Bioengineering of hatcheries for marine fish and shellfish

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Abstract. Dependable availability of quality fry to stock growout production systems has been one of the most critical factors in the commercial success of industrial production of fish and shellfish. Over the past two decades intensive larviculture of several fish and shellfish species has expanded into a multimillion dollar industry. Although much progress has been made in identifying the dietary requirements of the larvae of various aquaculture species, the mass culture of their early larval stages still requires the use of live feeds, i.e., selected species of microalgae, the rotifer Brachionus, and the brine shrimp Artemia. The latter two substitutes for natural zooplankton are eventually supplemented with selected lipids and vitamins so as to better meet the dietary requirements of the cultured larvae. An improved knowledge of the composition and functional role of the microflora present in the culture tank or added through the food has allowed improvement of disinfection protocols, eventually complemented with a probiotic use of selected microflora. Brachionus and Artemia can also be used as convenient carriers for oral delivery of chemotherapeutics, vaccines, and hormones. Improved zootecniqes have also made fish and shellfish larviculture more predictable and more cost-effective. Finally, improved broodstock management and feeding have resulted in better quality offspring. Present-day hatchery technology is very versatile, and the industrial production of aquaculture seed is extending rapidly to many new species of fish and shellfish.

Introduction

Much progress has been made in the last few decades in the industrial farming of several species of truly marine fish and shrimp (Sorgeloos and Léger 1992; Sorgeloos et al. 1995). The pioneering country has been Japan, with the red seabream, Pagrus major, and the kuruma prawn, Penaeus japonicus. In the last decade Europe has made rapid progress as well with seabass, Dicentrarchus labrax, and gilthead seabream, Sparus aurata. In terms of quantities of output, the biggest success has been achieved with a few species of penaeid shrimp in tropical Asia and Latin America. The most critical factor in this industrialization of fish and shellfish farming has been the dependable availability of quality fry, produced in hatcheries. Today the larviculture industry of marine fish and shrimp can be valued at several hundred million US dollars annually, for the production of more than 50 billion shrimp postlarvae and about 400 million marine fish fry.

Although the commercial hatcheries are much more cost-effective and their outputs much more predictable than ever before, the methods applied are still very empirical. This has a lot to do with the very primitive nature of the early larval stages of marine fish and shrimp. Only a few species (e.g., salmon) have a big yolk sac that provides endogenous foods for the larvae during their first few weeks of development. Most marine fish have very small and primitive larvae: the yolk sac provides food for only a couple of days and the digestive tract is still very inefficient at the start of feeding.

In nature, the larvae of most fish and shellfish species eat small phyto- and zooplankton. This diet not only provides a range of nutrients but, because of its auto digestion characteristics, facilitates nutrient uptake by the larvae.

The early pioneers in larviculture of fish and shrimp had to look to a suitable and practical substitute for natural plankton, taking into account availability, acceptability, and nutritional quality, as well as production costs, in the selection process. Over the years a limited number of algal species, the rotifer Brachionus plicatilis and the brine shrimp Artemia, have become the live feeds used on a worldwide scale in the industrial farming of fish and shellfish larvae (Sorgeloos and Léger 1992).

Microalgae

Today the most costly and perhaps least understood live feed are the unicellular algae, i.e., some 15 species of diatoms and green algae, ranging in size from 5 to 25 μm. They are used in first-feeding the zoa stage of penaeid shrimp, for culturing bivalve mollusks and the rotifer Brachionus, and
in freshwater and brackish water environments. 

Food quality is critical for the growth and survival of shrimp larvae. Studies have shown that the optimal food for shrimp larvae is rich in protein, fatty acids, and vitamins. The quality of the food can significantly affect the growth rates and survival rates of shrimp larvae. 

**Brine Shrimp Artemia spp.**

Brine shrimp, Artemia spp., are used as a food source for shrimp larvae due to their high nutritional content. Artemia is a crustacean that can live in saltwater environments and is easily cultured in small tanks. The eggs of Artemia can be obtained from suppliers and hatched into nauplii, which are fed to shrimp larvae. The nauplii contain a high amount of protein, fats, and vitamins, which are essential for the growth of shrimp larvae. 

**Bioengineering of hatcheries**

Bioengineering of hatcheries involves the use of technology and biology to improve the efficiency and productivity of shrimp hatcheries. This includes the use of automated feeding systems, computerized monitoring of water quality, and genetic selection of shrimp strains. The goal is to produce healthier and faster-growing shrimp larvae, which can lead to higher yields and profitability for shrimp farmers.

**Selection of appropriate strains and batches**

The selection of appropriate strains and batches of shrimp larvae is crucial for successful hatchery operations. Farmers should consider factors such as the age of the mother shrimp, the water quality, and the feeding regime when selecting shrimp larvae. The use of genetic selection can also improve the quality of shrimp larvae, leading to higher survival rates and better growth performance.

