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INVE AQUACULTURE

Shrimp Larvae Management Guide

Good practice in feeding and management of shrimp larvae is essential in ensuring optimum health, welfare and growth of farmed shrimp.

Shrimp larvae quickly go through major changes in body structure requiring a series of different feeds and environmental conditions to meet their needs. This manual describes the requirements of the larval and postlarval stages of the whiteleg shrimp, *Penaeus vannamei*.

Contents

What Benchmark does

Our mission is to enable food producers to improve their sustainability and profitability.

We develop products and solutions in genetics, health and nutrition that improve performance, animal health and welfare, and reduce environmental impact across the production cycle. Our aim is to be aquaculture's leading supplier of solutions in genetics, health and specialist nutrition.

Benchmark Genetics

INVE AQUACULTURE

A Benchmark Company

Benchmark Genetics is one of the world's leading producers of salmon eggs and produces broodstock and fry for shrimp and tilapia. All breeding programmes are aimed at producing balanced genetic progress in desirable traits such as growth, quality and disease resistance. Benchmark's breeding facilities are located in major aquaculture production markets including Norway, Chile, Iceland, Colombia, USA and Thailand.

Benchmark Genetics USA develops and globally distributes genetically improved, high performing USDA certified SPR/SPF shrimp strains. They have the highest adaptability to local environmental conditions and genetically improved disease resistance, yield, health and welfare. Benchmarks Genetics concentrates its efforts on developing breeders with a higher level of resistance to the major diseases affecting the shrimp industry worldwide, such as WSSV and AHPND.

Benchmark Advanced Nutrition — INVE Aquaculture is a world-leading provider of specialist nutrition, preventative health products and environment solutions for the early stages of shrimp and fish production. INVE has secure access to high-quality live feed (Artemia) which, enhanced by technology, improves nutrition and resilience.

Fry and larvae quality is one of the main drivers for successful fish and shrimp farming. INVE develops products that help early-stage fish and shrimp develop to their full potential throughout the production chain. Every day INVE products and protocols prove their added value in hundreds of hatcheries and farms worldwide.

Benchmark produces a range of shrimp strains to meet the needs of producers around the world:

BMKYield®
Selected primarily for growth with high survivability.

BMKProtect®
Selected for improved resilience to WSSV and AHPND/EMS.

BMKLowSal®
Selected to thrive in low salinity conditions.

bmkgenetics.com/services/shrimp

A range of feeds and protocols designed to match the requirements of shrimp larvae is available:

Artemia

- AF and BF (Specialty Cysts)
- EG and TQ (Regular Non-Enhanced Cysts)
- High 5 and IL (Regular Enhanced Cysts)

All of the above Artemia Cysts can be enhanced with the INVE patented SEP-*Art* technology.

FRiPPAK®

LANSY-Shrimp

inveaquaculture.com
or artemia.inveaquaculture.com

Biosecurity

Objective

Prevent the entry and spread of pathogens in the hatchery to produce healthy specific pathogen free (SPF) postlarvae (PLs).

Principles

Pathogenic disease challenge during larval shrimp culture can impact larval productivity and shrimp performance during grow-out. Risk of pathogen exposure therefore needs to be minimised by maintaining high levels of biosecurity and hygiene at all times within the hatchery.

Caution:

✘ Care should be taken when handling cleaning and disinfection reagents. Manufacturer's instructions should be followed, and appropriate personal protection equipment used. Cleaning and disinfection should only be carried out by trained, experienced personnel.

Biosecurity plan

As each facility is unique, there is no single biosecurity plan that fits all hatcheries. Hatchery managers should plan and implement a set of biosecurity measures designed to meet the specific needs of each hatchery. These measures should be written into Standard Operating Procedures (SOPs) for training and awareness of staff. The biosecurity plan must be regularly and frequently reviewed, updated and adapted as conditions and pathogens change over time.

Hatchery premises

The hatchery building and equipment should be designed to allow easy and effective cleaning and disinfection.

