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Effects of Feeding Diets with Different Protein Levels on Growth and Body Composition of Blue Catfish, *Ictalurus furcatus*, Grown in Cages

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ABSTRACT

Juvenile Kentucky-strain blue catfish, *Ictalurus furcatus*, with an average initial weight of 39.0 g, were stocked into 3.5-m³ floating cages at a rate of 250 fish/cage and fed one of three diets. Diets contained either 29%, 33%, or 38% protein. Fish were fed all they would consume in 40 min for 139 days. There were three replications per diet. At harvest, there were no significant differences ($P > 0.05$) in final individual weight, percentage weight gain, survival, and specific growth rate among treatments; these parameters averaged 127 g, 227%, 97%, and 0.85%/day, respectively. There were also no significant differences in whole-body composition of fish fed extra diet; these parameters averaged 49.5% protein, 36.6% fat, and 69.7% moisture among the treatments. Our study suggests that a non-domesticated strain of blue catfish from Kentucky can be fed a diet with 29% protein when grown in cages. This may allow producers to reduce feed costs and to increase profits.

INTRODUCTION

Diversification of agricultural crops will be essential for farmers in Kentucky if they are to maintain their farms into the next century. Aquaculture, or fish farming, may be a means whereby farmers could use existing resources to supplement income or to supply a protein source for their families. Aquaculture has been the fastest-growing segment of agriculture in the United States for the past 5 to 10 years. The channel catfish (*Ictalurus punctatus*) industry is the largest segment of U.S. aquaculture with sales of ca. $400 million in 1997 (USDA 1997). Most of the production occurs in Mississippi, Alabama, and Arkansas. The domination of the catfish market by these states, coupled with their longer growing season, make it difficult for producers in Kentucky to compete in growing and selling channel catfish to markets. Thus, another species may need to be examined if catfish farming is to be a viable aquaculture enterprise in the state.

Blue catfish, *Ictalurus furcatus*, possess several attributes that could make them a desirable culture species. They have a higher dressing percentage than white or channel catfish (Dunham et al. 1983), are easier to seine (Chappell 1979), appear to have similar growth rates as channel catfish in summer (Grant and Robinette 1992), and are resistant to some diseases that cause mortality in channel catfish, e.g., enteric septicemia (ESC) (Wolters and Johnson 1994). The latter is of special significance in regions of the United States, such as Kentucky, that tend to have cooler water temperatures (24–28°C) during the summer growing season, which is within the temperature range of this bacterium for occurrence of peak disease outbreak (MacMillan 1985).

Cages allows for the culture of fish in ponds where a seine would be difficult to use. This is especially advantageous for Kentucky fish producers since many ponds in Kentucky are small hilltop ponds that may not be amenable to seining due to deep or irregular bottoms. Cage culture also allows for easy observation of the condition and feeding habits of the fish and for ease of harvesting. However, growing fish in cages reduces the availability of natural foods to the fish and possibly alters the nutritional specifications of the diet required to grow the fish. Early research indicated that channel catfish grown in cages had higher growth rates when fed diets containing >35% protein compared to a diet with 30% protein (Lovell 1972). However, more recent data suggest that diets with as low as 28% protein could be fed to channel catfish and blue catfish grown in cages if fish are fed to satiation (Webster et al. 1994, 1995).

Most of the previous research on blue catfish has been conducted on semi-domesticated strains from commercial suppliers. Little research has been conducted on local "wild"

Table 1. Diet formulation and proximate analysis of prepared diets fed to blue catfish grown in cages.

Ingredient	Diet (% protein)		
	Diet 1 (29)	Diet 2 (33)	Diet 3 (38)
Herring meal (67%)	2.8	3.4	4.0
Soybean meal (49%)	25.0	36.0	47.0
Wheat mids	10.0	10.0	10.0
Corn	52.9	41.3	29.7
Meat & bone meal	5.0	5.0	5.0
Vitamin & mineral mix	2.0	2.0	2.0
Stay-C	0.05	0.05	0.05
Monocalcium phosphate	1.0	1.0	1.0
Menhaden oil	1.25	1.25	1.25
Moisture (%)	10.3	11.7	9.8
Protein (%)	29.2	32.5	37.9
Fat (%)[1]	6.7	7.2	6.9

[1] Dry-matter basis.

strains. The purpose of our study was to determine the effects of feeding diets with different protein levels on growth and body composition of a cage-grown, non-domesticated strain of blue catfish found in Kentucky.

