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INFLUENCE OF SELECTED FEED ADDITIVES ON THE GROWTH AND GONADAL MATURATION OF GOLDFISH *(CARRASSIUS AURATUS)*

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ABSTRACT
The present investigation was designed to study the influence of selected feed additives, *viz*., fish meal, shrimp head meal and soy flour on the growth and gonadal maturation of goldfish, *Carassius auratus*. The feeding trial was carried out for 60 days and the sampling was carried out once in a fortnight. The fish meal, at 30 per cent concentration had the highest mean body weight gain (1.966 g) and specific growth rate (0.320 %/day), which ranked first among all the concentrations tried. The mean body weight gain was five folds higher in 30% concentration when compared to control. In the case of gonadal maturation, the fishes fed with 40% yielded the best results in both male and female. The shrimp head meal, at 40% concentration yielded the best result with regard to the growth of the goldfish. With regard to breeding performance of goldfish fed with different concentration of shrimp head meal diet, 20% concentration yielded the best result followed by 40% concentration. The mean body weight gain of 1.351 g was observed at 30% concentration of soy flour fed fishes. These results indicated that fish meal at 30% concentration is the best for the better growth of goldfish.

INTRODUCTION

Ornamental fish keeping has been serving as a viable recreation, especially for hobbyists from time immemorial. The aquarium industry is growing at a rate of about 8% annually. Protein is one of the most important and expensive component in a fish diet (Kaushik, 1995). In aquaculture, generally the dietary animal protein source is fish meal, but its availability is limited and supply varies because of reduction in fish stocks related to factors such as climatic phenomena, over exploitation and decline of ocean fisheries stocks. This variability can seriously affect aquaculture sustainability and therefore research in identifying alternative dietary protein sources has increased (Kissil*et al*., 2000; Maylor*et al*., 2000). The percentage of annual global production of fish meal being utilized in aqua feeds has increased steadily over the last two decades from approximately 15 to 65% (Tacon and Metian, 2008). Over 11% of the fish meal was used in the aquafeed sector for carp feed in 2006. Nevertheless, continued growth of aquaculture production is fundamentally unsustainable if fish meal remains the primary protein and oil source used in aquafeed. Fish nutritionists have tried to use less expensive plant protein sources to partially or totally replace fish meal (Xie *et al*., 2000). The fish shows high body weight at 100% formulated feed as compared to 100% conventional feed. And fishes were having high Protein Efficiency Ratio and Gross FoodConversion Efficiency value as compared to conventional feed (Nalawade *et al*., 2011).In this context, research on substitutes for fish meal in the diet of fish, numerous studies have been made in the past decades (Kaushik, 1995., Mambrini *et al*., 1999). In current aquaculture, commercial feeds are often formulated to contain a slightly higher level of nutrient than required by the species for maximum growth. The extra nutrients are added to feeds to insure that the requirementfor maximum growth is fulfilled. (Bhilave *et al*., 2010) Hence, the present work was carried out to study the influence of alternative feed additives on the growth and gonadal maturation of goldfish.

MATERIALS AND METHODS

The present experiment was conducted for the period 60 days to find out the influence of selected alternative feed additives on the growth and gonadal maturation of goldfish.

Experimental animal

The experimental fishes (goldfish) were purchased from a private aquarium shop, Thoothukudi. The weight of the fishes ranged between 8.00 and 9.54 g. The fishes were acclimatized for a period of 10 days in the cement tanks. During the acclimatization process the fishes were fed with control feed prepared for the experiment.

Experimental setup

The experiment was carried out in the wet laboratory of the Department of Aquaculture. The setup comprised of 3 separate units. Each unit possessed six troughs for three different

concentrations having two replications. Two troughs were maintained for the control group of fishes. Before starting the experiment, the troughs were washed with the soap oil for disinfection purpose and they were dried under the sunlight. Water was filled in the troughs upto ¾ of its volume. All the troughs were connected with the proper aeration facility.

Feed additives

Feed additives such as fish meal, shrimp head meal, and soy flour were selected for this study. These additives were procured from the market and used for the incorporation in the experimental feed at three different concentrations.

Preparation of feed

Common ingredients were procured from the local market Thoothukudi, for the preparation of control and experimental feed. The ingredients were dried well and powdered. The major ingredients were mixed in the feed at three different concentrations *viz*., 20, 30 and 40%. The control feed was prepared without adding the major ingredients.

