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Composition and nutritional efficacy of adult fairy shrimp *Streptocephalus dichotomus* as live feed

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Abstract

Success in aquaculture is based on various criteria, in which selection of a suitable feed and its potential use is important. The suitability and potential use of the adult fairy shrimp, *Streptocephalus dichotomus*, as a live feed was investigated. *S. dichotomus* contains 55% protein, 9% carbohydrate, 19% lipids, 10% ash and an energy value of 20 kJ/g, which is equivalent to *Artemia* sps. The amino acid composition of adult *S. dichotomus* was determined; the levels of essential amino acids in proteins were 7.7% lysine, 2.8% methionine, 1.6% histidine, 7.4% arginine, 4.6% isoleucine, 8.2% leucine, 4.9% valine, 4.3% glycine, and 5% threonine which are higher than those of the *Artemia*. Analysis of the carotenoids showed the presence of astaxanthin, canthaxanthin and β-carotene. Effective utilization of adult fairy shrimp was studied using the ornamental fish, *Carassius auratus*, which showed equivalent growth performance similar to *Artemia*. The biochemical analyses of whole tissue of the fish fed with live feeds showed their efficient utilization. Fatty acid and amino acid compositions of carcasses of fish fed live diets showed their efficient consumption. Energy budget analysis of fish fed on the fairy shrimp, *S. dichotomus*, revealed that about 99.6% of the consumed feed was assimilated with a conversion ratio of 1.59, similar to *Artemia* (99.4% assimilated with a conversion ratio of 1.44). The presence of carotenoids, high energy content and optimal nutritional value offers the advantages of fairy shrimp as live feed in freshwater aquaculture.

Keywords: Amino acid; *Artemia*; *Carassius auratus*; Energy budget; Fatty acid; *Streptocephalus dichotomus*

1. Introduction

In nutrition, the main thrust of basic fish and crustacean research is focused on ensuring efficient utilization of feed for their growth (Rao, 1994). The presence of essential growth factors in live feed promotes growth, high survival, conversion efficiency and enhanced immune response (Awaiss, Kestemont, & Micha, 1992). Live feeds such as *Tubifex* sps. (Fischer, 1972), *Brachionus* sps. (Lim & Wong, 1997), *Daphnia* sps. (Rasawo & Radull, 1986), *Artemia* sps. (Baylon, Bravo, & Maningo, 2004), and *Moina* sps. (Alam, Ang, & Cheah, 1993) have been used preferentially in ornamental fish production.

Pertinent in this context is the freshwater anostracans (fairy shrimps), a special group of crustaceans having high biomass, rapid growth rate and cyst production, which have been extensively studied, mainly focusing on their taxonomic status and environmental context. Several studies have proven the use of adult *Artemia* as an excellent nursery, weaning or maturation diet in both marine and freshwater aquaculture (Sorgeloos, 1999; Tackaert & Sorgeloos, 1991). Hence, this work was focused on utilization of adult fairy shrimp, which is larger than brine shrimp, as a feed source. Feeding with a larger size range feed at low density enhances the feeding rate and satiates the fish more quickly than the smaller sized prey (James, Muthukrishnan, & Sampath, 1993).

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Evidence to utilize the fairy shrimp as a feed source came into view, as it has been shown to be an important component in the diet of fish (Leyse, Lawler, & Strange, 2004). Potential of the freshwater Anostraca for various technical applications has been discussed (Dumont & Munuswamy, 1997) and various researchers have utilized them as a feed source in intensive fish culture (Ali & Dumont, 1995; Meade & Bulkowski-Cummings, 1987; Velu & Munuswamy, 2003; Velu, Ramasubramanian, & Munuswamy, 1999). However, the feasibility and nutritional adequacy of the adult fairy shrimp has not been evaluated for commercially important ornamental fish. Among the various ornamental fish species, goldfish (*Carassius auratus*) has been a well-known aquarium fish for decades throughout the world and considered as one of the most commercially important species. Due to growing demand worldwide, popularity and high value, this ornamental fish is considered as the leading cash crop in the aquaculture economy (Chapman, Fitz-Coy, Thunberg, & Adams, 1997; Dixon & Issvoran, 1993).