The hatchery must be enclosed by a wall or fence with controlled entrance and exit points to prevent entry of non-authorized visitors or unwanted animals. A registration process should operate to monitor visitors to the site. Each functional, discrete area within the hatchery should have its own biosecurity level (e.g. reception for visitors, intake of materials, animal and feed production area etc). Movement between each area should be controlled with documented biosecurity procedures for equipment and people e.g. hand sanitation, change of footwear and clothing as required.

Vehicle traffic on the site should be discouraged, and external vehicles should not enter the hatchery unless absolutely essential. A specific point at the entrance to the site should be designated for delivery and unloading of feed and other supplies. After unloading, feed and supplies packaging should be disinfected if appropriate and transferred to a biosecure storage area. PL delivery or other essential vehicles should

be thoroughly disinfected before entering the site, and biosecure procedures for transferring PLs to the transport vehicle followed, without contact between the production area and vehicle or equipment.

Production areas

The areas used for production of shrimp or feed materials including algae or artemia are considered high risk areas and should be of highest biosecurity level. They should be divided into separate rooms for specific functions, such as quarantine, maturation, hatching, spawning, larvaculture, algae production and Artemia production. Biosecurity procedures to prepare each of these rooms prior to use should include the thorough cleaning and disinfection of floors, tanks, water channels and other equipment as a minimum between each production run.

Suggested Procedure for Tank Disinfection:

- Remove residual organic matter using brush and pressurized water
- Prepare liquid soap solution at 10 ml/l and apply with a brush at a rate of 300 ml / m^2 and others onto tank walls and bottom allowing a contact time of 1 hour and rinse with fresh water
- Apply Sanocare PUR 1% solution at a rate of 300 ml per m^2 with a brush onto tank surface allowing a contact time of 1 hour and rinse with fresh water
- Effective disinfection can be validated by swabbing and culture.

Suggested Procedure for Preparation of Larvaculture Tanks:

- Fill the larvaculture tank with filtered and treated sea water to 60% capacity
- Apply Sanocare PUR 1 mg/L or chlorine solution at 5–10 ppm for a minimum of 12 hours followed by dechlorination then apply strong aeration for 24 hours before stocking nauplii
- Commercial probiotics help to establish healthy gut microflora and prevent growth of pathogens. Probiotics such as INVE Sanolife® MIC or INVE Sanolife® MIC-S can be applied to reach 100.000 CFU/mL before stocking and 50.000 CFU/mL after each molt.

Equipment

Some equipment such as nets, buckets, probes should be cleaned and disinfected after each use. Where possible, each room or biosecure area should have dedicated equipment that it needs to carry out its function, but if occasionally equipment or materials need to be used in other rooms it should be thoroughly cleaned and disinfected. Colour coding can be used to ensure equipment is only used in a single room.

Shrimp hatcheries produce a substantial amount of waste water which needs to be treated according to local regulations and care taken to ensure that water is disposed of in a biosecure way.

People

Movement of people between different production areas presents a high risk for pathogen introduction and spread. Movement between areas should be minimised and where possible staff should work in one area per day. Workers should be regularly trained and updated in biosecurity procedures and follow these procedures when transferring between rooms.

Each production area or room should have its own dedicated clothing and footwear that is not to be used in other areas, possibly colour coded. Washing and sanitising hands using soap and water, and/or disinfectant gel is essential when entering each production unit. Footwear should be disinfected before entering biosecure areas (e.g. rubber boots or shoes) and footbath protocols enforced.

Materials used

Although the hatchery is a controlled, biosecure area, it cannot operate without physical inputs. Biosecurity precautions are needed to minimise the risk of introducing pathogens during normal operation of the hatchery.

Water

Water should be from a controlled, biosecure source away from other shrimp or aquaculture operations. Filtering water and high-throughput disinfection using ultra violet light or ozone can be used to reduce the risk of pathogens entering the hatchery. Microbiological status of intake water before and after treatment should be checked regularly (e.g. weekly). Where possible water should be used for a single tank before disposal or treatment in RAS to prevent contamination between groups.

