ว.เกษตรศาสตร์ (วิทย.) 25 : 463 - 468 (2534)

Evaluation of Channel Catfish Feeds in Long-term Pond Studies and Short-term Aquarium Studies

Wimol Jantrarotai[1] and Richard T. Lovell[2]

ABSTRACT

Responses of two sizes; 3 g and 60 g channel catfish (*Ictalurus punctatus*) to five commercial feeds (1, 2, 3, 4 and 5) and a negative control (contained low quality plant protein) were evaluated in earthen ponds and in glass aquaria, respectively. The commercial feeds were prepared from closed formulas but estimated to contain 32% crude protein, approximately 2.5 Kcal/g of digestible energy.

Growth rate of fish fed feed 1, 2 and 3 were higher than those of fish fed feeds 4, 5 and the negative control in both ponds and aquaria ($P<0.05$). There were no significant differences in weight gains among fish fed feed 1, 2 and 3 or among fish fed feeds 4, 5 and the negative control in the ponds ($P>0.05$). However, in the aquaria, fish fed feed 2 gained more weight than fish fed the other feeds, and fish fed feed 5 and the negative control grew less than those fed feed 4 ($P<0.05$). Feed conversion ratios for fish fed in ponds were higher than those for fish fed in the aquaria except for the negative control.

The correlation in weight gain between fish fed feeds in ponds and aquaria was 0.73 ($P<0.05$). The agreement in weight gain between ponds and aquaria was high for the good quality feeds but poor for the low quality feeds. There was no correlation in feed conversion ratio between fish fed in ponds and aquaria ($P>0.05$). The results indicate that aquarium studies are more sensitive than pond studies for evaluating nutritional qualities among practical diets. However, natural food from the pond can improve productivity of poor quality feeds.

INTRODUCTION

In fish nutrition research, earthen ponds are commonly used in evaluating practical feeds or feeding practices. Effects of environmental variables ponds are relatively high in comparison to experimental conditions in aquaria in a laboratory. Earthen ponds are often dissimilar and may be not suitable to use as replicates (Shell, 1966). Variations in availability of pond food organisms and water quality can confound the true effect of feeds being tested. Pond studies are costly and usually take the whole growing season to complete. However, information provided by pond studies is considered more applicable to commercial farm pond situations since the environmental variables are also present in the farmers' ponds.

Aquarium studies, which allow for control over environmental conditions, are generally used to evaluate the requirement or effect of a specific nutrient (Lovell, 1981). Evaluation of practical feeds is not often conducted in auqaria because the results would not seem applicable to pond conditions. However, if practical feeds could be tested in aquaria in the laboratory, the advantages would be that results would be obtained in a relatively short period (6-10 weeks), aquarium studies are much cheaper than pond studies, and these studies are independent of the seasons.

The purpose of the present study was to evaluate five commercial catfish feeds and a negative control feed containing low quality plant protein in a long-term feeding trial in ponds and in a short-term feeding trial in aquaria. Comparisons were made between the two feeding environments to determine the suitability of short-term aquarium studies for evaluating practical catfish feeds.

MATERIALS AND METHODS

Earthen Pond Study

Feeding trial Eighteen, 0.04-h (400-m^2) earthen ponds at the Auburn University Fisheries Research Unit, Auburn, Alabama were randomly assigned to six treatments with three replications each. The treatments consisted of five commercial catfish feeds and

1 National Inland Fisheries Institute, Bangkok, Thailand.
2 Fisheries and Allied Aquaculture Department, Auburn University, U.S.A.

a negative control feed.

Two hundred and fifty channel catfish with an average weight of 60 g were stocked into each pond on March 8, 1989. The fish were fed floating feed inside a 2.4-m diameter feeding ring.

Formulation of none of the commercial feeds was known; however, it was assumed that they were similar to the typical channel catfish feed formula shown in Table 1. The negative control was formulated to contain peanut meal as the primary protein source instead of soybean and fish meal (Table 1). Protein and digestible energy (DE) contents of the negative control were the same as those estimated for the commercial feeds. All feeds estimated to contain 32% crude protein; DE was estimated to be 2.5 Kcal/g.