Nutrient levels of brine shrimp have been known (Watanabe, Arakawa, Kitajima, Fukusho, & Fujita, 1978), but similar information is not available for the fairy shrimp, *Streptocephalus dichotomus*. The aim of the present study was to determine nutrient levels and suitability of adult fairy shrimp *S. dichotomus* as a live feed and compare with the well-known live feed, *Artemia*.

2. Materials and methods

2.1. Reagents

Carotenoid standards were purchased from F. Hoffman-La Roche Ltd., Basel, Switzerland and Sigma Chemicals Co., St. Louis, MO, USA. Amino acid standards and fatty acid standards were purchased from Hewlett–Packard, Palo Alto, CA, USA and Nu-Check-Prep, Elysian, MN, USA, respectively. HPLC-grade solvents (Sigma) were used for extraction procedures and chromatographic analyses. For biochemical analysis, analytical grade solvents and chemicals were used.

2.2. Feed

The fairy shrimp, *S. dichotomus*, was cultured as described previously (Munuswamy, Nazar, Velu, & Dumont, 1997). Adult parthenogenetic strain of *Artemia* was collected from a local salt pan located at Kelambakkam, South India.

2.3. Feeding trial

Carassius auratus (3 month old) were stocked and acclimatized for two days. Before starting the experiment, the juveniles were starved for 48 h to empty their gut contents. Three tanks were randomly assigned for each diet (triplicate) and there were no significant differences in the fish length and weight among replicates at the start of the experiment (33.7 ± 0.04 mm, length; 2.07 ± 0.17 g, weight) ($n = 15$, ANOVA, $p > 0.05$). Water temperature was maintained at 27–28 °C, pH 7.5 and ammonium nitrogen at <0.5 mg L^{-1} and aeration was supplied 24 h day^{-1}, photoperiod was controlled as 12 h dark: 12 h light using a 40 W fluorescent light with an animal density of 2–3 animals L^{-1} in a 6 L tank (30 cm × 15 cm × 15 cm).

For the feeding trial experiment, adult *S. dichotomus* and *Artemia* were offered at 10% of body weight per day (Meade & Bulkowski-Cummings, 1987), and dispensed 2 times a day in equal proportion. For energy content analysis, uneaten food and feces were removed, dried to constant weight at 70 °C and reweighed.

2.4. Biochemical analyses

At the end of the experiment (21 days), fish and live feeds were sacrificed and subjected to various biochemical analyses such as total protein (Lowry, Rosebrough, Farr, & Randall, 1951), total free sugar (Roe, 1955), protein bound sugar (Carroll, Longley, & Roe, 1956), total lipid (Barnes & Blackstock, 1973; Folch, Less, & Stanley, 1957) and water content determination (Passoneau & Williams, 1953).

2.5. Fatty acid analyses

Total lipids were extracted from the samples by homogenizing in 5 volumes of chloroform/methanol (2:1, v/v) and measured gravimetrically according to the method of Folch et al. (1957). According to Morrison and Smith (1964), the lipids were converted into fatty acid methyl esters (FAMEs) by saponification and methylation and then identified by gas chromatography. The fatty acid methyl esters were analyzed using a Hewlett–Packard 5890A gas–liquid chromatograph (Palo Alto, CA, USA) equipped with diethylene glycol succinate (DEGS) column (25 m length × 0.32 mm width × 0.5 μM diameter) (Agilent Technologies, Palo Alto, CA, USA) and flame ionization detector. Nitrogen was used as the carrier gas and temperature programmings for the oven was from 160 °C for 10 min and then to 180 °C at 1.5 °C/min which was then maintained for 5 min. Temperatures for the injector and detector were 200 and 300 °C, respectively. Individual FAMEs were identified by comparison with known standards (GLC-68A, Nu-Check-Prep, Elysian, MN, USA) and the results were expressed in mg/g and the total percentages were calculated.

2.6. Amino acid analyses

For amino acid determination, the samples were prepared using 6 N hydrochloric acid as described previously (Velu & Munuswamy, 2003). The peptides with N-terminal primary amines were derivatized using *O*-phthaldialdehyde (OPA) reagent (Hewlett–Packard, Palo Alto, CA, USA) (Lee & Drescher, 1978) and the resulting diastereomers

