Shrimp larvae do not feed like adult shrimp

How three decades of innovation continue to shape larval nutrition

By Eva Werbrouck



For more than three decades, shrimp hatchery culture has undergone a remarkable transformation. While advances in genetics, biosecurity, water quality management, nutritional strategies and digital technologies have reshaped farmed shrimp production, delivering the right nutrition to larvae during their most dynamic developmental phase remains a cornerstone of successful shrimp production.

Shrimp larvae are not simply small shrimp. In about eight days, they undergo multiple moulting events, completely changing their feeding behaviour, remodel their digestive physiology and transition from free-swimming planktonic organisms into bottom-dwelling post-larvae. Every developmental stage brings new nutritional demands, making early feeding one of the most technically demanding aspects of hatchery management.

It was precisely this biological complexity that inspired the development of the FRiPPAK range of products. For over 35 years, this range has been synonymous with premium larval nutrition. However, although the brand name has remained constant, the products and technologies behind it have continuously evolved to address new challenges and unlock new opportunities in hatchery production. Today, FRiPPAK FRESH is the latest expression of that commitment, delivering stage-specific nutrition designed around larval biology rather than manufacturing convenience.

This article discusses how larval nutrition has evolved as well as into why understanding shrimp biology remains the basis of successful hatchery production.



At a hatchery in Vietnam. with Eva Werbrouck, Product Manager Formulated Diets (right).

A pioneer that continues to evolve

When FRiPPAK was first introduced in the late 1980s, the concept of microencapsulated diets for shrimp larvae was still in its infancy.

At that time, hatcheries depended almost entirely on live food, struggling with its challenges, such as variable nutritional quality, unstable supply and biosecurity risks.

Artificial diets promised to be game changers by providing a consistent, readily available nutritional source. However, the early prototypes came with their own limitations, including poor water stability, rapid nutrient leaching and suboptimal particle characteristics.

FRiPPAK changed that by introducing pharmaceutical-inspired microencapsulation technology that protected nutrients until ingestion in stable particles tailored to each larval stage.

Since then, the FRiPPAK range has continued to evolve. We at INVE Aquaculture have continuously refined formulations, strengthened quality control and updated production technology, as our understanding of shrimp larval development grows. Throughout this evolution, one principle has remained unchanged: nutrition should support the biology of the animal rather than simply deliver nutrients.

One animal. Three different feeding strategies

Despite obvious biological changes - metamorphosis, during larval development, many larval diets still provide essentially the same nutritional profile throughout the hatchery cycle, as if larvae simply become larger versions of themselves. In reality, they become almost completely different animals every day.

The journey begins with the zoea stage. These tiny larvae behave as herbivorous filter feeders, continuously filtering microscopic particles from the water column. Their digestive tract has a very simple structure, essentially a short tube, with food passing rapidly through the gut. Digestion relies heavily on lipids and highly digestible nutrients. Particle size and buoyancy are critical. If particles sink too quickly or size exceeds the larval mouth size, feeding efficiency drops dramatically.

As larvae moult into the mysis stage, everything changes. They swim backwards and start hunting while maintaining their filter-feeding behaviour. Their nutritional needs shift toward high-quality proteins, while feed attractants become increasingly important to stimulate prey-capture behaviour.

Only a few days later comes perhaps the most demanding transformation of all. As late mysis metamorphose into post-larvae, they shift from a pelagic to a benthic lifestyle. At the same time, digestive enzyme activity temporarily declines, a phenomenon often referred to as the enzyme crisis, which continues until approximately postlarval stage 4.

Often forgotten is how wonderful this metamorphosis is. The animal is transforming body form and function while temporarily losing digestive capacity. If nutrition is not adapted to this challenge, performance can suffer.

This is precisely why FRiPPAK FRESH uses two specialised formulations, delivered as three different diets, rather than a single universal formulation.

"Instead of asking larvae to adapt to the feed, we adapt the feed to the larvae."

Feeding biology, not just growth

Rather than designing feeds around crude protein percentages, FRiPPAK FRESH follows the biology of each developmental stage.

The protocol begins with FRiPPAK FRESH #1 CAR, formulated specifically for zoea larvae with algae-derived ingredients that support the physiology of herbivorous larvae. Highly digestible marine proteins maximise peptide and amino acid uptake despite rapid gut passage, while enrichment with key nutrients delivers functional support for a smooth transition into the mysis stage.

As larvae enter the mysis stage, the protocol shifts to #2 CD. Marine proteins and carnivorous nutrient profiles reflect the larvae's changing digestive physiology and nutritional requirements, while specialised feed attractants encourage active hunting behaviour.

