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STATE OF THE ART IN LARVICULTURE OF FISH AND SHELLFISH

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Review

During the past decade aquaculture, more particularly the controlled production of fish and shellfish, has evolved from an artisanal or experimental activity into a successful bioindustry. In various countries in Europe, SE Asia and Latin America, aquaculture products already represent a significant export commodity and several hundred thousand new jobs were created. In 1989 total aquaculture production amounted to over 11 million metric tons, representing an increase of 70% over the past 5 years. In comparison capture fisheries in the same time period increased by 14% only. For some species such as penaeid shrimp and salmon, 25% of the annual world consumption is generated through aquaculture production, *i.e.* about 500 000 metric tons of cultured shrimp and 275 000 metric tons of salmon.

Dependable availability of seed (also called fry, fingerlings or postlarvae) to stock the grow-out ponds or cages is one of the most critical factors in the commercial success of industrial production of fish and crustaceans. A breakthrough was realized only in recent years by the domestication of species, involving the development of appropriate techniques for controlled reproduction in captivity and for larviculture of the very sensitive stages.

Larviculture nutrition, more particularly start feeding in the early larval stages, appears to be a major bottleneck, not the least at industrial upscaling. For a few selected species such as salmon, minimal problems had to be overcome because their larvae at hatching carry a big yolk sac with enough food reserves for the first 3 weeks of their development. Once the yolk is consumed and exogenous feeding is starting, fingerlings are already sufficiently developed and readily accept formulated feeds. Most marine fish with aquaculture potential have very limited yolk reserves at hatching lasting for not more than 1 or 2 days. At first feeding they still have small mouths, often with an opening size of less than 0.1mm as well as a very primitive digestive system. In shrimp larvae, the feed size is not the only problem because these larvae develop through different larval stages, eventually changing from herbivorous filter-feeding behaviour to carnivorous hunters.

Over the past two decades trial and error approaches have resulted in the selection and improvement of the following larviculture diets which are today applied worldwide in experimental and commercial larviculture of fish and shellfish:
- different species of unicellular microalgae
- the rotifer *Brachionus plicatilis*
- the brine shrimp *Artemia.*

Monocultures of selected species of microalgae are costly to produce and the harvested algae do not have a consistent quality. This provided the rational to look for alternatives or supplements to live microalgae. Different approaches and formulations are already used in commercial enterprises, and many new developments in producing more cost-effective products are to be expected, *e.g.* heterotrophically-produced microalgae, manipulated yeasts, microencapsulated feeds and different kinds of microparticulated diets.

Although rotifer culture appears to be simple, many fish hatcheries experience problems in maintaining large cultures and producing, on a predictable basis, the massive numbers of *Brachionus* of a suitable food value, that are required to feed the hundred thousands to millions of baby fish they have in culture. Different microparticulated, yeast-based single cell proteins and emulsified formulations have been developed to manipulate the biochemical composition of the rotifers in order to better suit the dietary requirements in essential fatty acids and other nutrients of the fish larvae.

Among the live diets used in larviculture, brine shrimp *Artemia* nauplii constitute the most widely used food item; *i.e.* annually over 700 metric tons of dry *Artemia* cysts are marketed worldwide for on-site hatching into 0.4mm nauplii. Although the use of these cysts appears to be most simple, considerable progress has been made in the past decade in improving and increasing its value as a larval diet, *e.g.* selection of the most appropriate strains and batches, new techniques for cyst disinfection and decapsulation, nauplius hatching, enrichment and cold storage. Using particulate or emulsified products, rich in highly unsaturated fatty acids (n-3) HUFAs, the nutritional quality of the *Artemia* can be further tailored to suit the predators' requirements by bioencapsulating specific amounts of these products in the *Artemia* metanauplii. Application of this method of bioencapsulation, also called *Artemia* enrichment or boosting, has had a major impact on improved larviculture outputs, not only in terms of survival, growth, and success of metamorphosis of the fish and crustacean larvae, but also with regard to their quality, *e.g.* reduced malformations, improved pigmentation and stress resistance. Nonetheless, in many species survival rates are still under the 20% level. For several marine fish species the optimal dietary levels of (n-3) HUFAs have not yet been met by *Brachionus* and/or *Artemia.* While (n-3) HUFAs have proven to be most critical, it is very likely that other nutrients (*e.g.* other lipid classes, vitamins, free amino acids) might appear equally important and in some species even having more impact. Also egg quality, which to a large extent might be influenced by broodstock nutrition, needs to be evaluated as it may alter the quantitative dietary requirements in the larval stages.

Off-the-shelf dry substitution products for live *Brachionus* and *Artemia* are being developed and commercialized as a much more user-friendly application for the farmer.

With some species such as penaeid shrimp, the moment is approaching when the use of live food in the hatchery operation may be virtually eliminated. Fish impose much more constraints, not only in terms of nutritional requirements, but also with regard to digestibility and physical properties of the feed, *e.g.* water stability, buoyancy, and palatability. Appropriate processing technologies will most probably be developed soon, but their commercial applicability and price competitiveness might not be adequate.

The intensification of hatchery operations, from experimental facilities to industrial complexes, producing millions of fingerlings per month, brought about several zootechnical and disease problems. The introduction and adoption of new equipment, materials, and procedures resulted in more predictable outputs. There is, however, still much room for improvement not the least by a better identification of the microbial environment and elucidation of the disease problems. Oral administration of antibiotics through bioencapsulation in *Artemia* and *Brachionus* might be considered as a more effective transfer of therapeutics.

Industrial hatchery enterprises vary from large units with nominal capacities of a few million fish fry and up to fifty million shrimp postlarvae per month, to small backyard hatcheries. During recent years the latter have been mushrooming to thousands in some SE Asian countries. The use of modular systems, which allow to operate and/or disinfect parallel units, is gaining more and more interest. Several factors such as profit margins, predictability of outputs, quality of seed produced, *etc.* will ultimately determine which systems will prevail. Because of species differences and geographical discrepancies, fish and shellfish hatcheries will probably never turn into standardized blueprint methods, which can adequately be used worldwide.

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