were separated by ion exchange chromatography. Based on the positive charge and ionic strength of amino acids, they bind to the sulphonic group or to the silica matrix. The entire amino acids move through the column at different rate, based on their p*K* values, but also in part on their adsorption or solubility in the silica particle. The amino acid levels were determined using a reverse-phase high-performance liquid chromatography system (Hewlett–Packard model 1100 series, Hewlett–Packard, Palo Alto, CA, USA) equipped with a Hypersil AA-ODS silica based C18 column (200 mm × 2.1 mm) (Hewlett–Packard, Palo Alto, CA, USA). Sodium acetate buffer (20 mM) with tetrahydrofuran (3 ml L^{-1}) was prepared and adjusted to a pH of 7.2 with 1% acetic acid and to this mixture triethylamine (180 ml L^{-1}) was added and the pH was rechecked (mobile phase A). Sodium acetate buffer (20 mM) was prepared and adjusted to a pH 7.2, and methanol (400 ml L^{-1}) and acetonitrile (400 ml L^{-1}) was added (mobile phase B). The separation was achieved using a gradient program by utilizing the two mobile phases according to the procedure described by the manufacturer (Hewlett–Packard, Palo Alto, CA, USA). Individual amino acids were identified by comparing their retention times with those of amino acid standards (HP 5062–2478, Hewlett–Packard, Palo Alto, CA, USA) run under identical conditions and expressed as percentage of total amino acids.

2.7. Carotenoid content

For carotenoid estimation, the adult fairy shrimps were homogenized, suspended in 10 ml of mixture containing methanol/methylene chloride/acetonitrile (10:20:70, v/v/v) and 1 ml of tetrahydrofuran and trimethylamine (0.3:1 v/v). The carotenoprotein complexes were then precipitated with ammonium sulphate (60% saturation) as outlined by Zagalsky, Ceccaldi, and Daumas (1970) and the precipitate was centrifuged (4500*g*, 30 min), dissolved in 50 mM phosphate buffer, pH 7, and dialyzed overnight in the same buffer. They were then purified by DEAE-cellulose ion-exchange chromatography using linear gradient (50–350 mM) of phosphate buffer (pH 7). Carotenoids were then liberated from carotenoproteins with acetone according to the procedure described by Shone, Britton, and Goodwing (1979) and using thin layer chromatography [thin layer of silica gel-G supported on 20 × 20 cm glass plate (Analtech Inc, Newark, DE, USA)]. Individual carotenoids were identified based on the absorption maximum and values were identified according to the standards (F. Hoffman-La Roche Ltd., Basel, Switzerland and Sigma Chemicals Co., St. Louis, MO, USA). The absorption maxima were determined with a Spektromom-203 spectrophotometer (Budapest, Hungary) as outlined by Czeczuga and Czeczuga-Semeniuk (1998).

2.8. Energy budget analyses

Energy content of the feeds, as well as the energy budget analyses of the fish from each tank (triplicate) were performed using an advanced isothermal bomb calorimeter (BCM 89016, Advance Research Instrument Company, Mumbai, India). Energy budget for the fish was worked out using the formula, $C = F + U + R + P$ (Petrusewicz & Mac Fayden, 1970), parameters were: *C*, food consumed; *F*, feces; *U*, urine; *R*, heat energy loss due to metabolism, and *P*, growth or conversion. Energy contents were expressed in kJ/g (dry weight). Rate of consumption, absorption conversion, specific growth rate, percent assimilation and conversion efficiencies were calculated (Ali & Dumont, 1995; Winberg, 1956).

2.9. Data analyses

Biochemical analyses and energy budget were performed at least three times, whereas the morphometric analyses were performed for 15 fishes (5 per treatment). Differences between the diets and the experimental animals were analyzed statistically using one-way analysis of variance (ANOVA) (Zar, 1984). Statistical significance (95%) on the biochemical constituent of the diets and the energy budget analyses were also determined. All statistical analyses were carried out using the STATISTICA (1998) program.