Stocking

The fishes weighing between 8.00 and 9.54 g were stocked at 10 numbers per trough.

Feeding

The experimental fishes were fed with experimental feeds (with additives) and control diet (without additives) was given to the control group of fishes. Every day, the fishes were fed at the rate of 5% of their body weight. The feeding ration was divided into two equal quantities and given twice a day *viz*., morning and evening.

Sampling

The sampling was carried out once in 15 days. The bio-growth parameters like Specific Growth Rate (SGR), weight gain and weight gain per day were calculated by using the data collected during the experimental period.

Gonado Somatic Index (GSI)

Sample fishes were sacrificed to observe Gonado Somatic Index before starting the experiment. Any further changes in the gonad weight were measured at the end of the 60th day ofexperiment.

RESULTS

Influence of feed additives on the growth of goldfish

The bio growth parameters of fish meal fed diet on the growth of goldfish are given in Table1. The mean body weight gain of goldfish was calculated to be 1.684, 1.966 and 1.197 g for 20, 30 and 40% inclusion respectively. The mean body weight gain in the control fish was 0.464 g. The mean body weight gain showed significant positive relationship with different inclusion levels of fish meal used in the diet.

The growth parameters of goldfish fed with shrimp head meal is given in the Table2. The mean body weight of shrimp head meal fed goldfish at 20, 30 and 40% were 8.607, 9.247, 9.322 g respectively at the beginning of experiment. The mean body weight gain of shrimp head meal fed goldfish was calculated to be 1.499, 1.539 and 1.690 g at 20, 30 and 40% inclusion respectively. Two way ANOVA of the data collections affirmed that among different inclusion level of shrimp head meal diets, mean growth values showed significant difference between the test diets.

The bio growth parameters of soy flour fed goldfish are given in the Table.3 The initial mean weight of the goldfish was 8.513, 8.427, and 8.514 g at three different concentrations 20, 30, and 40 percent respectively. The mean body weight gain was calculated to be 1.028, 1.351 and 1.161 g for 20, 30 and 40% inclusion level respectively. The mean weight gain showed significant positive relationship with different inclusion levels of soy flour diet. Fish meal and soy flour at 30% concentration yielded the best growth rate, but in the case of shrimp head meal 40% concentration yielded the best growth rate. Among the three, fish meal ranked first (SGR 0.320), followed by shrimp head meal (SGR 0.277) and soy flour (SGR 0.247). The mean weight gain of the fish meal diet fed fish were four fold higher (1.966 g) than that of the fish which were fed with control feed (0.464 g). With reference to the weight gain per day, the fish meal diet fed fishes recorded 0.032 g per day followed by 0.028 g for shrimp head meal and 0.22 for soy flour fed fishes. The fishes which were fed

Table1: Bio growth performances of goldfish fed under different inclusion level of fish meal

Sl. No.	Treatment	Inclusion level (%)	Mean body weight (g) 1stday	15th day	30thday	45thday	60thday	Mean body weight gain (g)	Average daily Growth (ADG)(g)	SGR (%/ day)
1	FM	20	8.386±0.05	8.8145±0.03	9.225±0.04	9.609±0.05	10.070±0.03	1.684	0.028	0.304
2	FM	30	9.282±0.04	9.710±0.03	10.064±0.03	10.764±0.04	11.248±0.09	1.966	0.032	0.320
3	FM	40	9.289±0.08	9.634±0.07	9.876±0.07	10.174±0.05	10.486±0.07	1.197	0.019	0.202
4	Control	0	8.350±0.05	8.428±0.06	8.543±0.06	8.659±0.06	8.814±0.05	0.464	0.007	0.090

Table2: Bio growth performances of goldfish fed under different inclusion level of shrimp head meal

Sl. No.	Treatment	Inclusion level(%)	Mean body weight (g) 1stday	15th day	30thday	45thday	60thday	Mean body weight Gain(g)	Average daily growth (ADG) (g)	SGR (%/ day)
1	SHM	20	8.607±0.05	8.972±0.04	9.238±0.03	9.740±0.03	10.106±0.03	1.499	0.024	0.267
2	SHM	30	9.247±0.06	9.694±0.05	10.080±0.03	10.464±0.03	10.786±0.05	1.539	0.025	0.256
3	SHM	40	9.322±0.04	9.674±0.06	10.081±0.05	10.566±0.03	11.012±0.03	1.690	0.028	0.277
4	Control	0	8.350±0.05	8.428±0.06	8.543±0.06	8.659±0.06	8.814±0.05	0.464	0.007	0.090

