Health & Welfare

Live protozoa: Suitable live food for larval fish and shrimp?

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Evaluation trials could help feed manufacturers formulate improved artificial diets

Recent work on alternative live foods for fish larvae suggests that some ciliated protozoa (ciliates) may be a valuable complimentary source of nutrients for first feeding larval stages. Traditionally, rotifers have been used as the initial food for marine fish larvae. However, for some species of fish, such as groupers and surgeonfishes, the mouth opening of the larvae is too small to allow them to feed on rotifers. Alternative, smaller-sized prey such as ciliates are thus needed for larviculture of these economically important species.

An aloricate ciliate, *Euplotes sp.*

Ciliates

Ciliates are eukaryotic, unicellular organisms that are abundant in most aquatic environments, including oceanic waters, wastewater, and aquaculture ponds where concentrations of 104 cells per mililieter have been reported. Generally, ciliates are categorized as loricate and aloricate, and they have a doubling time of 1 to 2 per day. Recently, Nagano et al. (*Plankton Biol. Ecol.* 47:93-99; *Hydrobiologia* 432:149-157) demonstrated that high concentrations of ciliates enhanced larval fish survival until 4-6 days post hatching, without the addition of rotifers (Table 1). These results indicate that ciliates can play an important role as an alternative food source by enhancing larval fish survival (especially for those species with a small mouth), and that ciliates may bridge the gap until the larvae attain a size when they can feed on rotifers.

Enhanced nutrition

Additionally, ciliates may provide nutrients that are not present, or present at low concentrations, in other live foods.

Decamp, Survival of fish larvae reared with ciliates, Table 1

Fish Species	Ciliate Density (no./ml)	Survival (%)
Grouper, *Epinephelus septemfasciatus*		

Fish Species	Ciliate Density (no./ml)	Survival (%)
With naked ciliates (*Euplotes sp. 1*)	12	38 ± 10
Without ciliates	0	16 ± 7
Grouper, *E. septemfasciatus*		
With loricate ciliates (*Favella taraikaensis*)	5	24 ± 1
Without ciliates	0	1 ± 1
Surgeonfish, *Paracanthurus hepatus*		
With loricate ciliates (*Amphorellopsis acuta*)	10	48 ± 4
With aloricate ciliates (*Euplotes sp. 2*)	13	12 ± 1
Without ciliates	0	0

Table 1. Survival of fish larvae reared with ciliates six days after hatching (n = 3).%

HUFAs and sterols

Protozoa such as ciliates and flagellates are sources of highly unsaturated fatty acids and/or sterols that have a known growth-promoting effect on most invertebrates and fish larvae. The neutral lipids of a species of scuticociliate were reported to consist of 29 percent sterols, 53 percent of which were cholesterol.

Trophic status important

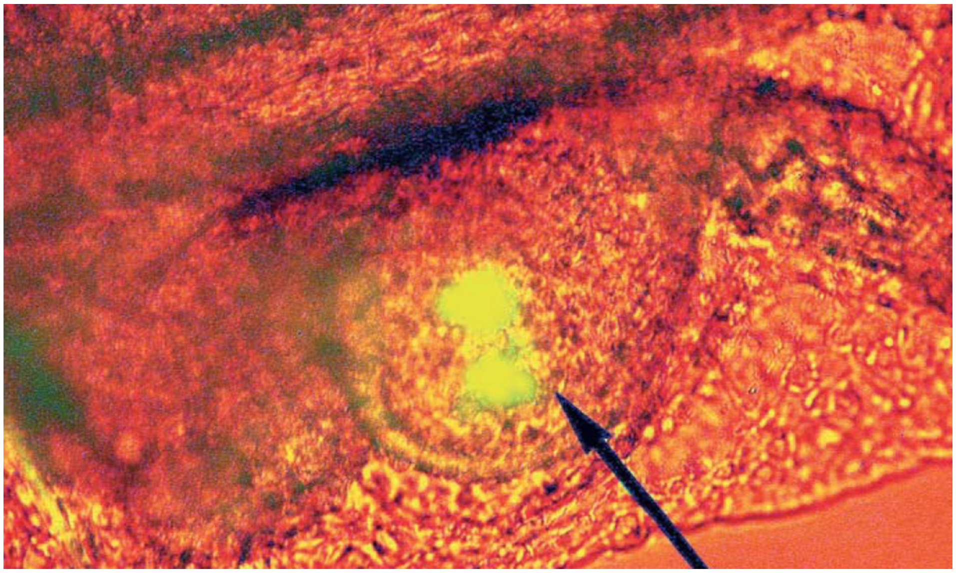
However, the biochemical composition of ciliates will change with the trophic status of the species. For example, bacterivorous ciliates (C:N ratio of 6.2 reported for a scuticociliate) are expected to be a poorer source of nitrogen than algivorous ciliates (C:N ratio of 4.6 to 4.7 reported for tintinnids). Similarly, the fatty acid composition of bacterivorous ciliates often includes substantial quantities of bacterial fatty acids.

Free amino acids

Finally, marine ciliates characteristically contain high intracellular concentrations of free amino acids that may be an important source of energy for larvae, especially for first feeding larval fish during the critical period after yolk-sac absorption.

Common feeding protocols

Although artificial feeds are increasingly being used in penaeid shrimp larviculture, the addition of known quantities of both live microalgae (such as *Chaetoceros*) and artemia to the larval rearing tanks is still the most common method to feed zoea and mysis stages of shrimp. A common protocol consists of providing microalgae (5 to 20 μm diameter) at the nauplius-5 or zoea-1 stage (1 to 2 days post hatching) and feeding artemia at the mysis-1 stage (six days post hatching).



Euplotes sp. labelled with fluorescent microspheres in fish gut.

Alternative live prey

However, because of growing concerns about the availability and cost of artemia, the use of alternative live prey has been investigated. For example, a mixture of nematodes and algae were reported to outperform the traditional artemia and algae diet. Also, larvae of the Pacific white shrimp (*Litopenaeus vannamei*) were reared solely on nematodes and rotifers, without the addition of microalgae. However, these larvae had lower survival and growth compared with microalgae-fed controls.

Interestingly, alternative live prey, such as ciliates that are characterized by a intermediate size, have not been adequately evaluated as an alternative live food for shrimp larvae, although Thompson et al. (1999) showed that larvae of *Penaeus paulensis* grew better when fed flagellates and ciliates compared with a diet exclusively of bacteria.

Conclusion

We propose that evaluating alternative live foods – such as ciliates – might be of value for two reasons. Firstly, the availability of alternative live foods to supplement or replace artemia would provide hatchery managers with greater options than what currently available using traditional methods of larval feeding. Secondly, and perhaps more importantly, information collected during evaluation trials using alternative live foods could be used by the feed manufacturing industry to formulate improved artificial diets. Artificial diets currently are formulated based on the biochemical composition of traditional live foods. By evaluating alternative live foods, we may be able to test species-specific nutrients that may positively impact larval shrimp and fish performance.

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