Finally, there is #3 CD which supports early post-larvae during one of the most vulnerable phases of development. Larger, slow-sinking particles mimic the size, movement and feeding stimulus of live *Artemia* nauplii, while fresh marine proteins and highly digestible ingredients help compensate for the temporary reduction in digestive enzyme activity.

The idea is simple. Instead of asking larvae to adapt to the feed, we adapt the feed to the larvae.

Knowing when to change diets

Designing stage-specific diets is only one part of the equation. Their success also depends on introducing each formulation at the right biological moment.

Although feeding protocols are often linked to the number of days after hatch, larval development is influenced by temperature, genetics, water quality and hatchery management. As a result, larvae of the same age do not always reach the same developmental stage at the same time.

For years, hatchery technicians have relied on their expertise and observations to assess larval development. That expertise remains essential. But today we also have tools that can help make those assessments more consistent.

One of those tools is SnappArt 360 S-SENSE™, an AI-assisted larval staging platform that analyses microscope images to determine the developmental stage of *Litopenaeus vannamei* larvae (Figure 1).

From observation to objective staging

SnappArt 360 S-SENSE analyses microscope images of shrimp larvae to identify their developmental stage. By providing a standardised assessment of larval development, it helps hatchery teams determine the optimal timing for transitions between diets, supporting more consistent implementation of stage-specific feeding protocols.



Figure 1. From observation to objective staging with *SnappArt 360 S-SENSE*.

Rather than replacing hatchery expertise, S-SENSE provides an objective and standardised assessment of larval development, helping hatchery teams determine the optimal moment to transition between #1 CAR, #2 CD and #3 CD.

The nutritional requirements of a zoea, a mysis, and an early post-larva are fundamentally different. Stage-specific nutrition delivers its greatest value when diets are changed according to larval development rather than simply according to the calendar.

Together, stage-specific nutrition and objective larval staging help hatcheries apply feeding protocols with greater precision and consistency.

The hidden challenge: metamorphosis

Nutrition during metamorphosis involves far more than supplying energy.

One of the requirements for successful metamorphosis is a successful moult. During each moult, larvae rapidly construct a completely new exoskeleton while breaking down and partially reusing the old one.

This period of increased metabolic activity naturally increases the production of ROS (reactive oxygen species), creating a greater risk of cellular damage to membranes, proteins and DNA. At the same time, larvae stop feeding and become temporarily more susceptible to bacterial infection while their protective barriers are rebuilt.

This is one of the reasons why we consider functional nutrition just as important as nutritional. Good larval nutrition is about producing robust post-larvae that continue performing during grow-out.

FRiPPAK FRESH incorporates targeted functional components to support four key physiological challenges during metamorphosis:

- proteins and mineral nutrition for proper exoskeleton formation;
- antioxidant protection to limit oxidative damage;
- immune-supporting ingredients during periods of increased disease susceptibility;
- osmoregulatory support during moulting and resilience to ionic imbalance during larval culture.

Engineering the feed particle

Formulation is just one piece of the puzzle. The physical characteristics of the feed determine whether nutrients reach the animal.

Larvae do not simply eat whatever is provided. Particle engineering is just as important as nutritional formulation.

Each diet is engineered with stage-specific particle sizes, progressing from 5–30µm during zoea to 90–150µm in early post-larvae.

Buoyancy also changes throughout development. Neutral buoyancy keeps particles suspended to enable zoea and mysis to feed naturally, while slow-sinking particles in #3 CD better match the feeding behaviour of benthic post-larvae.

Microencapsulation further protects nutrients against leaching, helping maintain water quality while ensuring nutritional value reaches the larvae rather than having the nutrients dissolve into the surrounding water.

Looking beyond feed

Although FRiPPAK FRESH has become one of the industry's best-known larval diet brands, successful hatchery nutrition is increasingly about integrated hatchery management rather than individual products.

No formulated diet works in isolation. The best hatcheries integrate live algae, *Artemia*, formulated diets, water quality management, health protocols and accurate larval monitoring into one coordinated production strategy.

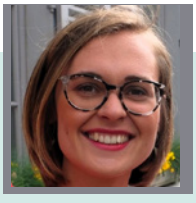
This philosophy aligns with the broader direction of modern hatchery production, where nutrition is one component of an integrated approach designed to improve consistency rather than simply maximise short-term growth.

Recent commercial work has demonstrated that optimising these nutritional transitions can translate into measurable production benefits. In one commercial evaluation in Ecuador, hatcheries using the FRiPPAK FRESH protocol achieved approximately 20% greater harvested biomass per tank. The target post-larval body weight was reached one day earlier under the evaluated production conditions.