Table 3: Bio growth performances of goldfish fed under different inclusion levels of soy flour

Sl. No.	Treatment	Inclusion level(%)	Mean body weight (g) 1st day	15th day	30th day	45th day	60th day	Mean body weight Gain(g)	Average daily growth (ADG)(g)	SGR (%/day)
1	SF	20	8.513±0.06	8.703±0.07	9.035±0.06	9.259±0.05	9.541±0.05	1.028	0.017	0.190
2	SF	30	8.427±0.07	8.980±0.14	9.110±0.07	9.492±0.07	9.778±0.08	1.351	0.022	0.247
3	SF	40	8.514±0.05	8.721±0.04	9.092±0.05	9.356±0.07	9.675±0.09	1.161	0.019	0.213
4	Control	0	8.350±0.05	8.428±0.06	8.543±0.06	8.659±0.06	8.814±0.05	0.464	0.007	0.090

Table 4: Influence of fish meal on the gonadal maturation of goldfish

Sl. No	Ingredients	Inclusion levels (%)	Sex	Initial weight (1st day) BW (g)	GW (g)	GSI	Final weight (60th day) BW (g)	GW (g)	GSI	Increment in GSI
1	Fish meal	20	B&	8.10	0.098	1.209	9.16	0.12	1.310	0.101
			@&	8.24	0.10	1.213	9.37	0.16	1.707	0.494
2	Fish meal	30	B&	9.35	0.14	1.497	10.07	0.17	1.688	0.191
			@&	9.55	0.17	1.780	10.26	0.23	2.241	0.461
3	Fish meal	40	B&	9.25	0.12	1.297	10.64	0.17	1.597	0.300
			@&	9.34	0.16	1.713	10.75	0.29	2.697	0.984
4	Control	0	B&	8.21	0.092	1.120	8.96	0.11	1.227	0.107
			@&	8.36	0.10	1.196	9.01	0.12	1.331	0.135

with control feed recorded the weight gain 0.007 g per day.

Influence of feed additives on the maturation of goldfish

The influence of fish meal on the maturation of goldfish is given in Table. 4 The initial Gonado Somatic Index (GSI) value for the male was calculated to be 1.209, 1.497 and 1.297 for the 20, 30 and 40% inclusion levels of fishmeal diet. The final Gonado Somatic Index (GSI) value of the male fishes were calculated to be 1.310, 1.688 and 1.597 for 20, 30 and 40% inclusion respectively. With regard to female fish, the initial Gonado Somatic Index (GSI) value was calculated to be 1.213, 1.780 and 1.713 for the respective inclusions. The final Gonado Somatic Index (GSI) value of female fishes were

Calculated to be 1.707, 2.241 and 2.697 for 20, 30 and 40% concentration respectively.

The influence of shrimp head meal on the maturation of goldfish is given in Table.5 The initial Gonado Somatic Index (GSI) value for the male was calculated to be 1.117, 1.438 and 1.735 for the respective inclusions. The final Gonado Somatic Index value (GSI) of the male fishes were calculated to be 1.397, 1.627 and 1.880 for 20, 30 and 40% respectively. In case of female fish the GSI value was calculated to be 1.343, 1.910 and 2.287 for the respective concentration. The final GSI value of the female fishes fed with shrimp head meal diet were calculated to be 1.830, 2.318 and 2.688 for 20, 30, and 40% respectively.

The influence of soy flour on the maturation of goldfish is given in Table.6 The initial Gonado Somatic Index value was calculated to be 1.040, 1.048 and 1.153 for the respective inclusions. The final Gonado Somatic Index value of the male fishes were calculated to be 1.218, 1.224 and 1.372 for 20, 30 and 40% respectively. The GSI value of female fish were calculated to be 1.130, 1.234 and 1.189 for the respective concentration levels. Finally the GSI value of the female goldfish were calculated to be 1.423, 1.619 and 1.492 for 20, 30 and 40% concentration respectively.