Water distribution system

Pathogens can colonise water pipes and channels. Modern hatcheries usually have all piping above ground at an angle to allow full drainage, and duplicated allowing one in use and one dry. A regular programme (e.g. weekly) of flushing, cleaning and disinfecting the water distribution system should be established to prevent build-up of microbes. Pipes can be disinfected using commercial disinfectants following manufacturer's instructions or 37% muriatic acid solution pH 4, or 2.5 g/l sodium hydroxide solution pH12 or 50–80 mg/l active ingredient calcium hypochlorite solution.

Nauplii

Nauplii should only be obtained from a reputable supplier with certified specific pathogen free (SPF) status for broodstock and resulting nauplii. Eggs and nauplii can have been in contact with female broodstock that may carry undefined microbial pathogens so they should be disinfected during transfer to hatching or larvaculture tanks. Eggs can be disinfected using 50 mg/l iodine –10% solution for one minute, and nauplii disinfected using Sanocare PUR at 30 mg/l for 45 seconds or other commercial aquaculture disinfectants according to manufacturer's instructions.

Feed

Algae and Artemia

Live algae and Artemia nauplii represent an important risk for introducing and spreading pathogens. High biosecurity measures in the feed production areas are therefore very important. Disinfection of Artemia prior to their use in larvaculture substantially lowers pathogen risk. Products that control proliferation of pathogens (e.g. D-fense technology for Artemia) can substantially lower pathogen levels.

Formulated feeds

Larval feeds should originate from trustworthy suppliers that certify absence of pathogens in the product and raw materials.

Caution:

- ✘ Care must be taken to avoid introducing the disinfectant into tanks containing shrimp larvae.
- ✘ Personal protective equipment should be used when handling chemicals and reagents.

Shrimp larvae biology, feeding and nutrition

Objective

Provide nutritious feed that is ingested and digested by shrimp larvae.

Principles

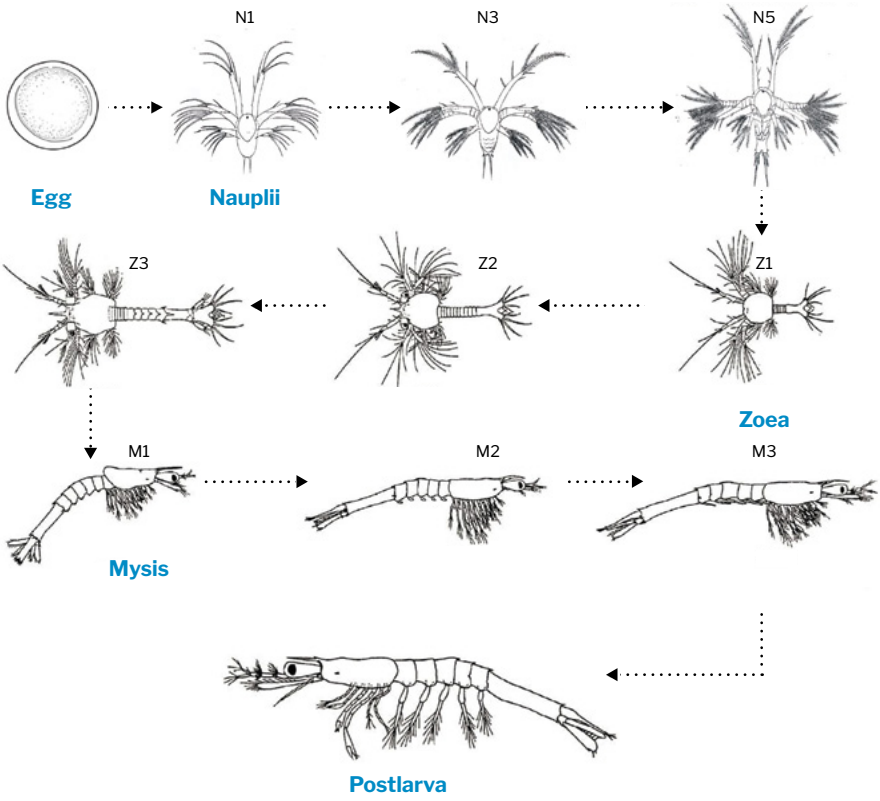
The feeding and nutrition of shrimp larvae is based on supplying feeds that are ingested by the larvae and meet the nutritional requirements of the different larval stages. Feed uptake and nutritional requirements vary because of biological differences between larval stages and a knowledge of shrimp larval biology helps in successful feeding.

