAqua – *InVivo NSA*	Royal Pepper Protein	Shrimp	Booster / Microbial	Suspension	Royal Pepper Protein is a high quality shrimp supplementary liquid feed aimed at improving health and stress resistance. Royal Pepper Protein is used throughout the larval cycle, and fences off Zoea syndrome and Post Larvae stress.	DATASHEET

SUPPLIER	PRODUCT NAME	SPECIES	PRODUCT TYPE	FORM	DESCRIPTION	DATASHEET
BioMar	LARVIVA Multigain	Rotifers *Artemia*	Enrichment		Complete dry formula to enrich live feed with all nutrients required by marine larvae or other first feeding species.	DATASHEET
Gold Coin Biotechnologies SDN BHD	**HiPro** (Early Post Larvae) (Late Post Larvae)	Shrimp	Larvae Feed	Powder	Minimal feed wastage promotes strong attractant for consumption and prolonged feed uptake by larvae. It is simple to use; just add straight into the rearing tanks.	
Industrial Plankton	PBR 1000L	Marine fish Shellfish	On site algae production equipment	Live Algae	Fully automated equipment produces live algae on site. 1000L tank, self cleaning and sterilizing, automated harvesting, UV sterilization, user friendly touch screen controls. Requires 4'X4'X7' space.	DATASHEET
Fritz Industries Inc.	TurboStart 700	All livestock	Freshwater nitrifying bacteria	Refrigerated liquid concentrate	TurboStart 700 contains the most concen-trated blend of proven, effective live fresh-water Nitrifying Bacteria, providing the proper balance of bacteria proven to rapidly seed biofilters, reducing the natural cycle time allowing for safe, immediate addition of livestock. Depending on livestock loads, TurboStart can cycle systems in 24 hours.	DATASHEET
Fritz Industries Inc	TurboStart 900	All livestock	Saltwater nitrifying bacteria	Refrigerated liquid concentrate	FritzZyme® TurboStart 900 contains the most concentrated blend of proven, effective Live Saltwater Nitrifying Bacteria. TurboStart provides the proper balance of bacteria proven to rapidly seed biofilters, reducing the natural cycle time allowing for safe, immediate addition of livestock. Depending on livestock loads, TurboStart can cycle systems in 24 hours.	DATASHEET
INVE AQUACULTURE	Sanolife GWS	Marine Fish	Dry algae	Powder	Off-the-shelf available product, gradually replaces the use of live algae. It considerably reduces the work load and allows increased larval output at lower costs.	
INVE AQUACULTURE	Sanolife MIC-F	Marine fish	Water treatment	Powder	One of the most advanced tools targeting the colonization of the fish tanks starting from the early larval rearing. Together with optimal feeds, feeding regimes and correct management, the practice of applying MIC F has been proven to be an integral part of the production of high quality fry.	
INVE AQUACULTURE	S.parkle	Marine fish	Rotifer feed	Powder	Performing and cost-effective rotifer culture diet that allows a sparkling clean rotifer production. It is formulated with high quality, protected ingredients and manufactured following INVE Aquaculture's strict quality control process.	