DISCUSSION

Protein is the most significant and expensive ingredient in any feed, where protein ingredients represent about 60% or more of the price of the fish feed. Therefore best use of dietary protein is necessary for economical production as stated by Andrew, 1977. The fish meal is incorporated at three different concentrations in order to assess the best concentration for the better growth of goldfish. Among the three concentrations used, fish meal at 30% concentration yielded the best result with regard to the growth of the goldfish. The mean body weight gain were observed to be 1.966 g which was five fold higher than that of the control fish (0.464 g).

Alam*et al.* (1996) reported that among all the available and commonly used feed ingredient the fish meal is considered to be the best ingredient for fish growth due to its compatibility with the protein requirement of fish.

Lochmann and Phillips (1944) determined the protein levels needed to optimize the weight gain and protein efficiency ratio for juvenile *C.auratus*. He obtained the best result in the diets containing 28.9% protein feeds. His results are almost similar to our results. The specific growth rate of goldfish at 30% concentration was observed to be 0.320. With regard to different concentrations used, the fish meal at 30% yielded the best result followed by 20% and 40%. In 40% inclusion although the growth rate was higher (ADG 0.0198) than the control (ADG 0.007) it performed poorer when compared to other concentrations *viz.*, 20 and 30%. This result confronted the result of Kruger *et al.* (2001b) who stated that at least 45% protein and 6% lipids levels is needed for the best SGR and feed conversion ratio of Swordtails. According to Elangovan and Shim, 1997, the comparison of protein requirements between fish species is complex since this can vary according to the size, life stages, diet formulation and farming conditions. In red tailed tin foil barb the optimal dietary protein has been reported to be 41.7% with positive effect on weight gain.

Chong *et al.* (2000) suggested that Discus has higher protein

Table 5: Influence of shrimp head meal on the gonadal maturation of goldfish

Sl. No	Ingredients	Inclusion level (%)	Sex	Initial weight (1st day)			Final weight (60th day)			Increment in GSI
				BW (g)	GW (g)	GSI	BW (g)	GW (g)	GSI	
1	Shrimp head meal	20	B&	8.23	0.092	1.118	10.02	0.14	1.397	0.279
			@&	8.19	0.11	1.343	10.38	0.19	1.830	0.487
2	Shrimp head meal	30	B&	9.73	0.14	1.438	9.83	0.16	1.627	0.189
			@&	9.42	0.18	1.910	9.92	0.23	2.318	0.408
3	Shrimp head meal	40	B&	9.22	0.16	1.735	11.17	0.21	1.880	0.145
			@&	9.18	0.21	2.287	11.16	0.26	2.688	0.401
4	Control	0	B&	8.21	0.092	1.120	8.96	0.11	1.227	0.107
			@&	8.36	0.10	1.196	9.01	0.12	1.331	0.135

Table 6: Influence of Soy flour on the gonadal maturation of goldfish

Sl. No	Ingredients	Inclusion level (%)	Sex	Initial weight (1st day)			Final weight (60th day)			Increment in GSI
				BW (g)	GW (g)	GSI	BW (g)	GW (g)	GSI	
1	Soy flour	20	B&	8.55	0.089	1.040	9.03	0.11	1.218	0.178
			@&	8.76	0.099	1.130	9.13	0.13	1.423	0.293
2	Soy flour	30	B&	8.68	0.091	1.048	9.80	0.12	1.224	0.176
			@&	8.91	0.11	1.234	9.88	0.16	1.619	0.385
3	Soy flour	40	B&	8.32	0.096	1.153	9.47	0.13	1.372	0.219
			@&	8.41	0.10	1.189	9.38	0.14	1.492	0.303
4	Control	0	B&	8.21	0.092	1.120	8.96	0.11	1.227	0.107
			@&	8.36	0.10	1.196	9.01	0.12	1.331	0.135

requirement due to its carnivorous habit. Since the experimental fish is an omnivore and specifically prefers vegetable matter, the protein requirement may be restricted to 30%. Carter and Hauler, 2000 opined that fish meal is a widely used and believed as an expensive protein components in a diet of fish. Therefore, it is necessary to reduce the amount of fish protein used for fish feed preparations. Ahmed (2000) reported that the excess protein in fish diet may be a waste and cause diets to be unnecessarily expensive.

Albert *et al*. (2010) reported that fish fed diet containing animal protein has better gonad development than the fish fed diet containing plant based protein ingredient, this could be attributed to the presence of adequate levels of essential amino acids and low level of anti-nutritional components in diets with animal based ingredients. The results of the present study is similar to the result of Albert *et al*. 2010 whom reported that the GSI of the fish meal fed diet fishes were better than the control. Adewumi *et al*. (2006) also reported faster gonad development in fish fed diet with animal based ingredient.