**Conclusion**

In conclusion, the quality of food and water are essential factors that affect the survival and growth of shrimp larvae. By improving the quality of the food and water, shrimp farmers can increase their yields and profitability. Bioengineering of hatcheries and the use of technology can further enhance the productivity of shrimp hatcheries, making them more efficient and sustainable.
Formulated feeds

The ultimate goal in commercial marine fish larviculture is to be able to rely on formulated dry diets right from the start of feeding. However, for most species of marine fish this remains a wishful thinking. Nonetheless, good progress has been reported, at the experimental level, with artificial diets for starting the feeding of some Japanese fish species and in advancing early weaning to 25 days or less after hatching in the European seasharp (Sorgeloos et al. 1995). We are convinced that application of the cofeeding principle, i.e., supplementing live food with formulated compounds, in the early larval stages might provide opportunities for better satisfaction of the qualitative/quantitative dietary requirements (e.g., through cofeeding with components such as phospholipids that can not be manipulated easily in the live food fraction). This might also allow for a possible reduction of live food requirements, eventually resulting in improved outputs as compared to a diet consisting of live food only.

Microbial control

An area that urgently deserves more attention is the microbial flora of marine fish hatcheries. With upsampling and expansion of commercial fish larviculture, hatcheries have been plagued by increased incidence of microbial diseases, often claimed to be caused by Vibrio spp. Similar to practices in marine shrimp hatcheries, the indiscriminate use of antibiotics in prophylactic treatment of the fish tanks has resulted in the development of resistant strains and the need to switch to other antibiotics, a practice which is doomed to fail.

Recent studies indicated that the microbial diversity in Mediterranean bass and bream hatcheries is enormous (i.e., over 1200 bacterial strains were identified from two commercial hatcheries) and that it varied from season to season as well as from hatchery to hatchery (Verdonck and Swings 1995; Verdonck et al. 1994). In one hatchery there was a clear succession of bacterial species as a function of time and the live food administered; a fish mortality outbreak could be correlated with an increase in Vibrio anguillarum during rotifer feeding. In another hatchery the diversity of bacterial species, including non-Vibrio, was much higher, and no larval mortalities were recorded. Quantitative data of the microflora in seabass and seabream hatcheries revealed the presence of 100–10,000 bacteria per rotifer and per brine shrimp nauplius; the bacterial numbers found in the gut of larvae increased with age and feeding regime, from 100 to 1000,000 per larva. The fact that the composition of the microflora in the intestines of healthy fish was not an exact copy of the microflora found in the culture water or the live food might be an indication of selective colonization of the gut or the existence of so-called probiotic bacteria. The major surprise of these microbial studies was the important input of bacteria (and potential fish pathogens) via the live food chain. One should consider new measures to reduce bacterial loads, as well as to selectively manipulate the microflora, both in the live foods produced in the hatchery and in the culture water prior to stocking of the fish larvae. Selected bacterial inoculation of the culture tank prior to stocking with the larvae would not only reduce the chances that opportunistic bacteria become dominant, but eventually have a beneficial effect on first colonization of the fish larva’s gut.

In general, strict hygienic measures should be taken in hatcheries. Furthermore, regular disinfection and dryout of the complete culture circuit (including all piping) between production cycles should be implemented. In that respect, new hatcheries should consider the use of modular systems rather than having all culture units in one building.

Conclusion

The intensification of hatchery activities brought about new problems not experienced at the experimental scale, e.g., in relation to scaling up live food production, washing and cleaning of live food, intensity of manual labor, etc. To date, limited attention has been paid to improved zootech-niques that might make larviculture, especially of marine fish, more predictable and more cost-effective, e.g., selection and use of new materials (i.e., stainless-steel welded-wedge filters instead of woven filters for Artemia washing), increased and better adapted methods to reduce the so-called human factor often responsible for reduced performances after several months of operation, etc.

In the past decade, fish and shellfish hatcheries have evolved from hit-and-miss ventures into profitable enterprises. Although there is still room for further improvement, especially with regard to cost-effectiveness, present-day hatchery technology has proven to be widely applicable both in terms of geographic location and species. The list of cultivated fish and shellfish species for on-growing and/or restocking purposes is growing rapidly (e.g., various shrimp and crab species; various oyster, scallop, clam, and abalone species; various bass and bream species; and turbot, Japa-nese flounder, fugu, milkfish, mullet), and many candidate species will hopefully soon join this list, e.g., dolphin fish, mahi-mahi, various grouper species, yellowtail, red snapper, Atlantic halibut, cod, wolffish, and spiny lobster.

References