Practical feeding regimes

Successful production of robust postlarvae for stocking in grow-out ponds largely depends on feed quality and the feeding schedule that is applied in the hatchery. The metamorphosis of *Penaeus vannamei* through larval stages into postlarvae is a complex process (see Figure 1, life cycle), which in the wild is characterised by migration to inshore, brackish estuaries. This shift from pelagic to bottom-dwelling benthic behaviour is accompanied by a change in feeding habit from a herbivorous to an omnivorous diet. Growth and development of the digestive system affects digestive capability, mainly due to qualitative and quantitative fluctuations in digestive enzyme production. Larval stages therefore, differ in nutritional requirements.

Formulated feeds need to take account of all the changes seen in shrimp larval development. Feed formulation and feed processing are tailored to the specific needs of each stage (Table 1) and nutritionists continuously improve feeds to maximise growth and robustness.

Figure 1. The larval stages of penaeid shrimp. For hatchery management and feeding, the important stages are zoea, mysis and postlarvae.



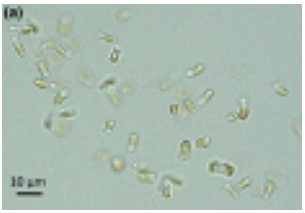
Adapted from: Wei et al, (2014) PLoS ONE 9(9): e106201. doi:10.1371/journal.pone.0106201

Table 1. Biological characteristics of shrimp larvae and postlarvae and corresponding feed specifications to ensure better feed utilisation, improved culture performance and improved postlarval quality.

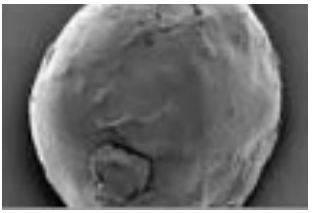
Biological characteristics	Feed characteristics
Zoea stages	
Z1, Z2, Z3 First feeding stages	Size range 5–30µm
Pelagic filter-feeder	High density of feed particles Neutrally buoyant or slow-sinking
Predominantly herbivorous	Co-feeding of dry feeds and live algae
High energy turnover, 10–20 minutes gut passage time	Dry feeds are algal replacement diets (e.g. FRiPPAK™ Fresh #1 CAR)
High lipase activity	Highly digestible feed
Mysis stages	
M1, M2, M3	High density of feed particles Size range: 30–90µm
Pelagic filter-feeder	Neutrally buoyant or slow-sinking particles
Omnivorous / carnivorous with poor hunting behaviour	Co-feeding of formulated feeds and heat-killed or frozen Artemia instar I nauplii
10–20 minutes gut passage time	Highly digestible feed
High protease and medium lipase activity	Moderate lipid level: 10–15% High protein level: 50–60%
Early postlarval stages	
PL1, PL2, PL3, PL4	Algal feed phased out Size range: 90–250µm
Pelagic filter-feeder	Neutrally buoyant or slow-sinking
Omni / carnivorous, active, hunting behavior	Co-feeding of Artemia instar I live nauplii and formulated feed
15–20 mins gut passage time	Highly digestible feed
Low enzyme activity	Highly digestible feed Moderate lipid level: 10–15% High protein level: 45–55%
Postlarval stages	
PL5–PL8/15 Increasing mouth opening	Size range: 300–500/800µm
Benthic feeder	Sinking feed
Omnivorous	Only formulated diets
30 mins gut passage time	Moderately digestible feed
Increased digestive capacity	Low lipid level: 5–10% Moderate protein level: 40–45%

Images

Zoea larva (*Penaeus vannamei*)



Algae (*Chaetoceros sp.*)