The fish were fed to satiation inside feeding rings 7 days per week, at around 1800 hours, for 128 days. Feed remaining after the fish stopped eating was collected with a net and counted to estimate amount consumed from the differences in weight of feed offered and weight of uneaten feed.

All ponds were harvested after 128 days of experimental feeding. The total number and weight of fish in each pond were determined. Five fish from each pond were randomly collected for determination of dressing percentage and analysis for crude fat.

Feed analysis Moisture, crude protein, crude fat, ash and fiber of each feed was analyzed as described by Lovell (1981). Density of each feed was determined by measuring the volume of water displaced by 100 g of feed in a 1-L graduated cylinder. Floatability of each feed was determined by measuring the percentage of pellets remaining afloat after 15 minutes in a container of water.

Fish body analysis Five fish from each pond were weighed individually before and after being dressed to determined dressing percentage. Fillets of those fish were ground separately and analyzed for crude fat using the modified Gerber method as described by Lovell (1981).

Aquarium Study

Laboratory conditions The short-term aquarium studies were conducted at the Nutrition laboratory, Auburn University Fisheries Research Unit. On August 2, 1989, each of 18, 40-L glass aquaria was stocked with 50 channel catfish fingerlings averaging 3.4 g each. The aquaria were equipped with air supply and overflow pipe allowing water flow through at the rate of 800 mL/min. Water temperature was maintained at 27±1°C throughout the experiment. All windows in the laboratory were shaded with aluminum foil to prevent sunlight from stimulating algae growth in the aquaria. Fluorescent light illuminated the laboratory for 12 hours per day, from 0800 to 2000 hours.

Experimental diets Triplicate aquaria of fish were fed each of the experimental feeds fed in the pond study. The floating pelleted feeds were processed into 1.6-mm diameter moist pellet for aquarium feeding trials. Each feed was finely ground through an 80-mesh sieve in a Wiley mill and then mixed well in a micromixer with 1.5% of a complete vitamin premix. The mixture was wetted with 25% water and extruded through a 1.6-mm diameter die in a food grinder. The moist feed was sealed in plastic bags, stored frozen at -18°C and thawed a few hours before feeding.

Management The fish were fed as much as they would consume twice daily, at 0800 to 0900 hours and at 1700 to 1800 hours. Uneaten feeds were estimated and siphoned out after 1 hour of feeding. The fish were sampled biweekly to determined weight gain.

Table 1 **Formula for a 32% protein preduction diet for catfish, similar to the commercial feeds tested and the negative control feed used in the studies.**

Ingredients	Production[1] feed (%)	Negative control (%)
Menhaden fish meal	8.0	0
Soybean meal (48% protein)	48.2	0
Peanut meal	0	60.0
Corn	31.1	34.0
Rice bran or wheat shorts	10.0	0
Dicalcium phosphate	1.0	2.0
Fat	1.5	1.5
Trace mineral premix	0.068	0.068
Vitamin mix	0.045	0.045
Coated vitamin C	0.034	0.034

1 The typical channel catfish feed formula used in the United States (Lovell, 1989)

Table 2 Proximate chemical compositions of five commercial catfish feeds and the negative control feed (as-fed basis).

Feeds	Moisture (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Fiber (%)
1	9.4	30.2	3.2	7.2	5.1
2	9.0	30.9	4.3	8.4	4.4
3	9.8	30.9	3.1	7.8	3.3
4	9.9	30.8	3.5	8.1	7.4
5	8.8	30.3	4.2	6.7	5.1
Neg control	8.2	27.8	3.0	5.5	5.2

At the end of the experiment, total number and weight gain of fish in each aquarium were determined. Three fish from each aquarium were collected for body fat analysis using the modified Gerber method.

Statistical Analysis

One-way analysis of variance and Duncan's new multiple range test, described by Zar (1984), were used to compute statistical differences among treatment means for weight gain and feed conversion ratio for the pond and aquarium studies, dressing percentage, and fat content in the dressed fish for the pond study. The correlation between pond and aquarium studies was determined for weight gain and feed conversion ratio using the simple linear correlation method.

