Effects of Dietary Protein and Lipid Levels on Growth and Body Composition of Silver Dollar (*Metynnis schreitmuelleri*) Fry

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Abstract

The aims of this study were to determine the effects of different levels of protein and lipid on the growth and body composition of fry of the silver dollar, *Metynnis schreitmuelleri* (Ahl). The fry were first fed diets containing 25, 35, 45, or 55% protein to determine the optimum protein level. The best growth, body composition, protein efficiency ratio, and food conversion ratio were obtained with the 35% protein diet. The fry were next fed diets containing 35% protein and 0, 3, 6, 9, or 12% lipid. The best growth, body composition, protein efficiency ratio, and food conversion ratio occurred with the diet containing 35% protein and 6% lipid.

Introduction

Protein and lipid nutrition is the most studied area of fish nutrition. Lipids are critical components of cell membranes and required in all animal diets to provide a store of chemical energy and for metabolic activity. Many studies have evaluated the dietary protein and lipid requirements for edible fish and crustaceans but little information is available on the dietary protein and lipid requirements of ornamental fish.

Aquarium fish fed live food attain better growth and survival than those fed artificial food. However it is not always possible to provide live food due to inconsistent and limited supply. Hence artificial feed that is nutritionally balanced with protein and lipid is commonly fed to ornamental fishes. It is therefore essential to evaluate the optimum nutritional requirements for each species, as the appropriate amount of dietary protein and lipid render better growth and survival.

The silver dollar, *Metynnis schreitmuelleri* (Ahl), is round flat freshwater ornamental fish belonging to the Characidae family. This fish is commercially important due to its shimmering silver color. The protein and lipid requirements of the silver dollar are unknown. The present study was conducted to determine the optimum dietary protein and lipid requirements of silver dollar fry.

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Materials and Methods

Silver dollar fry were obtained from a local hatchery and acclimatized for fifteen days in a plastic pool at the Taraporevala Marine Biological Research Station laboratory. The fish were fed a commercial flake feed of approximately 40% protein during acclimation.

In the first experiment, protein requirements were evaluated. Twelve groups of 10 fry each (0.660-0.705 g) were randomly selected, weighed, and stocked into experimental glass aquaria (45 x 30 x 30 cm) provided with aeration. Three groups were assigned to each of the four test diets. Experimental flake diets, prepared in the laboratory, contained one of four protein levels (25, 35, 45, or 55% by dry weight) and were nearly isocaloric (Table 1).

In the second experiment, lipid requirements were evaluated. Five test diets were formulated at 3% increments of lipid (from cod liver oil), ranging 0-12% (Table 2). The diets contained 35% protein, based on results from the first experiment, and were made isocaloric by adjusting the starch content. Lipid-free casein was used as the dietary protein source. Metabolizable energy values for silver dollar are unknown and were estimated according to protein 4.5 kcal/g (Smith, 1971), carbohydrate 3.49 kcal/g (Chiou and Ogino, 1975), and lipid 8.51 kcal/g (Austreng, 1978).

In both experiments, fish were fed twice a day (at 10:30 and 16:30-17:00) at 5% of their body weight, close to the maximum amount consumed by the fry during the acclimation period. Every ten days, the fish were weighed and counted, their lengths were recorded, weight gains determined, and feed allowances adjusted. Calculation of the total feed allowance was initially based on the average weight of the fish in all treatments. Subsequently, they were adjusted according to the average weight of the fish in each treatment and the number of fish in each aquarium. The fish were given the experimental diets for 30 days. Half the water in the aquaria was changed twice daily, at 10:00 and 16:00, before the fish were fed, and the aquaria were cleaned thoroughly every morning before the removal of the water. Water temperature, pH, and DO were measured daily.

At the end of each experiment, ten fish were randomly sampled from each treatment. They were pooled, ground, and freeze-dried, and body crude protein, lipid, moisture, and ash contents were determined (AOAC, 1984).

Table 1. Composition and proximate analysis (% dry weight) of the experimental diets in the protein requirement test.

	Dietary protein (%)			
	25	*35*	*45*	*55*
Ingredient				
Casein	17.0	27.0	37.0	47.0
Fish meal	17.0	27.0	37.0	47.0
Corn flour	33.0	23.0	13.0	3.0
Egg (whole)	33.0	23.0	13.0	3.0
Proximate analysis				
Moisture	6.0	5.5	5.0	5.0
Crude protein	25.1	34.9	44.8	55.3
Crude lipid	4.8	4.8	4.9	4.8
Ash	8.5	9.0	10.5	11.0

Table 2. Composition and proximate analysis (% dry weight) of the experimental diets in the lipid requirement test.

