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Intensive Marine Finfish Larviculture

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Marine finfish production is a rapidly expanding field, both in research and industrial aquaculture. A driving force behind this growth is the inherently high value placed upon marine finfish products in the marketplace. With this higher product value, marine finfish production is perceived to be a relatively robust prospect for investment from the private sector. Additional catalysts for the trend towards increased investment in marine aquaculture include limitations on wild harvesting, projections for increased global seafood demand, and increasing interest in aquaculture worldwide.

Fingerling production is one of the many challenges faced by those interested in promoting industrial production of emerging marine species. Marine finfish broodstock generally produce copious numbers of eggs during spawning; however, hatchling (or fry) production for marine species generally includes extended periods of complex live feeding requirements. Live feeds include rotifers, copepods, *Artemia*, and others, tiny creatures that are often the first foods in the marine food chain. In addition to these live feeding requirements, limitations exist in the types of live feeds that can be produced in numbers adequate to supply commercial production. Furthermore, understanding of the nutritional requirements for marine finfish larvae is limited, and knowledge on how to get these nutrients into live feeds for ingestion by the fry is even more limited. This publication provides an overview of basic fingerling production procedures for marine finfish such as cobia (*Rachycentron canadum*), flounder (*Paralichthys dentatus* and *P. lethostigma*), sea bass (*Centropristis striata*), and red drum (*Sciaenops ocellatus*).

Typical marine finfish larviculture is conducted in recirculating aquaculture systems (RAS). These systems link the production tank to the remainder of the RAS, which provides for solids removal, biofiltration, temperature control, and water sterilization. As such, “dirty” water flows out of the production tank, through the RAS for cleaning and sterilization, and returns “clean” to the production tank as needed (Figure 1). The use of RAS technology enhances biosecurity and increases environmental and hydrodynamic control, maximizing production survival and system reliability.


Fig. 1. RAS water treatment

Larviculture

Egg/sac-fry stage – Once marine finfish eggs are fertilized (see Figure 2), rapid development occurs followed by the hatching of sac-fry. Sac-fry (see Figure 3) subsist on endogenous reserves for a time period that is both species- and temperature-dependent. Dur-

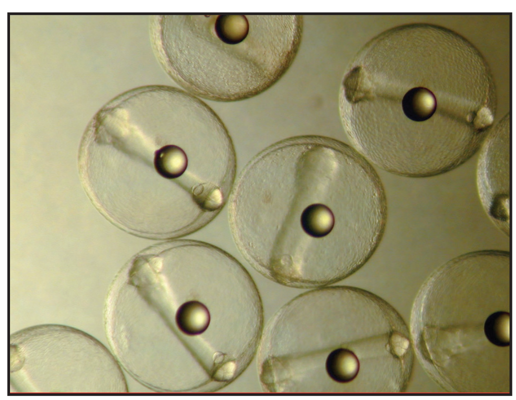
Fig. 2. Fertilized summer flounder eggs.

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ing this time, rapid physiological changes occur, such as the development of functioning eyes, mouthparts, and a rudimentary digestive tract. As endogenous reserves are utilized, the fry must begin to consume exogenous reserves or perish.

Fig. 3. Cobia sac fry

Fry stage – The first live feed which can be raised on a commercial scale and that has demonstrated palatability for the species listed as well as other marine finfish species is the rotifer *Brachionus* spp. (Figure 4). Rotifers range in size from 200 to about 400 microns (species dependent) and can be raised on algae or commercially available diets. Rotifers are required in large numbers during this feeding stage. A typical feeding rate for rotifers is based upon fry density in the production tank. For example, if cobia fry are stocked at 10 fry per liter at 28ºC (82ºF), then approximately 10,000 rotifers per liter should be added to the production system every 24 hours (numbers vary considerably based upon exchange and dilution rates for water in the production system). Thus, if 100,000 cobia fry have been stocked, then approximately 500 million rotifers per day will be required.

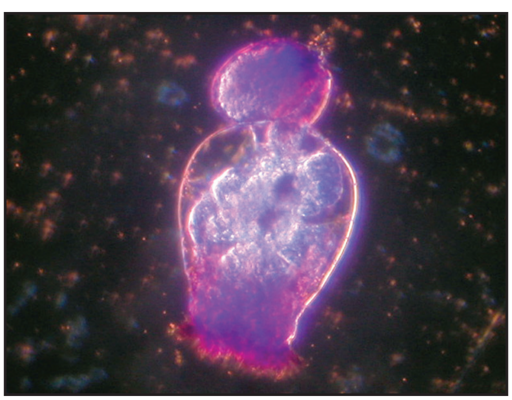

Fig. 4. Stained rotifer with egg

Before being fed to fry, rotifers require enrichment to enhance their nutritional value. Numerous commercially available products and techniques have been developed to accomplish this enrichment. Research and production protocols utilized by the Virginia Tech Aquaculture Group (VTAG) utilize an INVE product called Protein Selco Plus (*www.inve.com*). This product calls for a six-hour enrichment process wherein temperature, oxygen, and enrichment additions are closely monitored to maximize nutrient uptake by the rotifers. Once enriched, rotifers are rinsed, concentrated, enumerated, and placed into cold storage.