3. Results

The proximate composition of *S. dichotomus*, namely, protein, carbohydrates, lipid, energy content was equivalent to that of *Artemia* sps. and had a low ash content as shown Fig. 1. It is evident that goldfish, *C. auratus* actively feed on adult fairy shrimp; the biochemical analyses of the tissue of *C. auratus* fed on *S. dichotomus* showed more carbohydrate (1.3%) and lipid (1.7%) than fish fed on *Artemia* (Table 1). A significant difference ($p < 0.01$) existed between the composition of the feed and the fish fed on different feed. When comparing the length and weight, fish fed on *Streptocephalus* sps. attained a growth of 34.8 ± 0.05 mm and a weight gain of 3.00 ± 0.15 g, like that of fish fed on *Artemia* sps. (length, 34.8 ± 0.02 cm; weight, 2.99 ± 0.10 g) after 21 days ($n = 15$; $p > 0.5$). The specific growth and relative growth rates based on weight were as follows: for fish fed

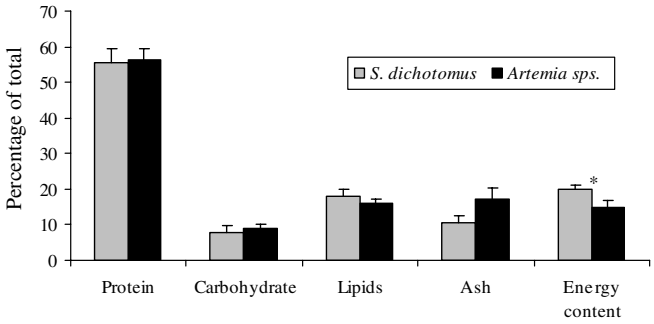

Fig. 1. Proximate composition of feeds used [Protein, carbohydrate, lipid and ash content are expressed as total %, whereas *energy content was expressed as kJ/g; $n = 6$, $p < 0.01$].

Table 1
Analysis of biochemical constituents in the tissue of *C. auratus* fed with different diet at the end of experimental period (expressed in μg/mg)[a]

Fish feed	Protein	Total free sugars	Protein bound sugars	Lipid	Water content (%)
Streptocephalus sps.	16.36 ± 0.34	4.34 ± 0.05	8.99 ± 0.04	23.02 ± 0.73	75.10 ± 1.50
Artemia sps.	16.44 ± 0.20	4.18 ± 0.04	9.22 ± 0.07	22.64 ± 0.75	75.16 ± 1.34
Percent change between *Streptocephalus* vs. *Artemia*	0	3.83	−2.49	1.69	−0.08

[a] Mean ± SD ($p < 0.01$) ($n = 6$).

on *Streptocephalus*, 0.89 ± 0.28% and 2.45 ± 0.83%, respectively, and for fish fed with *Artemia*, 0.87 ± 0.9% and 2.40 ± 0.26%, respectively.

S. dichotomus had a higher energy content of 20 kJ as compared to that of *Artemia* which had an energy content of 15 kJ as determined by calorimetric analyses (Fig. 1). Energy budget analyses on the experimental fish fed on *Streptocephalus* showed an assimilation and conversion efficiency of 99% and 63%, respectively (Table 2). Moreover, fish fed on *Artemia* also showed an assimilation of 99% and a conversion efficiency of 61% (Table 2).

A previous investigation reported a high level of C18 fatty acid series (18:1 *n*−7; 18:1 *n*−9; 18:2 *n*−6; 18:3 *n*−3; 18:3 *n*−6) and C20 fatty acid series (20:4 *n*−6; 20:5 *n*−3) in the adult fairy shrimp (Velu & Munuswamy, 2004), compared to that of *Artemia* sps. (Ramasubramanian, 1997). In the present investigation, the fatty acid profile of fish tissue fed on live feed reproduced the same fatty acid profile observed in the live feed (Fig. 2) ($p < 0.01$). More incorporation of C18 and C20 fatty acid series was observed in the fish fed on *S. dichotomus* compared to the fish fed on *Artemia*. The essential fatty acids (EFA) data from the present study were summarized and compared with those of other maturation diets used in ornamental fish culture. The data presented in this fashion, exhibit a high percent composition of either 18:2 *n*−6 or 20:4 *n*−6 (Table 3) in all live feeds.

S. dichotomus showed a high level of arginine, histidine, isoleucine, leucine, methionine, valine, lysine, glycine, threonine and glutamine (Fig. 3A) compared to that of *Artemia*. However, amino acids such as tyrosine and tryptophan were present in higher content in *Artemia*. Amino acid analysis on the whole tissue of the fish fed on these live feeds perfectly reflected their utilization, which showed moderate amounts of arginine, isoleucine, leucine, lysine, phenylalanine, tryptophan and valine in fish fed on *S. dichotomus*, compared to that fed on *Artemia* (Fig. 3B) ($p < 0.01$).

