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PROTEIN REQUIREMENTS OF CAGE-CULTURED CHANNEL CATFISH[1]

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ABSTRACT

Twenty suspended 1-m^3 cages were each stocked with 300 five- to six-inch channel catfish fingerlings to allow for the evaluation of five feeding regimens, each replicated four times. The experiment began April 15 and terminated October 21, providing for a 180-day feeding period. The daily feeding rate was 4% of biomass initially and decreased to 1.5% of biomass during the latter phase of the feeding trial. The experimental feeds were nutritionally complete, low-fiber, expanded (nonsinking) 3/16-inch diameter pellets. Treatments (diets) 1 through 3 contained protein levels of 40, 35, and 30%, with 38% of the protein in each diet coming from fishmeal and the remainder from plant sources. Diet 4 was designed to contain the same theoretical amino acid composition as diet 1 with only 17.5% of the protein coming from fishmeal and the deficient amino acids supplemented in isolated form. The fifth feeding regimen was feeding the 40% protein diet until the fish reached 0.5 lb then feeding the 30% protein diet for the remainder of the period. Mean responses to treatments 1 through 5, respectively, were as follows: weight gain per fish (lb), 1.31, 1.28, 1.24, 0.97 and 1.25; feed conversion ratio, 1.26, 1.26, 1.29, 1.36 and 1.31. Based upon diet ingredient costs treatment 3 effected the least cost per pound of gain, followed by treatments 2,5,4, and 1, respectively.

INTRODUCTION

Most of the guidelines for formulating practical catfish feeds have been developed for conventional pond culture where fish are stocked in nonflowing earthen ponds at densities not exceeding 2,000 fish per acre, and where natural pond foods supplement the diet. Making significant contributions in this area are Hastings (1969) who found that near 30% was the most economical level of dietary protein for catfish cultured in the Mississippi Delta, and Tiemeier and Deyoe (1969) who recommend 25% of protein for commercial catfish feeds in Kansas. As the culture environment becomes more artificial or as fish density increases, thus reducing the availability of natural food, nutrient specifications of the processed feed must change. Hastings and Dupree (1969) found that channel catfish fed practical-type diets in aquariums grew in a linear relation to protein percentage in the diets up to 40% protein. When the same diets were fed in ponds, weight gains were linear with protein percentage up to 28% protein. Prather and Lovell (1971; unpublished[2]) found that catfish feed containing 45% protein produced 30% more gain than one containing 32% protein when fed in nonflowing earthen ponds stocked with 4,000 channel catfish per acre; however, at a stocking density of 2,000 fish per acre the 45% protein feed was only slightly superior.

Attention is being directed toward culture modifications, such as many types of raceways, suspended cages, mechanical aeration, biological filtration, tanks and pens, which restrict or reduce the availability of natural food for intensively cultured catfish. Inasmuch as protein requirements of catfish feeds appear to be influenced by the culture environment, information on protein needs of inten-

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[2]Prather, E. E. and R. T. Lovell. 1971. Vitamin fortification in Auburn No. 2 fish feed. Fisheries Research Annual Report, 1971, Vol. I, Part I. Agricultural Experiment Station, Auburn University, Auburn, Alabama.

sively fed catfish in a practical type culture where natural food is limited would be useful. This study was designed to determine weight gains and feed conversion ratios for channel catfish grown to harvestable size in suspended cages with nutritionally complete diets containing varying levels and sources of protein.

MATERIALS AND METHODS

Twenty suspended 1-m^3 cages were each stocked with 400 five-inch catfish fingerlings to provide for the evaluation of five feeding regimens, each replicated four times. The ½- x 1-inch mesh, plastic-coated wire cages were suspended in a five-acre pond, S-28, at the Auburn University Fisheries Research Unit. The fish were stocked on March 3 and 4 and fed an expanded trout feed until April 15 at which time they were all feeding vigorously. On this date the fish were sampled and weighed and the cages of fish were randomly assigned to one of the five experimental treatments. The experimental period continued for 180 days and terminated on October 21.