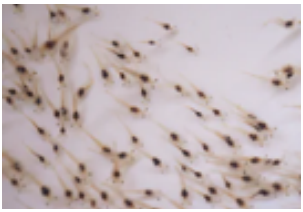


EM photograph of a microencapsulated feed

Mysis larvae (Pv)

Artemia nauplii, L: instar I, R: enriched during 24h instar III

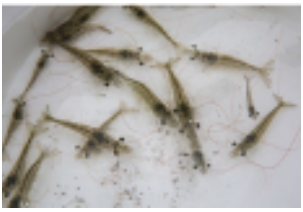
Harvesting newly-hatched Artemia nauplii instar 1



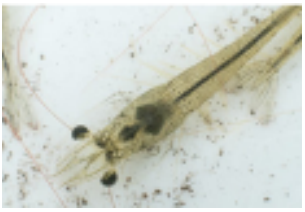
Early stage post-larvae (Pv)

Early stage post-larvae (Pv)

Dry feeds for postlarvae, Top: flakes, Bottom: microbound particles



Postlarvae (Pv)



Postlarva (Pv) feeding on feed crumbles

The main challenges in manufacturing larval feed are to provide a complete nutritional package in a sufficiently small particle that is easily ingested and digested by the larvae, and that prevents loss of nutrients into the water. Various types of larval feeds that meet these challenges are commercially available including microbound diets, flakes, granulated feeds, microencapsulated feeds. Microencapsulated feeds have a protective coating that minimises nutrient loss while remaining attractive to the animals.

Practical feeding regimes

The natural feeding habits of shrimp are replicated in hatcheries using different species of microalgae, zooplankton — mostly Artemia — and formulated feeds (see Table 2). Algal feeding is done once or twice daily to maintain the desired algal cell density. Amounts of dry feed gradually increase over time.

Table 2. Scheme of components and particle size range of dry feeds in a shrimp feeding regime.

Stage	L–D*	Dry feed (particle size)**					Algae**	Artemia**
		<30µm	30–90µm	75–150µm	100–200µm	200–300µ	Cells	Nauplii
N5	1L							
Z1	8L:4D							
Z1/Z2	7L:5D							
Z2	6L:6D							
Z2/Z3	6L:6D							
Z3	6L:6D							
Z3/M1	6L:6D							
M1	5L:7D							
M2	5L:7D							
M3	4L:8D							
PL1	4L:8D							
PL2	4L:8D							
PL3	4L:8D							
PL4	2L:10D							
PL5	0L:12D							
PL6	0L:12D							
PL7	0L:12D							
PL8	0L:12D							
PL9	0L:12D							
PL10	0L:12D							

* Ratio of live : dry feed. L represents live and D represents dry feed, with 8–12 rations per day.

** The color intensity indicates feed amounts per day (12 rations), while absolute quantities depend on the feeding rate applied in a hatchery.

Feeding behaviour moves gradually from filter feeding in zoea to hunting in mysis so it is good practice to provide heat-killed or frozen Artemia instar 1 stage nauplii from late zoea up to PL1 before using live Artemia. In general, from PL5 onward, no more Artemia is needed with only formulated feed being fed.

Nutrition

Formulated feeds have similar composition to microalgae and zooplankton with high levels of essential nutrients such as vitamins, astaxanthin, n-3 highly unsaturated fatty acids (HUFA), cholesterol and lecithin. Good quality feeds use highly digestible raw materials with good nutritional value such as meals and oils of marine origin, hydrolyzed proteins, yeast and algal meals.

Lipids play a key role in shrimp development, supplying building blocks and energy for maintenance and growth. Some lipids cannot be synthesized to required levels by shrimp e.g. cholesterol, phospholipids and sterols which need to be provided by the diet. Fat-soluble vitamins as well as carotenoids are also essential for shrimp larvae and postlarvae. Lipid requirement is highest in zoea stages and lower in PL and juvenile stages.

The optimum protein level in a larval diet varies with stage, protein source, digestibility and amino acid composition. Zoea protein requirement of 30% increases to 50%–60% for mysis stages and decreases to 40% in PL's.