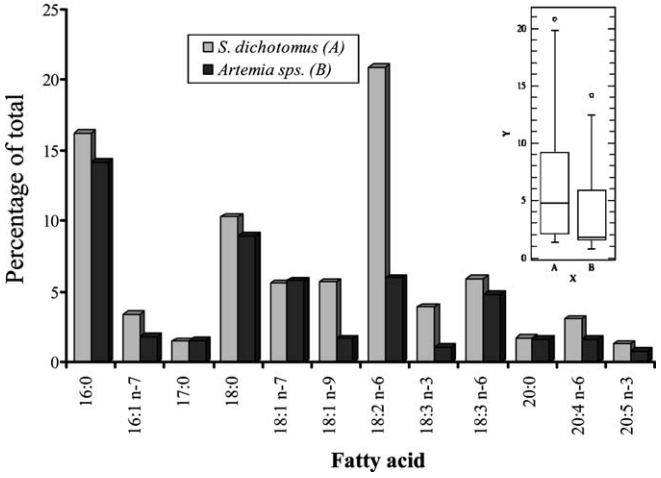

Fig. 2. Fatty acid profile of the muscle tissue of goldfish fed with *S. dichotomus* and *Artemia* sps. (expressed as percent of total fatty acids). The line through the middle of the box shows the median, and the outer edge of the box corresponds to the 25th and 75th percentiles ($n = 3$).

Characterization of carotenoid complex revealed a high level of carotenoids of 114.33 ± 8.62 μg g^{-1} dry weight in *S. dichotomus* adult. Thin layer (silica gel-G) chromatography revealed that astaxanthin (30.17%), canthaxanthin (45.73%) and β-carotene (8.78%) were the predominant carotenoids observed in the fairy shrimp (Fig. 4).

Table 2
Energy budget (kJ/d) construction for the goldfish *C. auratus* fed with live *S. dichotomus* and parthenogenetic strain of *Artemia* ($n = 3$) ($p < 0.01$)

Variables	Energy content (kJ/d)	
	S. dichotomus	*Artemia* sps.
Consumption rate	5	3.75
Assimilation rate	4.98	3.73
Conversion rate	3.14	2.58
Metabolic rate	1.84	1.15
Assimilation efficiency (%)[a]	99.6	99.4
Conversion efficiency (%)[b]	63.05	61.2
Conversion ratio[c]	1.59	1.44

[a] Assimilation efficiency = $A/C \times 100$, where A, absorption; C, food consumed.

[b] Conversion efficiency = $P/C \times 100$, where P, conversion/growth; C, food consumed.

[c] Conversion ratio (FCR) = food offered (dry weight)/weight (wet) gained.

4. Discussion

Use of *Artemia* juveniles and adults as live feed for fish and crustaceans is in practice (Smith, Brown, & Ritar, 2004), because of their optimal nutrition and energy value (Lavens, Leger, & Sorgeloos, 1986). For large fish which can handle large-size live feeds, these live feeds are being utilized as nursery/weaning/maturation diets; they also improve energy balance which results in better growth and physiological conditions. Culturing fairy shrimps, in wastewater, which filters or replenishes the water, yields a high biomass (200–300 adults^{-L} for *S. dichotomus*;

Table 3
Essential fatty acid profiles of maturation feeds used for freshwater ornamental fishes (expressed as percent of total fatty acids)

	Beef heart diet[a]	Beef liver[a]	Black tubifex worms[a]	Red tubifex worms[a]	*Moina* sps.[a]	Earthworms[a]	Mosquito larvae[a]	*S. dichotomus*[c]	*Artemia* sps.[b]
18:2 *n*−6	35.2	17.4	27	30.5	2.6	13.5	5.8	5.05	1.1
18:3 *n*−3	4.1	–	8.1	4.1	0.95	12.3	3.74	14.35	0.8
20:4 *n*−6	10.5	2.4	14.4	13.6	3.8	27.2	3.99	1.61	0.4
20:5 *n*−3	2.26	–	9.8	7.1	1.6	11.1	2.78	1.99	1.9

[a] Tamaru and Ako (2000).
[b] Webster and Lovell (1990).
[c] Velu and Munuswamy (2004).