Four nutritionally complete diets containing 45, 40, 35 or 30% protein were designed. To minimize change in protein quality as protein level varied, a nearly constant ratio of fishmeal protein to plant protein was maintained for all four of the diets; 38% of the protein in each diet was from fishmeal with the remainder coming from plant sources. A fifth diet was formulated to contain 40% protein but with only 17.5% of it coming from fishmeal and the remainder coming from plant sources and isolated amino acids. The ingredient composition of the five experimental diets is shown in Table 1. The diets were processed as expanded (nonsinking) feeds by a commercial manufacturer.

Table 1. Ingredient composition of five experimental catfish diets containing four percentages of protein and two ratios of animal-to-plant protein.

Ingredient	Percentage of Protein				
	45[1]	40	35	30	40 low[2]
	%	%	%	%	%
Fishmeal (70%)	24.1	21.7	19.0	16.3	10.0
Soybean meal (50%)	24.5	20.3	16.5	12.7	28.0
Peanut meal (50%)	24.5	20.3	16.5	12.7	28.0
Distillers' dried solubles	8.2	5.5	5.0	4.2	6.7
Corn	17.7	31.0	41.5	52.3	24.1
Dicalcium phosphate	0.5	0.7	1.0	1.3	2.0
Vitamin mix[3]	0.5	0.5	0.5	0.5	0.5
Methionine	0.02	--	--	--	--
Lysine (50%)	--	--	--	--	0.72

[1]The 45% protein diet did not float well when fed and feeding was discontinued shortly after the experiment began.

[2]The "40 low" diet contained 40% protein with 17.5% of protein coming from fishmeal; in all of the other diets 38% of protein was from fishmeal.

[3]Vitamin mix (mg/kg diet): vitamin A (325 USP units/mg), 17.0; vitamin E supplement (0.275 IU/mg), 120.0; vitamin D3 (200 ICU/mg), 22.0; vitamin B12, 0.028; riboflavin, 16.5 choline chloride, 1,542.0; niacin, 99.1; pantothinic acid, 60.6; thiamine, 220.0; menadione, 4.4; pyridoxine, 5.5; folic acid, 1.1; biotin, 0.0441; vitamin C, 881.1; ethoxyquin, 198.3.

Soon after the experiment began we found that the 45% protein diet did not float as well as the others, so it was decided to discontinue this diet. Another treatment was designed to replace the 45% protein diet. It consisted of feeding the fish the 40% protein diet until they reached the weight of 0.5 lb and changing to the 30% protein feed for the remainder of the feeding period.

The fish were fed once daily seven days per week until August 1 after which time they were fed six days per week. Every fourth week a minimum of 100 fish were dipped from each cage and weighed. Feed allowances were based upon the average weights of fish in each treatment. Allowances were adjusted biweekly according to the following schedule:

April 15 to June 24	4.0% of fish weight
June 25 to August 31	3.0% of fish weight
September 1 to September 30	2.0% of fish weight
October 1 to October 21	1.5% of fish weight

During the fourth and fifth weeks of the experiment an infection of *Aeromonas liquefaciens* accounted for mortality in 12% of the fish. The mortality wa distributed rather uniformly among all of the cages. When the infection was controlled by dietary application of antibiotic, the fish in each cage were removed and counted. Enough fish were randomly discarded from each cage group to allow 300 fish to be weighed and returned to the cage. Subsequently, no significant losses occurred for the remainder of the feeding period.

RESULTS

Average weight gains, feed conversion ratios and costs of feed ingredients per pound of gain are presented in Table 2. In spite of the bacteria epizootic in the early phase of the experiment, growth was excellent for all of the diets containing the higher level of fishmeal. The highest protein diet, containing 40% protein, provided a slightly but not statistically significantly ($P<0.05$) greater rate of gain than the diet containing 35% protein. Average gains from the 35 and 40% protein were significantly ($P<0.05$) greater than that of the 30% protein diet. The treatment in which fish were grown to 0.5 lb on the 40% protein diet and changed to the 30% protein diet for the remainder of the trial, showed no significant advantage over feeding the 30% protein diet for the entire 180-day period. The low-fishmeal diet showed disappointing productivity. This diet, which contained 40% protein with 17% of the protein coming from fishmeal as the only animal protein source, produced significantly ($P<0.01$) less growth than any of the diets containing the higher percentage of fishmeal protein.

