

Fairy shrimp, the freshwater relatives of the more popular *Artemia*, offer interesting possibilities as live food in larval culture. They are probably more appropriate for freshwater fish and crustacean cultures that depend on live foods. Their high carotenoid content makes them a candidate for color enhancement in ornamental fish culture. They are also amenable to enrichment and bio-encapsulation making them an ideal candidate for the delivery of valuable nutrients and other molecules to the young larvae.

Fairy Shrimps as Live Food in Aquaculture

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Fairy shrimp (*Streptocephalus spp.*; Figure 1) are freshwater relatives of brine shrimps, *Artemia spp.* Fairy shrimp nauplii closely resemble brine shrimp nauplii and are similar in size. Fairy shrimp normally inhabit temporary ponds that lack fish because they are eaten by fish in natural waters. The possibility of using fairy shrimp as diet in aquaculture has not been explored widely. Fairy shrimp have the potential to be used as a feed item for fish such as ornamental fishes that benefit from live food (Prasath *et al.* 1994) and their cysts and nauplii may be useful in larval culture. Nutrient levels in brine shrimps are known, but similar information has not been determined for fairy shrimps. Through funding from the International Foundation of Science (IFS), Sweden and the European Union, Belgium, we have demonstrated the utility of Indian fairy shrimps as live feed in practical aquaculture. With help from Prof. Henri Dumont of Ghent University, Belgium, we have also established a cyst bank of fairy shrimps collected from different parts of the world at the Ghent University. This article focuses on the potential of freshwater fairy shrimp, particularly the South Indian fairy shrimp, *Streptocephalus dichotomus* in finfish and shellfish culture.

Biology

The fairy shrimps belong to the family, Anostraca. They are widespread and form an important component of freshwater ecosystems in temperate and tropical regions. A recent checklist of the Anostraca cites 258 species and seven



Fig. 1: Adult Fairy Shrimps

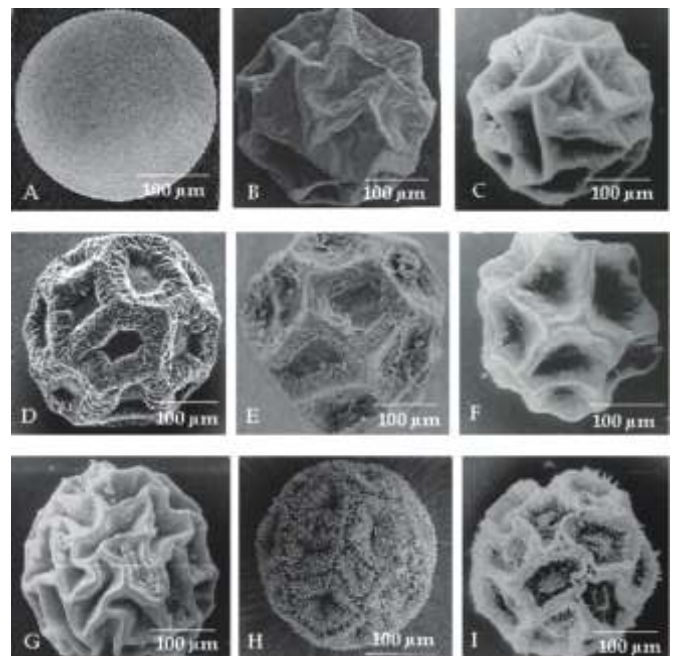


Fig.2: Egg morphology and size in Indian anostracans (A) *Artemia parthenogenetica* (B) *Streptocephalus dichotomus* (C) *S. simplex* (D) *S. longimanus* (E) *S. echinus* (F) *S. spinifer* (G) *Branchinella kugenumaensis* (H) *B. maduraiensis* (I) *B. nalurensis*.