The shrimp head meal is incorporated in the feed at three different concentrations *viz*., 20, 30 and 40%. In all the treatments a good growth increment was recorded. The mean weight gain of shrimp head meal fed group fishes were higher than that of control group fishes. Among the three concentrations used, shrimp head meal at 40% concentration yielded the best result with regard to the growth of the goldfish. The body weight gain were observed to be 1.690 g which was 4 fold higher than that of the control fish. Meyers (1986) reported that shrimp head meal contained high amount of protein with excellent amino acid profile comparable to fish meal and therefore shrimp head meal can adequately substitute fish meal in aqua feeds as the later is scarce and expensive. The specific growth rate of the goldfish at 40% concentration was calculated to be 0.277. With regard to different concentrations used, the shrimp head meal at 40% yielded the best result followed by 30% and 20%. There was an increase in average daily growth rate corresponding to the increase in the protein inclusion level. The average daily growth rate in 40% concentration was four fold higher than that of the control but among the treatments there was no significant difference.Adewumi*et al*. (2006) reported faster gonad development in fish fed diet with animal based ingredient. The result of the present study is similar to his results.

Among all protein rich plant feed stuffs soybean meal protein has one of the best amino acid profiles to meet the high protein requirement and provides an added advantage in feed formulation because of its essential amino acid contents. The amino acid profile of soy protein is generally superior to those of the other plant proteins (O'keefe, 2003).

Many plant protein sources have been used partially or almost totally to replace dietary fish meal in order to reduce cost of feed ingredients (Kaushik *et al.,* 1995; Refstie *et al.,* 2000). It was found that costly fish meal can be replaced with low cost but equally effective plant protein sources for the preparation of aquaculture feeds (Eid*et al.,* 2008; Abbas *et al.,* 2010; Nazish and Mateen, 2011). Soy products have become a widely used protein rich feed ingredient in diets for fish species, which is due to its moderate price, high availability in the market and the relatively well-balanced amino acid profile (Kaushik*et al.*, 1995; Davies and Morris 1997; Ustaoglu and Rennert 2002; Romarheim*et al.,* 2006; 2008; Bilguven and Baris, 2011). A considerable success has been achieved in supplementing of FM with SBM plant proteins in aquatic animals. (Kaushik *et al.,* 1995).

The soy flour is incorporated at three different concentration in order to assess the best concentration for the better growth of goldfish. Among the three concentrations, soy flour at 30% concentration yielded the best result with regard to the growth

of goldfish. The mean body weight gain was observed to be 1.351 g which was 2.5 fold higher than that of the control fish. The specific growth rate of goldfish at 30% concentration was observed to be 0.247.With regard to different concentration, the soy flour at 30% yielded the best result followed by 40% and 20%. A three fold increase in average daily growth was reported in 30% concentration when compared to control.

Viola *et al*. (1982) reported that soybean meal is deficient in available energy and lysine as well as methionine for carp (*C. carpio*). Reduction in growth of goldfish in our study might be caused by an imbalance of amino acids which was covered by fish meal protein in other diets.

When compared with fish meal diet fed fishes with soy flour diet fed fishes, the fish meal diet fed fishes performed better than the soy flour fed fishes. At 30% concentration the mean body weight gain of the fish meal diet fed fish was 1.966 g and the corresponding value for the soy flour fed fish was 1.351 g. Similarly the SGR for the fish meal diet fed fish was 0.320 and soy flour diet fed fish was 0.247. Abi-Ayad and Kestemont (1994) reported that the growth performance of *C.auratusgibelio* were the highest when the fish were fed with animal protein diets. Goldfish fed with the animal diets had lower FCR than plant diet. The lower feed intake and highest FCR in plant diet fed fish were probably due to the existence of anti-nutritional factors and/ low palatability (Watanabe *et al.*, 1992). Plant meals contain anti-nutritional factors including protease inhibitors and complex carbohydrates (oligosaccharides; phytates), which can impair growth performance and nutrient utilization in monogastric animal including fish (Wilson and Poe, 1985; Hernandez- Infante*et al.*, 1998). The fish meal at 30% concentration yielded the best result for the better growth of goldfish.

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