SUPPLIER	PRODUCT NAME	SPECIES	PRODUCT TYPE	FORM	DESCRIPTION	DATASHEET
INVE AQUACULTURE	RoBoost	Marine Fish	Rotifer feed	Powder	Compared to traditional dry diets, the use of fresh yeast boosted by the specific ingredients of RoBoost will result in a very clean culture, with rapidly growing rotifers containing already excellent nutritional characteristics. Starting from the first day of use, the population will exhibit excellent	
INVE AQUACULTURE	DHA Protein Selco	Marine Fish	Rotifer enrichment	Powder	Powdered enrichment product for rotifers, designed to compensate for the nutritional short-comings of rotifers as a natural feed for fish larvae. The use of DHA Protein Selco on the last day of the culture cycle will increase the rotifer's level enriching the live	
INVE AQUACULTURE	Easy Dry Selco	Marine Fish	Rotifer and *Artemia* enrichment	Powder	The ultimate powered enrichment product suitable for Rotifers and *Artemia*. EDS boosts the nutrional content of live feed and increase the stress resistance and the	
INVE AQUACULTURE	S.presso	Marine Fish	Rotifer and *Artemia* enrichment	Liquid	Liquid enrichment product for rotifers and *Artemia*, formulated with the finest raw materials and developed based on advanced knowledge of the larval nutritional needs. The product itself is a suspension/emulsion in which liquid and insoluble particles are mixed. This guarantees an optimal intake of the various ingredients by the rotifers and *Artemia* and to reach a DHA/EPA ratio	
INVE AQUACULTURE	Easy DHA Selco	Marine Fish	*Artemia* enrichment	Liquid	Liquid enrichment product for *Artemia,* designed to supplement the natural nutritional features of the nauplii to ensure	
INVE AQUACULTURE	A1 Selco	Marine Fish	*Artemia* enrichment	Liquid	Liquid enrichment diet for *Artemia* nauplii that compensates for the nutritional shortcomings of *Artemia* as a natural feed for marine fish larvae. The application of this product to live INSTAR II *Artemia* nauplii will significantly increase their levels	
INVE AQUACULTURE	Sanocare ACE	Marine Fish	Water conditioner	Liquid	For use during *Artemia* hatching for better hatching, survival and vitality of *Artemia* nauplii and during enrichment to increase the DHA/ EPA ratio of *Artemia* nauplii.	

SUPPLIER	PRODUCT NAME	SPECIES	PRODUCT TYPE	FORM	DESCRIPTION	DATASHEET
INVE AQUACULTURE	Sanocare Sure	Marine Fish	Water conditioner	Powder	The first rotifer conditioner that is composed of natural ingredients, such as berberine and thyme. It allows the suppression of *Vibrio*, thus reducing fish mortality. At the same time, it improves the quality and color of the rotifers in order to make them more attractive to the fry, improving the growth of fish larvae.	
INVE AQUACULTURE	Sanoguard S-PAK	Shrimp	Health booster	Crumble	Health booster for schimp, for improved resistance to stress and diseases. Strenghtens the immune system and health. Facilitates recovery after a period of stress. Improves survival and growth rates.	
INVE AQUACULTURE	Sanolife MIC	Shrimp	Water treatment	Powder	Microbial mixture for disease control and improved water quality in shrimp hatcheries. Inhibits Vibrio and other pathogenic bacteria. Produces enzymes and degrades waste. Colonizes the digestive tract. Produces strong PLs while improving survival and growth rates.	
MEGASUPPLY	EPICIN G2 Hatchery	Shrimp Marine and freshwater fish	Probiotic for hatchery water	Powder	EPICIN-G2 is a natural microbial ecosystem with added stabilizers and growth stimulants for detoxifying aquaculture hatchery water. It eliminates water-fouling waste products such as ammonia, nitrites and hydrogen sulfide, thereby lowering stress and providing a healthier environment for aquatic animal growth. It also improves animal health and disease resistance by creating a probiotic environment.	DATASHEET
MEGASUPPLY	EPICIN G2 DFM	Shrimp Marine and freshwater fish	Direct fed probiotic	Powder	EPICIN-G2 DFM is a natural microbial ecosystem with added stabilizers and growth stimulants. It eliminates water-fouling waste products such as ammonia, nitrites and hydrogen sulfide, thereby lowering stress and providing a healthier environment for aquatic animal growth. It also improves animal health and disease resistance by creating a probiotic environment. When applied to feed at the feed mill, EPICIN-G2 DFM is especially effective in improving FCR and reducing secondary pathogen mortality in viral weakened shrimp.	DATASHEET