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Table 1: Carotenoid and amino acids content in two entomostracan crustaceans

Carotenoid	<i>Streptocephalus diaphanus</i>	<i>Moina</i>
?-carotene	β-ψ	βa%
?-cryptoxanthin	β-ψ	βg{+?
Lutein	β-ψ	βg{+?
Antheraxanthin	β-ψ	
Violaxanthin		βg{+?
Canthaxanthin	β-ψ	βa%
Astaxanthin	β-ψ	βg{+?
Total content of carotenoids in ?gg ¹ drymass	β-ψ	β-ψ
Carotenoprote in complex Max. Absorb.In0.05 phosphate buffer solution at pH7.0	β-ψ	β-ψ
Prosthetic group	β-ψ	Canthaxanthin
Amino acids (in mol%)		
Lys	6.24	3.12
His	2.52	1.65
Arg	2.38	2.04
Asp	10.24	9.16
Thr	6.10	5.85
Ser	7.36	4.01
Pro	5.94	11.02
Glu	9.82	12.14
Gly	7.32	14.28
Ala	7.90	6.80
Val	6.16	4.25
Cys	0.24	1.02
Met	1.12	0.20
Ileu	4.08	4.12
Leu	6.18	3.60
Tyr	2.02	1.08
Phe	3.36	1.95

* Ref. Velu *et al.* (2003)

The advantages of using the freshwater anostracans as live feed includes:-

- High individual biomass;
- Possibility of bioencapsulation with PUFA, other nutrients and drugs for delivery into the recipient organism; and
- Rich source of carotenoid pigments

Both larvae and adult live fairy shrimps can be used as live food to a variety of aquaculture organisms. The cysts of fairy shrimps contain 45-50% protein; and 5-6% of lipids. While fairy shrimps compete with *Artemia* in applications where only nauplii are needed, full-grown fairy shrimps offer unique benefits. We have developed technology in our laboratory to culture fairy shrimp biomass using livestock wastes (Munuswamy *et al.*, 1997). The biomass thus produced can be used as nursery and maturation feed for ornamental fishes. It can also be considered as live food in the hatchery production of freshwater prawns and fishes.

Nutritional value

The nutritional value of freshwater fairy shrimps has been documented by Munuswamy *et al.* (1992). While fairy shrimps are comparable to *Artemia* in its nutrient content, the former are distinguished by the high amount of carotenoids present in them. Due to their coloration, Anostracans might have potential as ornamental animals themselves, with specimens of medium-sized species like *S. torvicornis* and *S.*

proboscedeus in laboratory conditions having reached longevities of nearly one year (Dumont and Munuswamy, 1997). The life span of larger species like *Branchinecta gigas* and *B. ferox*, which reach sizes of 8-10 cm is not yet known.

In Anostraca, Goodwin (1984) reported canthaxanthin as the major carotenoid pigment. Recently, carotenoprotein complexes have been studied in the fairy shrimp *Chirocephalus diaphanus*. Our investigation on *Streptocephalus* has revealed high levels of carotenoid complex with large amounts of astaxanthin and canthaxanthin and also the presence of antheraxanthin was observed (Velu *et al.*, 2003).

Table 1 compares the pigment content of the fairy shrimp with that of the daphnid, *Moina*. It also provides the amino acid profile of the two live food organisms showing that the fairy shrimp contains high levels of many essential amino acids.

Studies conducted in our laboratory show that the intake of fairy shrimp as live food improves pigmentation in shrimp (Figure 3) and gold fish (Figure 4). With respect to nutrient availability, our experimental studies using *Oreochromis mossambicus* have shown that the fish assimilated about 90% of energy in the live feed. More than half of the food assimilated was converted into tissue production. The conversion efficiency of about 54.25% is very high compared to other live feed such as *Artemia* and Chironomous larvae.

Enrichment and bioencapsulation

The nutritional quality of the fairy shrimps can be improved by enriching them with exogenous source of nutrients. Bioencapsulation is defined as the process by which live food organisms are enriched with specific nutrients or drug molecules (for example, vaccines) and fed to the target organism.