	Dietary lipid (%)				
	0	*3*	*6*	*9*	*12*
Ingredients					
Casein	47.0	47.0	47.0	47.0	47.0
Starch	50.5	41.0	32.0	22.5	13.0
Lipid [a]	0.0	3.0	6.0	9.0	12.0
Vitamin mix	0.1	0.1	0.1	0.1	0.1
Carboxymethyl cellulose	1.9	1.9	1.9	1.9	1.9
Cellulose	0.5	7.0	13.0	19.5	26.0
Metabolizable energy [b]	315	315	315	315	315
P/E ratio (mg/kcal)	111.11	111.11	111.11	111.11	111.11
Proximate analysis					
Moisture	14.5	15.0	13.9	14.0	15.0
Crude protein	35.1	35.2	35.1	34.9	35.1
Crude lipid	0.0	3.1	6.1	9.1	12.0
Ash	4.1	4.0	4.0	4.2	4.1

[a] Lipid source: cod liver oil
[b] Metabolizable energy estimated according to protein 4.5 kcal/g (Smith, 1971), carbohydrate 3.49 kcal/g (Chiou and Ogino, 1975), and lipid 8.51 kcal/g (Austreng, 1978).

Table 3. Growth, feed conversion ratio (FCR), and protein efficiency ratio (PER) of silver dollar, *Metynnis schreitmuelleri* (Ahl), fry fed different levels of dietary protein (means±SE).

	Dietary protein (%)			
	25	*35*	*45*	*55*
Initial avg length (cm)	3.51±0.08	3.47±0.04	3.49±0.02	3.50±0.04
Final avg length (cm)	4.09±0.02	4.46±0.08	3.98±0.08	3.98±0.06
Length gain (%)	16.50±0.08[a]	28.67±012[b]	14.04±0.04[c]	13.55±0.02[d]
Initial avg wt (g)	0.70±0.08	0.66±0.04	0.68±0.08	0.66±0.02
Final avg wt (g)	1.48±0.09	1.73±0.06	1.34±0.08	1.18±0.04
Wt gain (%)	110.63±2.16[a]	162.12±1.08[b]	96.35±2.24[c]	78.19±2.36[d]
FCR	1.34±0.04[a]	0.92±0.04[b]	1.55±0.06[c]	1.93±0.04[d]
PER	2.97±0.06[a]	3.08±0.08[b]	1.42±0.02[c]	1.21±0.04[d]

Values in a row with different superscripts are significantly different ($p<0.05$).

Table 4. Proximate body composition (%) of silver dollar fry fed different levels of protein (means of three replicate groups±SEM).

	Initial body composition	*Dietary protein (%)*			
		25	*35*	*45*	*55*
Moisture	80.90±0.60	82.00±0.60[a]	81.50±0.50[a]	80.50±0.50[a]	80.60±0.50[a]
Crude protein	11.12±0.06	11.15±0.06[b]	11.45±0.05[c]	11.45±0.06[d]	11.50±0.05[e]
Crude lipid	1.35±0.01	1.35±0.01[a]	1.36±0.01[a]	1.37±0.01[a]	1.38±0.01[a]
Ash	4.00±0.05	3.99±0.04[b]	3.45±0.02[c]	3.45±0.03[d]	4.01±0.03[e]

Values in a row with different superscripts are significantly different (p<0.05).

Table 5. Growth, feed conversion ratio (FCR), and protein efficiency ratio (PER) of silver dollar fry fed different levels of dietary lipid (means±SE).

	Dietary lipid (%)				
	0	*3*	*6*	*9*	*12*
Initial avg length (cm)	3.88±0.05	3.86±0.02	3.87±0.02	3.84±0.04	3.87±0.03
Final avg length (cm)	4.30±0.02	4.37±0.02	4.51±0.01	4.32±0.02	4.28±0.01
Length gain (%)	10.82±0.20[a]	13.21±0.25[b]	16.38±0.2[c]	12.63±0.2[d]	10.59±0.2[e]
Initial avg wt (g)	1.08±0.01	1.08±0.01	1.10±0.01	0.99±0.01	0.98±0.01
Final avg wt (g)	1.45±0.02	1.51±0.01	1.73±0.03	1.46±0.02	1.42±0.01
Wt gain (%)	34.25±0.10[a]	39.81±0.20[b]	56.10±0.10[c]	47.47±0.20[d]	44.67±0.10[e]
FCR	2.62±0.02[a]	2.26±0.02[b]	1.59±0.01[c]	1.89±0.03[d]	2.01±0.04[e]
PER	1.08±0.01[a]	1.26±0.02[b]	1.79±0.01[c]	1.51±0.01[d]	1.41±0.02[e]

Values in a row with different superscripts are significantly different (p<0.05).