In India, application of these diets increased body weight by 59% and length by 18% on average at PL3 stage. This growth advantage was maintained during post-larval culture and reduced the culture cycle by two days. Earlier harvest not only reduces the costs associated with the final days of production but also lowers exposure to late-stage mortality and enables hatcheries to complete more production cycles using the same infrastructure.

In conclusion, ultimately, the objective is not to sell another feed, but to increase the profitability of hatcheries through improved production efficiency and to deliver robust post-larvae that perform in the ponds.

For more than three decades, the philosophy behind FRiPPAK has been to support hatcheries with nutrition that follows the biology of the animal. That is still what drives its development today.



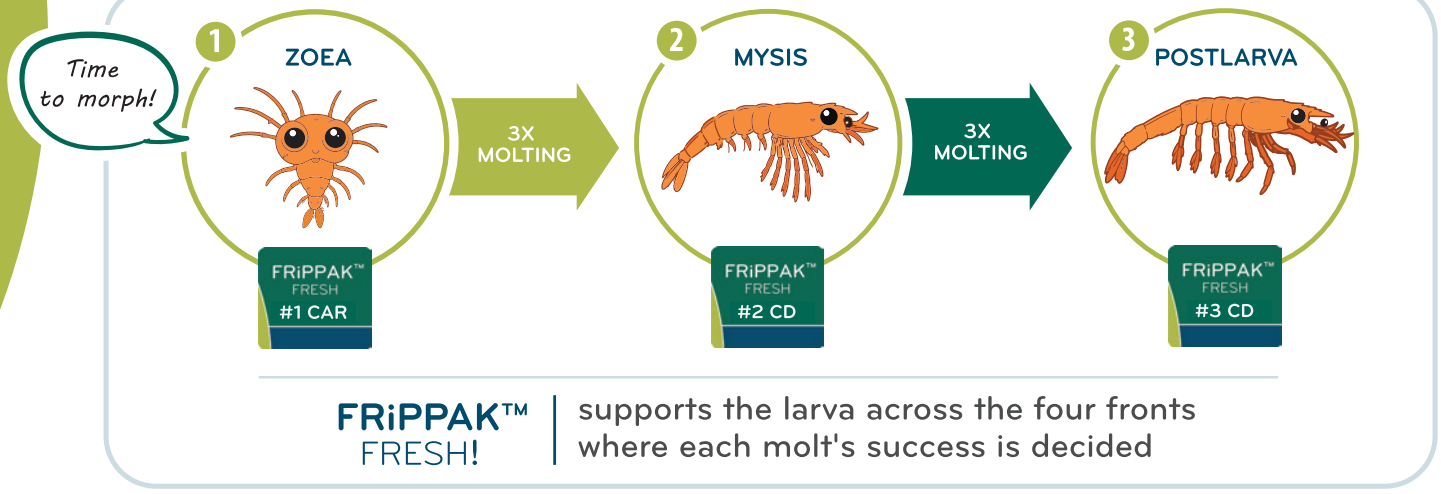
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FRiPPAK™ FRESH
Functional Support

INVE AQUACULTURE

METAMORPHOSIS WITHOUT PAUSE

Exoskeleton change - Oxidative stress - Salinity stress - Immune defense challenge



FRiPPAK™ FRESH! supports the larva across the four fronts where each molt's success is decided

HOW FRiPPAK™ FRESH SUPPORTS METAMORPHOSIS

INSIDE
Internal biological processes

EXOSKELETON CONSTRUCTION (MOLT)
Molting demands energy and minerals — failure means mortality.

- **Supplies minerals and proteins** - the structural building blocks of the new exoskeleton
- **Stabilizes the newly formed cuticle**
- **Provides precursors** for the hormones that control molting

ANTIOXIDANT CAPACITY
Metamorphosis triggers free radicals that damage cells if unchecked.

- **Vitamin C**— neutralizes oxidative stress and supports cuticle formation
- **Vitamin E**— protects cell membranes from oxidation
- **Astaxanthin**— strengthens antioxidant capacity and stress resistance

OUTSIDE
External environmental pressure

RESILIENCE TO SALINITY CHANGES
Salinity fluctuations challenge a still-developing osmoregulatory system.

- **Acts as an osmolyte,** helping maintain internal balance
- **Stabilizes cell membranes** against changing conditions
- **Supports the function** of the Na^+/K^+ pump

IMMUNE STIMULATION
Immature defenses leave larvae vulnerable to pathogens.

- **Activates the immune system** for a faster response
- **Stimulates the production** of immune cells
- **Strengthens the integrity** of epithelial tissue

FOUR FRONTS, ONE GOAL



CARE FOR GROWTH



HELPING EVERY LARVA REACH THE NEXT STAGE

Contact us to learn more about **FRiPPAK™ FRESH!**