Feed conversion ratios were lowest for the 40 and 35% protein diets. The conversion ratio for the 30% protein diet was slightly but not significantly ($P<0.05$) higher than those of the two higher protein diets. It was slightly but not significantly ($P<0.05$) lower than the conversion ratio for the high protein-low protein regimen. The low-fishmeal diet was significantly ($P<0.01$) less efficiently converted into weight gain than any of the diets in the other treatments.

The differences in diet ingredient costs per pound of weight gain among the five treatments were not large. The 30% protein diet was slightly more economical than the 35% protein diet although the 35% protein diet produced significantly faster growth. The 40% protein diet was the most expensive.

The weight gain data indicate that under the feeding regime followed in this study there was no significant growth advantage in increasing the dietary protein level above 35%, and only a slight advantage in increasing the protein level above 30%. Feed conversion was nearly as efficient at the 30% protein level as at the two higher protein levels. The feeding rate used in this study was considerably higher than that recommended by Schmittou (1969) for cage culture of catfish where a 40% protein trout feed was used. If the daily feed allowances had been lower, the higher protein feeds would probably have shown greater superiority.

Table 2. Average weight gain, feed conversion ratio, and cost of diet ingredients per pound of gain for caged channel catfish subjected to various dietary protein regimens for 180 days.

Diet regimen	Avg. wt. gain/fish[1]	Food conversion ratio[1]	Diet ingredient cost/lb gain[2]
(% protein)	(lb.)		($)
40	1.31a	1.26a	0.068
35	1.28a	1.26a	0.064
30	1.24b	1.29a,b	0.062
40 low[3]	0.97c	1.36c	0.067
40-30[4]	1.25b	1.30b	0.067

[1]Values in columns having same superscript are not significantly different ($P<0.05$).
[2]Based on prices f.o.b. Atlanta, Georgia (Agricultural Marketing Service, August, 1971).
[3]Diet containing 40% total protein, 17.5% fishmeal protein; all other diets contain 38% fishmeal protein.
[4]40% protein diet fed until fish reached 0.5 lb.; 30% protein diet fed remainder of feeding period.

Another apparent reason for the 30% protein diet providing nearly as much growth and feed efficiency as the 35 and 40% diets was the high quality of protein and energy in the three diets. As amino acid balance of protein improves, the quantity of protein required to achieve optimum growth decreases. Thirty-eight per cent of the protein in the diets was from herring meal which has excellent biological value (Neuhaus and Halver, 1969) for fish growth. These diets contained very little plant-cell-wall material; hence, the energy sources were highly available to the fish to spare the protein.

The low-fishmeal diet, supplemented with lysine, contained the essential amino acids in the proper ratio for a balanced protein for salmon (Neuhaus and Halver, 1969). Yet, growth, feed conversion and economics of this diet were markedly inferior to the 30% protein diet which was lower in total protein but had a higher percentage of fishmeal protein.

There was no growth or economic advantage to feeding the 40% protein diet to the caged catfish for the first part of the growing period over continuous feeding of the 30% protein diet. Perhaps, under our feeding regime, 40% protein was too high initially; and, perhaps the fish could be finished on a diet with a protein percentage below 30.

We conclude from this study that with good quality dietary protein and energy, 35% is the maximum level of protein to use in diets for catfish in artificial-type cultures. If feeding rates lower than those used in this study are applied, higher protein levels may possibly be justified. Plant protein plus the limiting amino acid(s) in isolated form do not appear to effectively replace fishmeal protein in rations for channel catfish grown to harvestable size in artificial-type cultures.

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