Enrichment of live food with n3 highly unsaturated fatty acids (n3-HUFA), particularly eicosapentenoic acid (EPA) and docosahexenoic acid (DHA) has proven to be beneficial in larval and maturation feeds. Rotifers and *Artemia* are naturally deficient in n-3 HUFA and particularly DHA. This can be corrected by pre-feeding them with n3 HUFA enriched products. Like *Artemia*, fairy shrimp nauplii can readily ingest lipids and significant increase their HUFA content significantly. Large-scale HUFA enrichment of *Streptocephalus* spp. is possible using emulsified diets that contain high levels of HUFA (Table 2). In the recent past, we have developed a protocol to enrich *S. dichotomus* with essential fatty acids using a self-emulsifying n-3 polyunsaturated fatty acid (PUFA) concentrate. Enrichment of fairy shrimps with the commercial



Fig. 3: Photomicrograph showing the length and coloration of prawn larvae fed with diets: (A) *Artemia*; (B) *Streptocephalus*;



Fig. 4: Photographs showing the coloration of gold fish fed with (A) dry artificial diet; (B) live feed.

Table 2: Fatty acid profiles (expressed in total percentage) of unenriched and enriched adult fairy shrimps with commercial sources of fatty acids. Velu et al. (2003).

Fatty acids	Unenriched (0 hours)	Enriched with ALGAMAC 2000		Enriched with DHA-SELCO	
		3 hours)	(6 hours)	3 hours)	(6 hours)
$\beta^{-}\omega\dot{1}$	1.33	1.76	2.24	1.48	4.16
$\beta^{-}\omega\dot{1}$	1.56	0.40	1.95	1.09	1.78
$\beta^{-}\omega\dot{1}$	4.90	8.24	12.73	12.98	13.53
$\beta_{,}^{\prime}\gamma z -\beta$	3.70	0.71	2.22	6.01	2.93
$\beta^{-}\omega\dot{1}$	0.84	0.74	1.34	0.86	0.76
$\beta^{-}\omega\dot{1}$	2.67	3.03	3.67	4.01	2.68
$\beta_{,}^{\prime}\gamma z -\beta$	2.08	1.49	2.87	2.81	1.95
$\beta_{,}^{\prime}\gamma z -\beta$	10.71	11.60	13.27	11.96	11.05
$\beta_{,}^{\prime}\gamma z -\beta$	4.57	2.90	4.22	4.09	4.79
$\beta_{,}^{\prime}\gamma z -\beta$	14.35	14.80	19.78	17.72	16.20
$\beta_{,}^{\prime}\gamma z -\beta$	0.40	0.38	0.41	1.01	0.63
$\beta^{-}\omega\dot{1}$	0.19	0.30	0.26	0.10	0.80
$\beta_{,}^{\prime}\gamma z -\beta$	1.61	1.69	2.91	2.44	4.99
$\beta_{,}^{\prime}\gamma z -\beta$	1.99	8.52	13.29	11.39	8.82
$\beta_{,}^{\prime}\gamma z -\beta$	0	0.35	0.94	1.92	3.19

product, ALGAMAC 2000, showed an overall increase in the DHA (0.35%) and EPA (8.52%) contents in 3 hours incubation in the enrichment medium. Fairy shrimps incubated for 6 hours showed an increase of linoleic (4.22%), linolenic (19.78%), EPA (13.29%) and DHA (0.94%) contents. Another commercial product, DHA-SELCO, enriched fairy shrimps with EPA (11.29%) and DHA (1.92%) in 3 hours. After 6 hours of enrichment, further accumulation of DHA (3.19%) in the body tissue of fairy shrimp was observed.

Conclusions

Our research on fairy shrimps for the past two decades amply demonstrate that these organisms can be used as a potential, cost-effective, nutritionally adequate, yet economically feasible source of live feed of practical utility in aquaculture both at hatchery level as well as maturation. The relatively high contents of carotenoid pigments increase its nutritional value. The nutritional value can be further increased through enrichment of its HUFA levels.

Acknowledgments

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