Water-soluble vitamins are essential for all shrimp stages and need to be included in diets to optimise growth and development and — in particular with vitamin C — to maximise resistance to stress and disease.

Shrimp larvae do not appear to require carbohydrates in the diet with energy obtained from lipids and proteins. Carbohydrates are often included in larval feeds as binders.

Environment

Objective

To provide larval shrimp with good quality water in clean tanks of a structure and design which allows optimum growth of manageable groups.

Housing and tank layout

Larval rearing should take place in a separate, dedicated house or area. Depending on production levels, there may be several larval rearing areas and each should be managed as a biosecure unit (see Biosecurity Section).

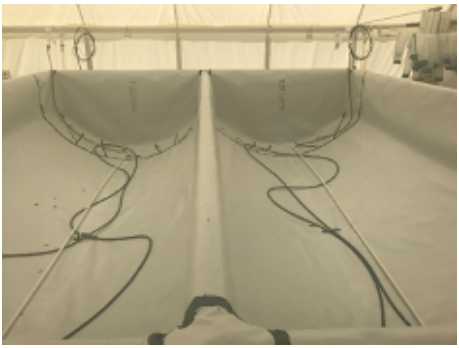
Larval rearing tanks vary in size and shape in different regions. Tanks with V or U-shaped bottoms which are common in the Americas make it easier to circulate water, but flat-bottomed tanks favoured in Asia give good results provided sufficient water movement is maintained by aeriation.

Successful larval rearing can take place in tanks ranging from 4 m^3 to 100 m^3 with a tendency for tanks to be smaller in Asia (typically 4 m^3 to 12 m^3) than in Americas (typically 10 m^3 to 100 m^3).

Various materials can be used for construction including concrete, fibreglass, plastic-lined all of which provide durable and cleanable options. It is important for cleaning and biosecurity that tanks and associated pipework, valves etc can be easily dismantled, cleaned, disinfected and re-assembled. Pipes should be accessible and located above ground, ideally duplicated allowing one system to be in use with the alternative dry and clean. Piping should be installed at an angle to allow full drainage.

Figure 3. Typical flat-bottomed tank configuration in Asia — 4 m^3 capacity with aeration stones.

Figure 4. **Typical tank configuration in Americas — duplex, 35 m³ capacity with PVC aeration pipe.**



Mesh of the appropriate size should be used at outflow from the tank to prevent losses. Mesh size of 300–400 µm is required for Mysis to PL4 and 500 µm for PL5 onwards.

Water Quality

Shrimp larvae require high quality, oceanic marine water to grow and develop well. Hatcheries should be located away from river mouths or industrial, agriculture, aquaculture or urban discharge points. Intake water should be filtered to 0.5–5 µm and disinfected with UV or commercial disinfectant according to manufacturer's instructions. Generally, hatcheries use flow through water systems although a small number of RAS systems are in operation.

Oceanic, marine water should fall in the range of water quality parameters in table 3. Aeriation and water exchange should be managed to maintain water quality in the optimum range. Water quality parameters should be checked regularly at the suggested frequency to ensure that shrimp larvae do not experience poor conditions.

Table 3. **Water quality for shrimp larvae.**

Parameter	Min	Max	Monitoring Frequency
Temperature °C	28	32	Hourly
Oxygen mg/l	5.0	8.2	Hourly
pH	7.8	8.2	Daily
Salinity ppt	29	34	Daily
Alkalinity ppm	120	200	Daily
Ammonia (NH_3) mg/l	0.01	0.10	Daily
Nitrite mg/l		0.10	Daily
Calcium (Ca^{2+}) mg/l	350	450	Weekly
Magnesium (Mg^{2+}) mg/l	1200	1350	Weekly
Potassium (K^{+}) mg/l	375	400	Weekly

Feeding

Objective

Provide nutritious feed that is ingested and digested by shrimp larvae.

Shrimp larvae develop through a series of stages each requiring a different mix of feed type, size and texture. Formulated feed has developed to meet the needs of shrimp larva and reduce the need for live feed, but in general good growth and development still requires inclusion of algae and Artemia.