RESULT AND DISCUSSION

Feed Evaluation

The chemical analysis of the experimental feeds are presented in Table 2. All five commercial catfish feeds contained approximately 30% protein on an as fed basis. The lowest protein percentage was found in the negative control feed. Guaranteed protein content in the commercial feeds was 32%. On a moisture-free basis, the commercial feeds contained 32 to 33% protein.

Feeds 2 and 5 contained slightly higher crude fat than the other four feeds. The negative control had the lowest fat content. However, fat content in none of the feeds was over 6%, which is the maximum level for proper energy-protein balance in 32% production feeds for catfish.

Ash percentage is an indication of the amuont of fish meal in feeds because fish meal is high in bone ash. On the basis of ash content, the fish meal content in feed 5 may be lower than that in the other commercial feeds. The negative control feed was also low in ash but it contained no fish meal.

Density and floatability of the feeds are summarized in Table 3. The density ranged from 0.63 g/cm^3 in the negative control to 0.90 g/cm^3 in feed 5. Floatability of feeds 1, 3, and the negative control were 100%. Floatability is considered to be poor by commercial fish farmers if less than 85% of pellets float after 15 minutes (Lovell, 1989). Feeds 2 and 5 had floatability of only 75% after 15 minutes. Improper manufacturing procedures, involving the level of moisture, temperature, or pressure are likely the causes of the poor floatability.

Pond Study

The results of the pond feeding trial are presented in Table 4. Weight gains of fish fed feeds 1, 2 and 3 were significantly higher than weight gains of those fed feeds 4, 5 and the negative control (P<0.05). There was no significant difference among first three feeds or among the last three feeds.

Dressing percentage of the fish fed the negative control feed was lowest and significantly different from the other groups while fat content in the dressed fish was not different among treatments (P<0.05). This suggests that the fish fed the negative control feed had more fat in the abdominal cavity, which was discarded when the fish was dressed. The reason for the reduced dressing percentage for fish fed the negative control feed is presumed to be the slightly lower protein percentage and the low concentration of the

Table 3 Physical qualities of five commercial catfish feeds and the negative control feed.

Feeds	Density (g/cm^3)	Floatability[1] (%)
1	0.81	100
2	0.87	76
3	0.79	100
4	0.85	98
5	0.90	75
Neg control	0.63	100

1 Percentage of feeds remaining afloat in water after 15 minutes.

essential amino acid lysine in the peanut meal protein. As concentration of dietary protein or essential amino acids decreased, with no reduction in dietary energy, protein gain by the fish usually decreased while fat gain increased (Deru, 1985).

Feed conversion ratios agreed generally with weight gain data. Wasted feed did not influence these conversion ratios because the uneaten feed was removed and measured after fish stopped eating. Lower floatability of feeds 2 and 5 had no effect on feed conversion ratios because Leibovitz (1981) reported that catfish will eat the feed which sinks before they begin to consume the floating pellets.

Aquarium Study

Results from the aquarium study showed that weight gain of fish fed feed 2 was significantly higher than weight gain of fish fed the other diets (Table 5). There was no difference in weight gain among fish fed feeds 1, 3 and 4. Fish fed feed 5 had significantly higher weight gain than those fed the negative control feed, but both groups grew significantly less than those fed feeds 1, 3 and 4. The reason for the differences among treatments is presumed to be because of protein quality since all feeds were supplemented with a complete vitamin mix. The negative control was 3% lower in protein content but this would not account for the approximately 50% reduced growth rate by this group.

In contrast with the pond study, fish fed the negative control feed in aquaria grew poorly and the feed conversion ratio was high. Natural food in the ponds probably supplemented the low quality protein in the negative control feed. Chaupohuk (1977) reported that channel catfish get only a small amount of protein from natural pond organisms; however, they may have gotten enough to supplement the amino acid deficient protein in the negative control. Also, the large fish in the ponds had lower protein requirements than the small fish in the aquaria, so that negative control diet would not have been as deficient in the limiting amino acids for large fish as for the small fish.

The superior performance of fish fed feed 2 was probably related to protein or energy content. Feed 2 contained more crude fat than the other feeds except feed 5. Also, it possibly contained more fish meal than

Table 4 Weight gain, feed conversion, dressing percentage, and fat percentage of fish feed five commercial catfish feeds and the negative control for 128 days in ponds.