SUPPLIER	PRODUCT NAME	SPECIES	PRODUCT TYPE	FORM	DESCRIPTION	DATASHEET
MEGASUPPLY	EPICIN HOD	Shrimp / marine and freshwater fish	Probiotic	Powder	EPICIN-HOD Hatchery Organics Digester is a natural microbial ecosystem for detoxifying the tank environment in aquaculture hatcheries by mineralizing and bio remediating solid organic waste and detritus, which usually settles on the tank bottom. The biologic catalysts of EPICIN-HOD Hatchery Organics Digester immediately start the process of digesting accumulated organic matter; these microor-ganisms have been specially selected due their ability to produce a wide variety of powerful enzymes to decompose the different organic wastes produced in the larviculture tanks. It also improves animal health and disease resistance by creating a probiotic environment; EPICIN-HOD Hatchery Organics Digester is fortified with unique accelerators to increase the microbial action.	DATASHEET
MEGASUPPLY	Epicin Ponds	Shrimp Marine and freshwater fish	powder	Biological aquaculture pond soil treatment	EPICIN-Ponds is a natural microbial ecosystem with added stabilizers and growth stimulants for detoxifying aquaculture grow-out ponds. It eliminates water-fouling waste products such as ammonia, nitrites and hydrogen sulfide, thereby lowering stress and providing a healthier environment for aquatic animal growth. It also improves animal health and disease resistance by creating a probiotic environment.	DATASHEET
MEGASUPPLY	EpicinPST	Shrimp Marine and freshwater fish	powder	Biological aquaculture pond soil treatment	EPICIN-PST pond soil treatment is a specially formulated biological and biochemical system designed to accelerate the biological decomposition of highly fouled aquaculture pond soil. It is a natural microbial ecosystem to inoculate the soil wastes and start the bioremediation process. It also is fortified with unique accelerants to speed the microbial action.	DATASHEET
MEGASUPPLY	Epizym AGP-Complete	Marine and freshwater microalgae	liquid	Algae growth media for pure and indoor cultures	EPIZYM-AGP-C is a complete concentrated medium for producing high levels of nutritious marine algae and other phytoplankton used for feeding shrimp and other marine animals. It is a one-pack, liquid version of the Guillard's f/2 medium with added cellular growth stimulants.	DATASHEET

SUPPLIER	PRODUCT NAME	SPECIES	PRODUCT TYPE	FORM	DESCRIPTION	DATASHEET
MEGASUPPLY	Epizym AGP (M)	Marine and freshwater microalgae	Liquid	Algae Growth Media For Large and Outside Culture Tanks	EPIZYM-AGP-M is a concentrated medium for producing high levels of nutritious marine algae and other phytoplankton used for feeding shrimp and other marine animals. It is a one-pack, liquid version of the trace elements, micro-nutrients, vitamins and minerals of the Guillard's f/2 medium with added cellular growth stimulants.	DATASHEET
Pacific Trading Aquaculture	Super Fresh Chlorella SV-12	Fish Rotifers	Rotifer diet green-water technique	Fresh live chilled liquid	Super Fresh Chlorella SV12 has been developed in Japan especially for Rotifer cultivation. Each cell contains DHA, EPA and Vitamin B-12 ensuring optimal enrichment. Delivered live and fresh within 5 days of order and is considered a vital cornerstone of RELIABLE stable high and low density rotifer cultivation.	DATASHEET
Pacific Trading Aquaculture	Emerald	Rotifers	Rotifer diet	Powdered	• Spray dried fine Chlorella powder • Axenic culture production (Patented process) • Economical • Designed for high and low density rotifer cultivation • Long shelf life • Stable production	DATASHEET
Phibro Aqua	PAQ-Gro for Hatchery	Shrimp, Tilapia	Nutritional Feed Additive	Powder	PAQ-Gro for Hatchery is a proprietary blend of natural ingredients, specifically formulated for the early stages of aquaculture development, showing good bioavailability following extrusion. The product can be integrated into aquafeed by top-coating after feed production or in the premix before pelleting or extrusion.	
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Algae** Isochrysis 1800	Finfish Zooplankton and *Artemia* enrichment, Bivalve Shellfish Shrimp	Single-species Microalgae, 8% dry weight	Refrigerated liquid concentrate; no blending required	Always available. ***Isochrysis 1800*** can be used to replace live algae production, augment existing production during peak season, or to have available in case of a culture crash. ***Isochrysis*** is high in DHA and often used to enrich zooplankton such as rotifers or *Artemia*.	