Food intake depends on several factors such as temperature, water quality, and growth potential of the strain amongst others. Variation in feed quality can also influence the amount of feed required.

A range of commercial diets is available for larval shrimp. Extensive research and testing by INVE has resulted in development of feeds and feeding protocols designed to meet the needs of all stages of larval shrimp. Table 4 shows the feed amounts required by *P. vannamei* being fed FRiPPAK diet in typical conditions. Other commercial diets and feeding regimes are available that meet the requirements of shrimp larvae e.g. LANSY-Shrimp. Manufacturer's instructions should be followed when using commercial feeds.

Table 4. Feed amounts of FRiPPAK diet under typical conditions.*

Stage	Algae (1000 cells/ml/d)	Artemia (np/larvae/d)	Dry feed (grams/million larvae/day)				
			#1 CAR 5–30µm	#2 CD 30–90µm	#3 CD 90–150µm	PL+150 100–200µm	PL+300 200–300µm
N4	Cha** 60						
Z1	Cha 80		15				
Z2	Cha 80		22				
Z3	Cha 100	10	22				
M1	Cha 100	16		29			
M2	Cha 100	23		44			
M3	Cha 80	30		35	30		
PL 1	Cha 60	40			110		
PL 2	Cha 60	40			165		
PL 3	Cha 40	30			165	50	
PL 4		25			60	190	
PL 5		20				240	80
PL 6							385
PL 7							445
PL8							480
PL 9							510
PL 10							540

* Typical conditions: temperature 30–32 °C, oxygen > 5 mg/l, normal, marine salinity.
** Chaectoceros spp. algae. Other species of algae such as *Thalassiosira weissflogii* can also be used.

The feed amounts in table 4 are a guide to the requirements in typical conditions. The daily amounts will need to be adjusted according to observations of shrimp larvae, water quality and tank condition.

The gut health and immune competence of shrimp larvae and water quality may be optimised by supplementation with probiotics such as INVE Sanolife® MIC and immune system stimulants such as INVE Sanocare® FIT.

Although there is no strong evidence for effect of light intensity and photoperiod on larval development, it is considered good practice to keep shrimp on low level constant light to promote feeding. While feeding algae, care should be taken to avoid algal blooms with Chaectoceros being more prone to blooms than Thalassiosira.

Responsive management.

Effective management of shrimp larvae involves responding to changes in the condition of the larvae and tank environment for optimal growth and development. Good hatchery management involves fast detection of deviations from the expected development profile or tank environment and adjustment of feeding and other variables to compensate.

Advice given in feeding tables is a guide to the expected feed requirements and amounts will need to be adjusted in response to condition of shrimp larvae and tank environment.

Water exchange, flow rate and oxygenation rate will need to be adjusted to maintain water quality.

Routines for regular assessment of larvae and tank environment need to be documented as Standard Operating Procedures (SOP) and followed by trained, experienced personnel. SOP's should be established for each hatchery depending on circumstances.

It is good practice to have the required daily feed divided in 4 to 12 equal amounts over each 24 hour period. Checking the condition of larvae involves observation and monitoring of several parameters which can be subjective or objective. Subjective measurements such as activity or morbidity can be used for quick and frequent checking of larvae status at each feeding — see Table 5. Objective quantifiable measurement can be used for more detailed daily assessment of status — see Table 6.

Table 5. Subjective observations at each feeding.

Criterion	Observation
Swimming Activity	Highly active to inactive
Mortality	Zero, low or high numbers of dead larvae
Morbidity	Zero, low or high numbers of morbid larvae
Disease symptoms	Zero to high
Tissue pigment and condition	

Table 6. Objective observations at least twice per day. Larval condition can be determined by assessing at least 20 larvae using low power microscope.