Feeds	Wt. gain /fish[2] (g)	Feed Conversion[1,2]	% Dressing[2]	% Fat[2]
1	412[a]	1.27[ab]	57.6[a]	5.5[a]
2	436[a]	1.21[b]	58.5[a]	6.4[a]
3	414[a]	1.22[b]	58.3[a]	6.3[a]
4	355[b]	1.44[c]	58.4[a]	6.0[a]
5	359[b]	1.37[ac]	57.1[a]	7.0[a]
Neg control	363[b]	1.36[ac]	52.6[b]	7.7[a]

1 Dry-matter basis.
2 Means within a column followed by same letter are not significantly different (5% problability level).

Table 5 Weight gain, feed conversion ratio, and body fat content of fish fed five commercial catfish feeds and the negative control in aquaria for 9 weeks.

Feeds	Wt. gain /fish[2] (g)	Feed conversion[1,2]	Body fat content[2] (%)
1	22.4[a]	0.96[a]	8.0[a]
2	26.9[b]	1.11[bc]	8.8[a]
3	22.0[a]	1.09[c]	8.5[a]
4	20.7[a]	1.17[b]	7.7[a]
5	16.5[c]	1.18[b]	9.2[a]
Neg control	8.5[d]	1.63[d]	8.2[a]

1 Dry diet basis.
2 Means within a column followed by same letter are not significantly different (5% problability level).

the others, on basis of the ash content.

Although the fish fed feed 4 grew poorly in the ponds, they grew as fast as those fed feeds 1 and 2 in the aquaria (P>0.05) when the feeds were fortified with a complete vitamin mix. This means that feed 4 may have been deficient in some essential vitamins.

The reason that fish fed feed 5 and the negative control grew poorly is probably because these two feeds contained lower quality protein. Peanut meal in the negative control feed is low in lysine, methionine, and threonine (Lovell, 1984). Feed 5 probably contained a low proportion of fish meal, as indicated by the low ash content, and it may also have contained low-quality plant protein.

Feed conversion ratios in the aquarium study ranged from 0.96 for feed 1 to 1.63 for the negative control feed. Except for the negative control diet, the conversion ratios were lower than those in the pond study. Mangalik (1986) found that small (10 g) channel catfish had lower feed conversion ratios than large (250 g) channel catfish. However, his data showed that for each gram of dry feed consumed, small channel catfish gained the same amount of protein and fat but more water and, thus, more weight than the large fish.

Fat content of the aquarium fish was not significantly different among treatments (P>0.5). Mangalik (1986) found that body fat content of small channel catfish was not affected by the diets contained different concentrations of protein but contained the same amount of DE.

Comparison of Pond and Aquarium Data

The fish fed the negative control feed grew significantly less in both the ponds and the aquaria. Also, fish fed diets 1, 2 and 3 grew significantly better than those fed feed 5 and the negative control in both the ponds and the aquaria. However, the aquarium study showed differences between feeds 2 and the others and between the negative control and feed 5 while the ponds did not. Also, fish fed feed 4 performed better in the aquaria than in the ponds.

Perecentage of weight gain data (Table 6) indicated relatively good agreement between ponds and aquaria for the higher quality feeds (1, 2 and 3) but poor agreement for the lower quality feeds (4, 5 and negative control). Feed 5 and the negative control provided for less growth in aquaria than in ponds which indicates that pond food improves poor quality feeds, or that fish grown to a larger size, which do not need as much protein, are less sensitive amino acid deficiencies in the feed. With feed 4, however, growth was better in aquaria than in ponds. As discussed previously, the poor performance of fish fed feed 4 in ponds may have been caused by vitamin deficiency which was corrected by vitamin supplementation of the feed prior to feeding in the aquaria.

With the exception of feeds 4 and the negative control, there was generally good agreement between the pond and aquarium feeding responses. Aquarium studies, with the absence of natural foods and faster growing fish, is more sensitive to diet differences. This is indicated by diet 2 providing higher growth, and diet 5 and negative control providing lower growth in the aquaria.