SUPPLIER	PRODUCT NAME	SPECIES	PRODUCT TYPE	FORM	DESCRIPTION	DATASHEET
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Algae** Nanno 3600	Finfish as a rotifer feed or for greenwater	Single-species Microalgae, 18% dry weight	Frozen or Refrigerated liquid concentrate; no blending required	***Nanno 3600*** is our original high-yield rotifer feed. It is a single-species product (*Nannochloropsis*) and produces phosphor-lipid-rich rotifers. It also provides a high Feed Conversion Rate with minimal organic waste, and gives an EPA and ARA pre-enrichment boost for use with high-DHA enrichment protocols. Store frozen for 2 years.	
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Algae** Pavlova 1800	Finfish Zooplankton enrichment; Bivalve Shellfish; Shrimp	Single-species microalgae, 8% dry weight	Refrigerated liquid concentrate; no blending required	*Pavlova* is a small golden/brown flagellate whose nutritional profile is very similar to ***Isochrysis***. It is excellent for enriching rotifers and other zooplankton. Its sophisticated sterol composition makes it particularly popular in cold water fish hatcheries. *Pavlova* is very difficult to grow so it is not produced by many hatcheries.	
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Algae** Tetraselmis 3600	Finfish feed stimulant effect for zooplankton and Brine Shrimp; Bivalve Shellfish; Shrimp	Single-species microalgae, 18% dry weight	Frozen liquid concentrate; no blending required	*Tetraselmis* is a large green flagellate with a very high lipid level. It contains natural amino acids that stimulate feeding in marine animals. *Tetraselmis* increases fecundity in zooplankton, is a standard feed for many Bivalves, and is excellent for increasing growth rates and fighting "Zoea Syndrome" in larval Shrimp.	
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Algae** TW 1200	Finfish Zoo-plankton; Bivalve Shellfish; Shrimp	Single-species microalgae; 6% dry weight	Refrigerated liquid concentrate; no blending required	*Thalassiosira weissflogii* is a large diatom used in Shrimp and Bivalve Shellfish larvi-culture. Considered by many to be the single best algae for larval Shrimp, the large cell size (5 – 15 micron) extends the algae feeding period until the end of the PL stage.	
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Algae** Shellfish Diet 1800	Bivalve Shellfish; Ascidians/ Tunicates; Sea Urchins; Soft Corals; Brine Shrimp; and Copepods	Microalgal blend; 8% dry weight	Refrigerated liquid concentrate; no blending required	***Shellfish Diet 1800®*** is a mix of six marine microalgae that have all demonstrated success with a variety of Shellfish including Oysters, Clams, Mussels, and Scallops. Shellfish Diet can be used with pre-set larvae all the way up through broodstock as a **complete live algae replacement.**	
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Algae** RotiGrow *OneStep*	Finfish Zooplankton feed	Microalgal blend; >14.8% % dry weight	Frozen liquid concentrate; no blending required	**RotiGrow *OneStep*** is a clean, high-yield, microalgal blend rotifer feed that maximizes balanced pre-enrichment levels of DHA, EPA and ARA. RotiGrow *OneStep* eliminates the secondary enrichment step for those fish with a higher DHA requirement at the larval stage.	