	Optimum Condition	Response if out of range
Stage	Percent at each stage	
Length — from PL onwards		
Small or weak %.		
Gut fullness %.	>90% of population show 80% full gut	Increase feed
Lipid droplets in hepatopancreas %.	>90% of population have lipid droplets	Increase feed
Fouling %.	<5%	Decrease feed. Increase water exchange / add water conditioner.
Deformities %.	<5%	
Necrosis %.	<5%	Increase water exchange, add probiotic* and adjust feed levels.
Muscle : gut ratio 6th tail segment — PL8	Normal is 1:4.	
Tissue pigment and condition %	PL < 5% white or milky colour. 0% transparent	Bacterial count, add probiotics.*
Molting problems %.		Lower salinity gradually by 2 ppt** Check alkalinity and ion balance Ca/Mg/K

* INVE Sanolife® MIC-S at a rate of 100.000 cfu/ml or INVE Sanolife® PRO-W at 100.000 cfu/ml.
** Some producers find improved molting with 1 ppt reduction in salinity per day after ZII.

Water quality should be assessed at least twice per day in the morning and afternoon. See Table 7.

Table 7. Water quality and tank environment recorded twice daily

Criterion	Target
Tank fill –% of max volume	See table 8
Exchange rate	See table 8
Temperature	30–32 °C
Dissolved oxygen (DO)	>5 ppm
pH	7.8–8.2
Alkalinity	130–160 mg/l
Other indicators — qualitative	e.g. turbidity, smell

Table 8. Suggested tank fill percent water exchange rates by larval stage.

Stage	Volume %	Water Exchange Rate %/d*
Z1	50	0
Z2	60	0
Z3	70	0
M1	80	0
M2	90	0
M3	100	0
PL 1	100	25
PL 2	100	25
PL 3	100	30
PL 4	100	30
PL 5	100	30
PL 6	100	40
PL 7	100	40
PL8	100	40
PL 9	100	40
PL 10	100	50

* Water exchange rates depend on density, water quality, temperature and feeding rates. Exchange rates can be adjusted depending on observed water quality. Biofloc systems require less water exchange.

Feed amount and type can be adjusted according to changes in shrimp condition. Water flow rate and oxygenation can be adjusted to control water quality.

A health plan for treatment in response to disease challenge should be prepared so that immediate action can be taken if there are signs of disease.

Postlarvae quality

Shrimp producers need PL that are fit for purpose, i.e. robust and capable of fast growth. To assess the fitness for purpose, or quality of PL the parameters shown in table 9 are important.

Table 9. Important parameters for assessing postlarvae quality.

Pathogen Status		
Free from: WSSV, IHHNV, YHV, DIV–1, TSV, IMNV, AHPND, EHP, NHP — using PCR.		
Bacteria:	*Vibrio harvei* *V. parahaemolyticus* *V. alginolyticus*	0 <100 cfu/g <1000 cfu/g
Size and Uniformity		
Size:	Target — 9–10 mm for PL10	
Uniformity:	Target — CV < 10%	
Robustness		
Stress test*:	90–100% survival at PL8	

* Salinity stress test — 34ppt to 0 ppt (distilled or drinking water) for 30 minutes, then back to 34 ppt for 30 minutes.

PLs should attain the target physiological assessments in table 10.

Table 10. Target quality assessment for shrimp PL.

Observation	Target
Hepatopancreas	Lipids >90% Free from necrosis Free from EHP spore <5% tubule deformities
Gut	>90% of population show 80% full gut
Necrosis	<5% of population show necrosis on appendices
Deformities	<5% of population show deformities
Fouling	< 5% of population show fouling (filamentous bacterial, protozoan, etc)
Colour	< 5% of population show whiteness or milky colour Free from transparent colour larvae
Swimming behaviour	Active swimming against current and towards light
Rostrum teeth	3–4 PL5, 5–6 PL10

These quality standards are typically achieved by hatcheries across the globe that meet the management standards and use feed and feeding schedules described in this document. A process of continuous review of performance, and procedures should be followed to ensure ongoing improvements in quality and performance of larvae and PLs.

Further information

Food and Agriculture Organisation of the United Nations (FAO) provide information on the culture of aquatic species: http://www.fao.org/fishery/culturedspecies/Penaeus_vannamei/en

World Organisation for Animal Health (OIE) provides information on diagnostic tests: https://www.oie.int/standard-setting/aquatic-manual/

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