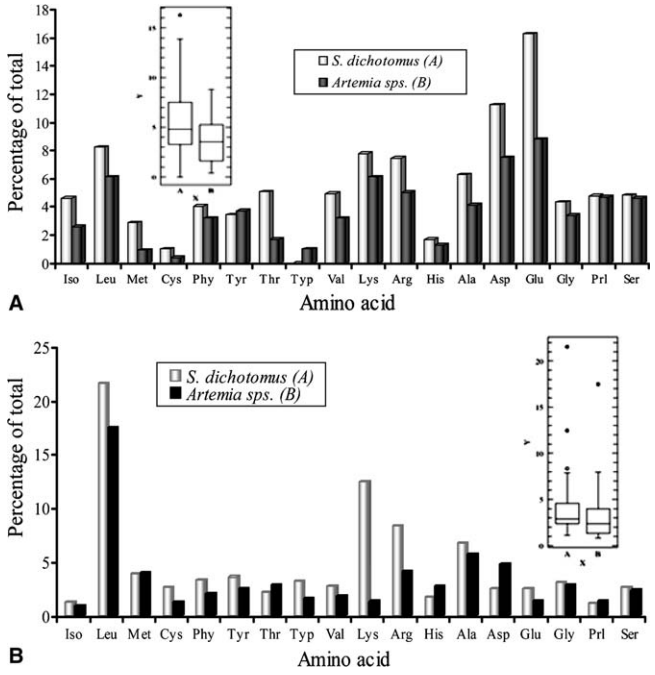

Fig. 3. Amino acid composition (expressed as percent of total amino acids) of the experimental diets (live feeds) (A) and the tissue of goldfish fed with live feeds (B). The line through the middle of the box shows the median, and the outer edge of the box corresponds to the 25th and 75th percentiles ($n = 3$).

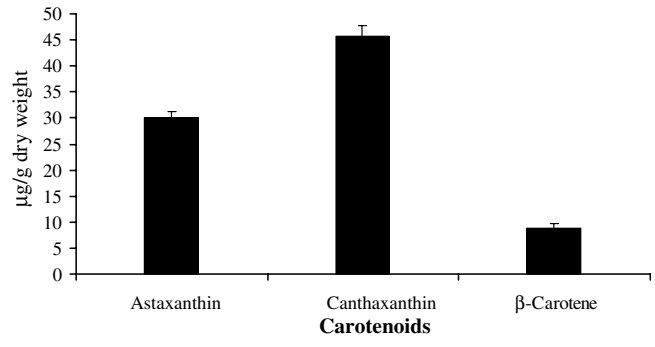

Fig. 4. Major carotenoprotein levels observed in adult fairy shrimp, *S. dichotomus* (expressed as µg g^{-1} dry weight; $n = 3$) ($p < 0.01$).

100–400 adults^{-L} for *S. macrourus*) (Mitchell, 1991; Munuswamy et al., 1997) and feeding them to fish is of economic value in freshwater aquaculture.

Nutritive value of feed is important as it reflects on the consumer organisms. Having 40% protein content in the brine shrimp, is considered as an important criterion for using it as live feed (Rasawo & Radull, 1986). Equivalent to this, adult *S. dichotomus* also has high protein (50%) and lipid (10%), and has all essential amino acids and fatty acids. With this high nutritional quality, this live feed has the advantage for use in diverse aquaculture operations, which in turn promotes high protein content in the consumer organisms (Gallagher & Brown, 1975). In addition, *S. dichotomus* has high levels of reproductive hormones (Nithya & Munuswamy, 2002), might also trigger maturation like that of *Artemia* (Sorgeloos, 1999). Additionally, fairy shrimp can be used as a dietary ingredient or gustatory attractant in artificial/pellet diets for fish and crustacean larvae.

In the present study the ornamental fish *C. auratus* actively utilized the carbohydrates (as protein-bound and total free sugars) for their metabolism. When comparing the weight gain, the fish fed on live feed showed a higher weight gain compared to that fed on pelleted feed (data not shown), this is further supported by findings of Bergot and Breque (1983) who showed that excess carbohydrates assimilate at a higher rate, resulting in a better weight gain.