SUPPLIER	PRODUCT NAME	SPECIES	PRODUCT TYPE	FORM	DESCRIPTION	DATASHEET
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Algae** RotiGrow *Plus*	Finfish Zooplankton feed	Microalgal blend; >14.8% dry weight	Frozen liquid concentrate; no blending required	**RotiGrow *Plus*** is a clean, high yield rotifer feed that maximizes pre-enrichment levels of DHA, EPA and ARA. The essential first step in the **RotiGrow System.** Depending on the nutritional requirements of the fish larvae, it can be used as a stand-alone feed.	
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Algae** RotiGrow *Nanno*	Finfish Zooplankton feed	Microalgal blend; >16.4% dry weight	Frozen liquid concentrate; no blending required	**RotiGrow *Nanno*** is a clean, high yield single species rotifer feed that produces phospholipids-rich rotifers. Our highest yielding feed, it provides the highest bio-mass conversion rate of our products, with the least organic waste in the tank. Gives a high EPA and ARA pre-enrichment boost for use with high DHA-enrichment protocols.	
Reed Mariculture ENSURING HATCHERY SUCCESS	**Chlorella Ltd.** Chlorella V12	Finfish Zooplankton feed	Live microal-gae concen-trate; 14% dry weight	Refrigerated algal concentrate – delivered fresh and alive	This ***Chlorella,*** grown in Japan, is a super fresh grow-out feed enriched with DHA using a patented methodology. It provides a moderate DHA, EPA and ARA enrichment (25mg/g HUFA pre-enrichment). It is naturally high in vitamin B-12, a nutrient necessary for larval health.	
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Algae** RotiGreen *Omega*	Finfish Greenwater	Microalgal blend; 8% dry weight	Frozen liquid concentrate; no blending required	**RotiGreen *Omega*** is effective Greenwater with Optimum DHA, EPA & ARA nutrition for fish larvae as well as enrichment maintenance for rotifers in the larval tank. Marine microalgae concentrates stay extremely clean with excellent suspension in the tank. ***RotiGreen *Omega*** may require special care for larva with an inflating air	
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Algae** Rotigreen *Nanno*	Finfish Greenwater	Microalgal blend; 8% dry weight	Frozen liquid concentrate; no blending required	**RotiGreen *Nanno*** balances DHA/EPA with ARA to optimally nourish fish and maintain the health of rotifers. Extremely clean, it offers excellent suspension in the water column. **RotiGreen *Nanno*** is as effective as live *Nannochloropsis*, and is replacing our **Nanno 3600** for greenwater applications.	
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Algae** RotiGreen *Iso*	Finfish Greenwater	Microalgal blend; 8% dry weight	Refrigerated liquid concentrate; no blending required	**RotiGreen *Iso*** is a pure algae formulation that is as effective as live**.** A highly nutritious greenwater when swallowed or gill fed by larvae, it can maintain or further increase the DHA/EPA ratio in your rotifers and larval fish to meet their nutritional requirements. Naturally high in the carotenoids necessary for larval health.	

SUPPLIER	PRODUCT NAME	SPECIES	PRODUCT TYPE	FORM	DESCRIPTION	DATASHEET
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Zooplankton** "Mini L 160" Live Rotifers	Finfish Live Larval Feed	Live zooplankton	A dense culture of live zoo-plankton packaged in 1 – 1.5 liters of salt water in breath-able bags.	Reed Mariculture supplies pure cultures of a strain of *Brachionus plicatilis* (L-type) with a typical lorica length of about 160 µm. This species is euryhaline, capable of thriving in salinities of 5-40 ppt. It is available in quantities from 1 million to 1.5 billion, concentrated and packaged into "breathable" bags.	
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Zooplankton** *Apocyclops panamensis* Copepods	Finfish Live Larval Feed	Live zooplankton	Incredibly durable cyclopoid copepod that is eurythermic, euryhaline and can tolerate poor water quality.	Newly hatched nauplii of *A. panamensis* typically measure 90µm long by 65µm wide, making them highly suitable for small gape fish larvae. Good source of fatty acids and antioxidants including Vitamin C and E. Unlike other species of highly valued copepods, this animal will readily consume Reed Mariculture's algal concentrates, which will make culturing them less expensive and less time consuming. Successfully used to culture snapper, seahorses, pipefish, clownfish and more.	
Reed Mariculture ENSURING HATCHERY SUCCESS	**Instant Zooplankton** Parvocalanus crassirostris Copepods	Finfish Live Larval Feed	Live zooplankton	A dense culture of Live Zoo-plankton packaged in 1 – 1.5 liters of salt water in breath-able bags.	Copepods are the feed of choice for wild marine finfish. *Parvocalanus crassirostris* is a small, pelagic calanoid copepod. The nauplii (newly hatched larvae) are small measuring in the 40-100 µm range, making them a suitable feed for small-gape fish larvae. Adults are in the 200 to 400 µm range.	
Reed Mariculture ENSURING HATCHERY SUCCESS	**APBreed** RGcomplete	Finfish Zooplankton Feed	Microalgal blend; 4.4% dry weight	Very stable refrigerated liquid concentrate; includes ammonia control; no blending required.	***RGcomplete*** is a super-concentrated microalgal-based premium quality feed for filter-feeding invertebrates. It has been sized especially for Breeders, Aquarists, and Propagators and includes both a pH buffer and ClorAmX® (ammonia neutralizer). It has a long refrigerated shelf life of at least six months. Suitable for a wide range of zooplankton with a balanced Omega profile.	
Reed Mariculture ENSURING HATCHERY SUCCESS	**APBreed** SDaquarist	Shellfish, Corals	Microalgal blend; 4.4% dry weight	Very stable refrigerated liquid concentrate; includes ammonia control; no blending required.	A mixed diet of four marine microalgae (*Isochrysis, Pavlova, Tetraselmis* and *Thalassiosira pseudonana)* that provides superior nutrition for all types of shellfish, crustaceans and other filter feeding invertebrates, increasing both growth rate and survival. Complete with ammonia con-trol and buffered for a long refrigerated shelf life.	