Correlation in weight gain between fish from the pond and aquarium studies was 0.73 (P<0.05). The coefficient of the determination was 0.53. Correlation in weight gain between fish from the two studies was 0.9 and 0.85 respectively, if feeds 4 and the negative control are excluded from the experiment. Relative to the other feeds, feed 4 produced much better response in aquaria and feed 5 produced much poorer response in aquaria. This indicates that the lower quality diets impaired the weight gain correlation between the ponds and the aquaria.

Table 6 Comparison of weight gain percentage and feed conversion ratio for fish grwon in ponds and aquaria fed the same diets.

Feeds	Weight gain (%)		Feed conversion[1]	
	Pond[2]	Aquarium[2]	Pond[2]	Aquarium[2]
1	687[a]	679[a]	1.27[ab]	0.96[a]
2	726[a]	769[b]	1.21[b]	1.11[bc]
3	690[a]	647[a]	1.22[b]	1.09[c]
4	592[b]	627[a]	1.44[c]	1.17[b]
5	599[b]	485[c]	1.37[ac]	1.18[b]
Neg control	605[b]	250[d]	1.36[ac]	1.63[d]

1 Dry diet basis.

2 Means within a colum followed by same letter are not significantly different (5% problability).

No correlation in feed conversion ratios between fish fed in ponds and aquaria was found (r=0.42, P>0.05). The greatest contrast in feed conversion occurred between the fish fed the negative control feed. The feed conversion of the negative control group in ponds was similar to that of groups 4 and 5, but in aquaria the feed conversion of the negative control groups was much higher than that of any of the other groups.

Aquarium studies are more precise than pond studies in determining differences among feeds for channel catfish. Aquarium studies have the advantage over pond studies in that they consume less time and facilities. In this study the smaller aquarium fish gained the same percentage of their body weight in 9 weeks as the pond fish in 20 weeks. Difference in responses in the aquaria were seen as early as 4 weeks.

However, aquarium studies are not suitable for predicting fish responses from feeds designed to be fed for a growing season in ponds. Feed conversion will generally be lower in aquarium studies because of smaller fish size. Kamarudin (1984) found that small channel catfish fed 32% crude protein twice daily had better feed conversion ratio than large catfish fed the same diet two time a day. Also, growth and feed conversion of fish fed in aquarium will be poorer for lower quality feeds due to the absence of natural food organisms. Moreover, aquarium studies with small fish will not be suitable for predicting the composition of gain for fish fed to harvest size because large fish put on more fat than small fish.

LITERATURE CITED

Chaupohuk, W. 1977. Nutritional contribution of natural pond organism to channel catfish growth in intensively-fed ponds. Ph.D. dissertation, Auburn University. 56 pp.

Deru, J. 1985. Effects of dietary energy-protein ratio on composition of gain by channel catfish and auto-oxidation of the fish in frozen storage. Master's thesis, Auburn University. 56 pp.

Kamarudin, M. S. 1984. Effects of fish size and isocaloric diets of two protein concentrations on gain and conversion efficiency in weight, protein, fat and energy of channel catfish. Master's thesis, Auburn University. 63 pp.

Leibovitz, H. E. 1981. Replacing fish meal with soybean meal in practical catfish diets. Master's thesis, Auburn University. 33 pp.

Lovell, R. T. 1981. Laboratory Manual for Fish Feed Analysis and Feeding of Fish Studies. Dept. of Fisheries and Allied Aquacultures. Auburn University, Auburn, Alabama. 65 pp.

Lovell, R. T. 1984. Use of soybean products in diets for aquaculture species. Animal Nutrition Research Highlight. American Soybean Association. 6 pp.

Lovell, R. T. 1989. Nutrition and Feeding of Fish. Van Nostrand Reinhold, New York. 260 pp.

Mangalik, A. 1986. Dietary energy requirements of channel catfish. Ph.D. dissertation, Auburn University. 126 pp.

Shell, E. W. 1966. Comparative evaluation of plastic and concrete pools and earthen ponds in fish cultural research. Prog. Fish-Cult. 24(1) : 37-40.

Zar, J. H. 1984. Biostatistical Analysis. 2nd Edition. Prentice-Hall, Inc., Englewood Cliffs, N. J. 620 pp.