Fish need to meet their specific amino acid requirements for optimal production, growth, feed conversion and carcass quality potential. Usually the required amino acids are supplied as supplements in their feed ingredients and the reasoning is that fish have fairly simple digestive system. Like other animals, fish also require at least 10 essential amino acids (EAA), especially the importance of amino acids such as methionine, proline, alanine, tyrosine and cysteine for fish has been reported (Wilson, 1994; Wilson & Poe, 1985). However, the EAA requirement for goldfish has not been defined so far. In the absence of such data, it has been suggested that the amino acid profile of the muscle protein can be used as an index for EAA requirement (Mambrini & Kaushik, 1995; Wilson, 1994). From the amino acid analysis, it is evident that adult *S. dichotomus* has a high amount of individual amino acids compared to that of *A. parthenogenetica* and the attempt to study the amino acid profile of goldfish fed on these live feed also perfectly reflected the utilization of amino acids available in the feed.

In relation to fatty acid requirement, freshwater fish differ significantly from marine fish. Presumably freshwater

fish satisfy their requirement from the diets, having high C18 polyunsaturated fatty acids (PUFA) (Tocher & Ghioni, 1999; Tocher, Carr, & Sargent, 1989), which is also documented for goldfish (Pozernick & Wiegand, 1997). The fatty acid profile of adult fairy shrimp showed a high level of both PUFA and highly unsaturated fatty acids (HUFA), such as 18:2 $n-6$, 18:3 $n-3$, 20:4 $n-6$ (Velu & Munuswamy, 2004). Compared to *S. dichotomus*, these fatty acids levels are low in the Indian strain of *Artemia* sps. (Ramasubramanian, 1997). Consumption of these fatty acids is evident from the fatty acid analysis of fish tissue after the experimental period which reflects its significance. Both 18:2 $n-6$ and 20:4 $n-6$ have a significant biological role; especially 20:4 $n-6$ is the precursor of prostaglandin hormones which are essential for reproduction and vitellogenesis in freshwater ornamental fish (Bell & Sargent, 2003; Tamaru, Ako, & Paguirigan, 1997; Tamaru & Ako, 2000). Thus, various live feeds (Table 3) serve a critical role as a source of 18:2 $n-6$ and 20:4 $n-6$, as these feeds are regularly used by most fish breeders.

Intensity of skin colour increases the commercial value of goldfish and the colouration is due to various carotenoid pigments. Generally, fish are not able to synthesize carotenoids on their own and hence dietary sources play an important role in determining the fish colour. Due to increased expense in aquaculture, providing carotenoid pigments is limited (Meyers & Latscha, 1997) which forces farmers to utilize the natural sources of pigments. In the present study, the fish fed on live feed showed increased colouration compared to that of fish fed on inert diets (data not shown). High levels of astaxanthin and canthaxanthin (Fig. 4) in the fairy shrimp might have increased the colouration. Goldfish pigmentation was enhanced using carotenoid rich diets (Paripatananont, Tangtrongpairoj, Sailasuta, & Chansue, 1999) and the intermediates lutein and zeaxanthin (Hancz et al., 2003). These intermediates have been reported in the fairy shrimps as well (Velu, Czeczuga, & Munuswamy, 2003) using thin layer chromatography, partition coefficient and mass spectral studies.

The definition of the energy requirement and nutrient utilization of fish species has become a research priority for fish nutritionists. Based on methodological approach on the nutrient and energy intake, catabolism and retention, a better understanding of growth and nutrient utilization has been achieved (Ohta & Watanabe, 1998; Rodehutscord & Pfeffer, 1999; Schwartz & Kirchgessner, 1995). Energy budget analysis in the present study clearly shows that *S. dichotomus* has a higher energy content and the fish fed on live feed also showed high conversion efficiency [fairy shrimps (63%), brine shrimp (61%)]. The conversion ratio of fish fed on *S. dichotomus* (1.59) demonstrates its nutritional value and also reflects its higher assimilation energy. The utilization of adult *Artemia* and *S. proboscideus* is practiced due to high feed conversion ratio (FCR) compared to other small-size live feeds such as *Moina*, *Daphnia*, among others (Ali & Dumont, 1995; Lim, Soh, Dhert, & Sorgeloos, 1999).

The present investigation assessed the nutritive value of adult fairy shrimp, *S. dichotomus*, as a potential candidate which can be used as a maturation diet. Our previous study further strengthens the utilization of adult fairy shrimp by enhancing the nutritive value by exogenous sources (Velu & Munuswamy, 2004). Although fresh-live diet forms have high nutritive value, harvested fairy shrimp can also be frozen, freeze-dried or acid preserved for later use or made into flakes or other forms of formulated feeds like *Artemia*, and will increase their utility and initiate a new approach in using these fairy shrimps in aquaculture.

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