SUPPLIER	PRODUCT NAME	SPECIES	PRODUCT TYPE	FORM	DESCRIPTION	DATASHEET
SKRETTING a Nutreco company	ORI-ONE	Marine fish	Combined rotifer culture & enrichment product	Powder	Diet which has been developed to offer excellent rotifer reproduction and measured nutritional incorporation without the need for a separate enrichment.	
SKRETTING a Nutreco company	ORI-CULTURE	Marine fish	Rotifer culture product	Powder	Diet which has been designed to offer excellent rotifer reproduction and to increase the rotifers natural protein profile & fertility.	
SKRETTING a Nutreco company	ORI-GREEN	Marine fish	Rotifer & *Artemia* enrichment	Powder	Diet which has been designed to ensure a very fast and efficient uptake by the live feed. The algae in the formulation also provide a natural pre-biotic effect and stimulate rotifer and *Artemia* condition.	
SKRETTING a Nutreco company	ORI-GOLD	Marine fish	*Artemia* enrichment product	Liquid	Natural blend of encapsulated marine HUFAs, algae and proteins for enriching *Artemia*. It is boosted with specific proteins to offer a more balanced profile.	
SKRETTING a Nutreco company	ORI-N3	Marine Fish	*Artemia* enrichment product	Liquid	A unique oil free, algal based DHA enrichment for maximal DHA incorporation & the ultimate in user flexibility.	
Tromso Fiskeindustri	Phosphonorse	Rotifers and *Artemia*	Enrichment	Oil	A blend of phospholipids, marine oils, vitamins and carotenoides. Designed to boost the DHA content of rotifers and *Artemia*, and give an excellent nutritional composition of the live prey.	
Zeigler	EZ Bio	Shrimp	Larvae, PL	Powder	A multi-functional biologic treatment for use in shrimp and fish hatcheries. Used to lower risk from pathogenic bacteria and improve water quality.	DATA SHEET
Zeigler	Rescue hatchery probiotic™	Shrimp	Probiotic	Powder	A unique blend of natural microbes specifically selected to control *Vibrio spp*. and other pathogenic bacteria.	DATASHEET
Zeigler	Remediate hatchery probiotic ™	Shrimp	Probiotic	Powder	A natural microbial treatment designed to improve water quality through reduction of ammonia and organics.	DATASHEET