Weight gain (%), feed conversion ratio (FCR), and protein efficiency ratio (PER) were determined according to the following formulas: wt gain = 100[(final wt - initial wt)/initial wt], FCR = dry wt of food consumed/increase in wet wt of animal, and PER = increase in wet wt of fish/dry wt of protein fed. Data were analyzed using one-way analysis of variance (Snedecor and Cochran, 1967).

Results

Weight gains, FCR, and PER in the protein experiment are given in Table 3. Water parameters were favorable: temperature ranged 24-26ºC, pH 7.1-7.2, and dissolved oxygen 5.3-5.8 mg/l. Fish fed 35% protein had the highest weight gain, length gain, and PER and the lowest FCR. The protein level in the tissue of the fish significantly differed among treat-

Table 6. Proximate body composition (%) of silver dollar fry fed different levels of lipid (means of three replicate groups±SEM).

	Initial body composition	Dietary lipid (%)				
		0	*3*	*6*	*9*	*12*
Moisture	79.50±0.50	80.50±0.60^{a}	81.00 ±0.60^{a}	80.50±0.60^{a}	81.50±0.50^{a}	81.60±0.60^{a}
Crude protein	11.10±0.05	11.35±0.06^{a}	11.40 ±0.06^{b}	11.65±0.05^{c}	11.55±0.06^{d}	11.60±0.05^{e}
Crude lipid	1.30±0.02	1.04±0.02^{a}	1.50 ±0.03^{b}	1.56±0.03^{c}	1.57±0.02^{d}	1.58±0.03^{e}
Ash	4.10±0.04	4.05±0.04^{a}	3.95 ±0.03^{b}	3.47±0.05^{c}	3.55±0.05^{d}	4.05±0.04^{e}

Values in a row with different superscripts are significantly different ($p<0.05$).

ments and increased as the dietary protein level rose (Table 4).

Weight gains, FCR, and PER in the lipid experiment are given in Table 5. Growth, PER, and FCR were significantly superior with the diet containing 6% lipid while the poorest growth was obtained in fish fed the lipid-free diet. Lipid body contents rose significantly with higher lipid diet contents (Table 6).

Discussion

The majority of fish species require 40-50% dietary protein (Cowey et al., 1975). The protein requirement for optimum growth of *Cyprinus carpio* fingerlings is around 40% (Ogino and Saito, 1970) and for carp fry around 45% protein (Sen et al., 1978). The highest weight gain in grass carp (*Ctenopharyngodon idella*) was obtained with a dietary protein level of 40% (Dabrowski, 1977) while the optimum dietary protein level for *Pleuronectus platessa* is approximately 50% (Cowey et al., 1972). The weight gain of milk fish fry is directly related to the dietary protein level, with a 40% protein diet producing the highest weight gain (Lim et al., 1979). In *Clarias batrachus* fingerlings, diets containing 37.72-35.69% protein produced best results in terms of weight gain and feed conversion (Cruz and Laudencia, 1976).

The positive correlation between dietary lipid and body lipid contents may indicate that when dietary lipid is supplied in excess, a proportion of this lipid is deposited as body fat. Our results are in agreement with results for other fish species such as rainbow trout (Lee and Putnam, 1973), channel catfish (Garling and Wilson, 1977), common carp (Takeuchi et al., 1979), red drum (Ellis and Reigh, 1991), and hybrid *Clarias* catfish (Jantrarotai et al., 1994).

Both protein and lipid are important in fish diets. Lipids are well utilized by most fishes, but may reduce fish growth at high dietary levels (Garling and Wilson, 1977; El Sayed and Garling, 1988; Ellis and Reigh, 1991). Similar results were observed in the present study. Fatty acids, which are not synthesized by the organism, are necessary for cellular metabolism as well as for maintenance of membrane structure integrity. Lipid also serves as a vector during intestinal absorption of liposoluble vitamins and carotenoid pigments (Jean et al., 2001). This is very important in ornamental fishes as the quality of the fish depends on its color. The silver dollar is known for its shimmering silver color. In fish fed the lipid-free diet, blackishness shed over the silver, affecting its appearance.

In summary, the diet containing 35% protein and 6% lipid maximized weight gain and food conversion in silver dollar fry. Hence, this is the most effective diet, producing maximum growth in minimum time.

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