An important component typically associated with the rotifer feeding stage in fingerling production is the use of microalgae, typically *Nannochloropsis* spp. (see Figure 5). Depending upon the species and resultant cell size and density, a typical algal addition to the production tank ranges between 100,000 to 150,000 cells per milliliter. The addition of these algae to the tank water gives the water a green hue, and is thus commonly referred to as the "greenwater" stage.

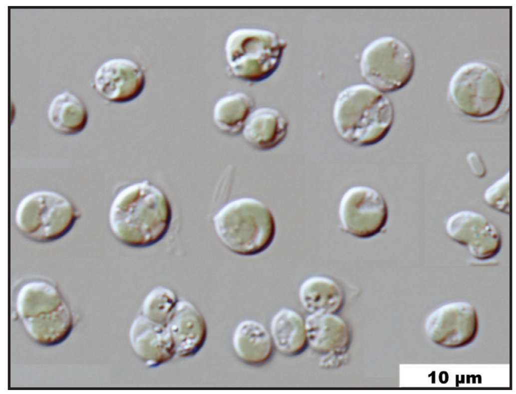

Fig. 5. Live algae *Nanno*. spp.

In the past, marine hatcheries have had to utilize significant production space and labor resources for the production of live algae. However, recent advances in technology have made concentrated algae pastes available. These pastes come in concentrations as high as 16 billion cells per milliliter, and have demonstrated viability for live algae replacement during greenwater applications as well as rotifer production. These algae pastes can be purchased from companies such as Reed Mariculture (*www.reed-mariculture.com*) and can provide a significant cost savings to hatcheries along with reducing the risks associated with unexpected crashes in live algae production.

Artemia: As fry get larger, they quickly outgrow the prey size represented by rotifers, and a larger live feed is required. After rotifers, the most common live feed utilized during marine finfish fingerling production is *Artemia* spp. *Artemia* (Figure 6) generally range from 500 to 900 microns, and represent the transitional feed after which artificial dry feeds can be used. *Artemia* are typically purchased as dry cysts and are

Fig. 6. *Artemia*

packaged in vacuum-packed containers that have a long shelf life. *Artemia* are also fed based upon fry density – for the same number and density of cobia fry used in the rotifers example, approximately 250 million *Artemia* would be needed every 24 hours.

The first phase of *Artemia* production is typically hydration, followed by decapsulation. During hydration, the eggs are placed in an agitated and aerated container filled with salt water for 24 hours. Thereafter the eggs are filtered out and added to a buffered, cold bleach solution that chemically burns away the exterior of the *Artemia* egg casing. Once decapsulated, the eggs are once again placed into salt water and hatched for 24 hours, or placed in a refrigerator for later use. The hatching vessel is temperature-controlled and injected with pure oxygen to maintain oxygen levels. After hatching, the *Artemia* are harvested, rinsed, and placed into an enrichment vessel.

Like rotifers, the inherent nutritional value of *Artemia* is low, resulting in similar enrichment requirements. *Artemia* enrichments are also commercially available. Research and production protocols utilized by the VTAG call for an INVE product called DC DHA Selco. This product provides a 24-hour enrichment process whereby temperature, oxygen, pH, and enrichment additions are closely monitored to maximize nutrient uptake by the *Artemia*. Once enriched, *Artemia* are rinsed, concentrated, enumerated, and placed into cold storage for tank additions as necessary.

Cold storage is a process whereby live feeds, after having undergone a process to maximize their nutritional value, are rapidly cooled and maintained below 7°C (45ºF) for up to 24 hours to minimize their metabolic activity. By minimizing metabolic activity, their energy and nutrient reserves are maintained for transfer to the fry upon consumption. This cold storage method reduces hatchery labor by requiring only one enrichment process per day for each live feed type. A typical live feed cold storage setup (see Figure 7) consists of a cooler, floating ice bottles, and aeration to keep live feeds in suspension.

Feeding regimens are species- and temperature-dependent. With cobia as an example, algae, rotifers,

Fig. 7. Live feeds cold storage

and/or *Artemia* are added to the tank in predetermined levels every six hours. When the fry are large enough to begin the transfer to dry diets, a co-feeding period begins for a few days. This involves adding the dry diet to the tank (generally with an automatic feeder; see Figure 8) at a set time period just before the addition of *Artemia*. After a few days of co-feeding, a weaning process occurs whereby more frequent dry diet feedings occur in conjunction with a gradual elimination of the live feed. The fry are considered weaned once they are feeding solely on dry diets. At this point, they can be considered fingerlings, and the process of fingerling production is complete.

Fig. 8. Automatic dry feed feeder

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