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MARCH	
6 – 10: 2017: Offshore Mariculture Conference Mexico, Ensenaba, Baja California, Mexico	http://www.offshoremariculture.com/mexico
7 – 9: AFIA 2017 Purchasing & Ingredient Suppliers Conference, Orlando, Florida	http://www.afia.org
14 – 15: International Conference on Marine Science & Aquaculture, Kota Kinabalu, Sabah, Malaysia	http://www.ums.edu.my/ipmbv2/icomsa/
15 – 17: VIV Asia 2017, BITEC, Bangkok, Thailand	http://www.vivasia.nl/en/Bezoeker.aspx
20: Giant Prawn 2017, AIT, Bangkok, Thailand	http://www.giantprawn.org./
April	
17 – 18: Food & Feed Drying Technology short course, Ås, Norway	https://fie.com.au/events/drying-norway
17– 20: 10th WESTPAC International Scientific Conference, Qingdao, China	http://www.iocwestpac10.com/
24 – 26: Aquaculture Extrusion Technology short course, Ås, Norway	https://fie.com.au/events/aquafeed-extrusion-norway
26-27: 7th European Algae, Industry Summit, Nice, France	mailto:dpavlyk@acieu.net
May	
15– 18: Tuna Conference, Lake Arrowhead, California, USA	http://www.tunaconference.org/
25– 27: 6th Global Summit on Aquaculture & Fisheries, Osaka, Japan	http://aquaculture.global-summit.com/
June	
2– 4: 12th China (Fuzhou) International Seafood & Fisheries Expo (FIFE), Fuzhou, China	http://www.chinafife.com/portal/index/index/l/en-us.html
8– 9: XXVIII FEFAC Congress and the V Animal Nutrition Congress, Cordoba, Spain	http://www.fefac.eu/news.aspx?CategoryID=2063&EntryID=22943
13– 14: FVG Select (by Victam International), Cologne, Germany	http://www.victam.com/?i=372
14: Aquafeed Horizons Europe, Cologne, Germany	http://feedconferences.com
26 – 30: World Aquaculture, Cape Town, South Africa	http://www.marevent.com/WA2017_CAPETOWN.html
July	
24– 27: Asian-Pacific Aquaculture 2017, Kuala Lumpur, Malaysia	https://www.was.org/meetings/Default.aspx?code=APA2017

NEW EVENT!

FVG select 2017

FIAAP VICTAM grapas

13 – 14 JUNE 2017 · KOELNMESSE, COLOGNE, GERMANY

FVG Select 2017 is a new event which will be organized by Victam International BV. The event will focus on a series of high quality industry **conferences** and **matchmaking** with colleagues and clients in the **animal feed processing, grain processing, ingredients & additives, aquafeed, petfood and biomass pelleting** industries. The event will be complemented by an **industry expo** for a select group of companies.

THE CONFERENCES AND DELEGATE PROFILES

Tuesday 13th June

1. PETFOOD FORUM EUROPE
Production technology and specialist ingredients for dry petfoods.
Organizer: WATT Global Media
Delegate profile: CEOs, directors, mill and plant managers, head and senior nutritionists, formulators from dry petfood production plants.

2. THE GLOBAL MILLING CONFERENCE WITH GRAPAS
Processing technology and additives used within flour milling and grain processing.
Organizer: Perendale Publishing
Delegate profile: CEOs, directors, mill and plant managers, nutritionists from flour mill, rice mills and grain processing plants.

3. VICTAM FEED PROCESSING CONFERENCE
Production technology and equipment used within the animal feed production processes.
Organizer: Wageningen University and IFF
Delegate profile: CEOs, directors, mill and plant managers, head and senior nutritionists, feed formulators from commercial feed production plants, integrators, etc.

● Evening **network reception** for exhibitors, delegates and visitors.

Wednesday 14th June

1. FIAAP ANIMAL NUTRITION
The use of specialist additives and ingredients used within the production of animal feeds.
Organizer: WATT Global Media
Delegate profile: Head and senior nutritionists, feed formulators, CEOs, directors, mill and plant managers from commercial feed production plants, integrators, specialist feed producers, etc.

2. AQUAFEED HORIZONS
Production technology and specialist ingredients for aquaculture feeds.
Organizer: Aquafeed.com
Delegate profile: CEOs, directors, mill and plant managers, head and senior nutritionists, feed formulators, integrators, specialist aquaculture feed producers, etc.

3. BIOMASS PELLETING
Production technology for the pelleting of bio-degradable materials for biomass pellets.
Organizer: AEBIOM (The European Biomass Association)
Delegate profile: CEOs, directors, mill and plant managers from biomass pelleting plants.

A fee of €95 per person (valid for two days) will be charged to each individual attending the event, both exhibitors and visitors, and includes lunch, two coffee and tea breaks a day, the network reception and access to our matchmaking service. A separate fee will be charged for each conference. More details can be found on our website.

THE INDUSTRY EXPO

There will be 9m² and 18m² standard shell scheme booths available during the two day event. The expo will take place in the adjoining hall to the conference rooms and will also be the venue for all the refreshments.

EVENT ORGANIZERS

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