MATERIALS AND METHODS

Experimental Conditions and Animals

Blue catfish juveniles (average individual weight ±SE of 39.0 ± 2.0 g), obtained from the Kentucky Department of Fish and Wildlife, were stocked on 21 May 1997 into twelve 3.5-m^3 floating cages moored over the deepest area (4 m) of a 1.0-ha pond (average depth, 2.0 m) located at the Agricultural Research Farm, Kentucky State University, Frankfort, Kentucky. Two hundred and fifty juveniles were hand-counted and randomly stocked into each cage. Fish were fed one of three extruded diets for 139 days. Diets were formulated to contain 22%, 27%, or 32% protein; however, a problem at the mill resulted in diets actually containing 29%, 33%, and 38% protein (Table 1). Diets were extruded into floating pellets by a commercial feed mill (Integral Fish Foods, Inc., Grand Junction, Colorado). Fish were fed once daily (0900) all they would consume in 40 min. There were three replications per treatment.

Diets were analyzed for protein, fat, and moisture. Crude protein was determined by the macro-Kjeldahl method; crude fat, by the acid-hydrolysis method; and moisture, by drying samples to constant weight (AOAC 1990). Digestible energy (DE) values were calculated from the diet ingredients for channel catfish (NRC 1983). Diets were stored in plastic-lined bags in a freezer (-10°C) until fed.

Each cage had a frame made of polyvinyl chloride (PVC) tubing with a removable lid and was constructed of 10-mm polyethylene mesh. A panel of polyethylene mesh (0.2-mm mesh, 20 cm high) was installed around the top of the inside of each cage to prevent loss of floating diet. Cages were anchored to a floating dock; the distance between cages was 2 m.

Temperature and dissolved oxygen (DO) were monitored twice daily (0830 and 1530) outside the cages, at a depth of 0.75 m, with a YSI model 57 oxygen meter (Yellow Springs Instruments, Yellow Springs, Ohio). If DO was graphically predicted to decline below 4.0 mg/liter, aeration was provided with an electric paddlewheel (5 HP, S&N Sprayer Co., Inc., Greenwood, Mississippi). No other water quality requirements were measured due to the constant nature of the pond water quality in previous years (Webster et al. 1994, 1995).

Data Collection

Fish were harvested on 8 October 1997; total number and weight of fish in each cage were determined. Three whole fish from each cage were homogenized in a blender and analyzed for protein, lipid, moisture, and ash. Protein was determined by the Kjeldahl method; lipid, by ether extraction; ash, by a muffle furnace; and moisture, by drying in an oven at 100°C to constant weight (AOAC 1990). Feed conversion ratio (FCR) and specific growth rate (SGR) were calculated as follows: FCR =

Table 2. Mean (±SE) of final weight, percentage weight gain, percentage survival, feed conversion ration (FCR), specific growth rate (SGR), and body composition of blue catfish reared in cages and fed diets containing various percentages of protein. Means in the same row with different superscript letters are significantly different ($P < 0.05$).

	Diet (% protein)		
	29	33	38
Final wt. (g)	120.1 ± 8.7[a]	126.6 ± 9.4[a]	132.6 ± 3.1[a]
Weight gain (%)	209 ± 22[a]	231 ± 24[a]	241 ± 8[a]
Survival (%)	94.8 ± 0.2[a]	98.4 ± 0.2[a]	97.5 ± 1.5[a]
FCR	2.18 ± 0.21[a,b]	2.72 ± 0.19[b]	2.06 ± 0.09[a]
SGR	0.81 ± 0.05[a]	0.86 ± 0.05[a]	0.88 ± 0.02[a]
Body composition			
Protein (%)[2]	49.0 ± 0.6[a]	49.4 ± 0.3[a]	50.0 ± 0.7[a]
Fat (%)[2]	37.4 ± 1.3[a]	36.2 ± 1.7[a]	36.3 ± 0.7[a]
Moisture (%)	69.8 ± 0.2[a]	69.3 ± 0.4[a]	70.1 ± 0.2[a]

[1] Values are means of three replications
[2] Dry-matter basis

total weight of diet fed/total fish weight gain; SGR (%/day) = $[(\ln W_t - \ln W_i)/T] \times 100$, where W_t is the average individual weight of fish at time t, W_i is the average individual weight of fish at time 0, and T is the culture period in days.

Statistical Analysis

Data were analyzed by GLM using SAS (SAS 1988); Duncan's multiple range test was used to determine differences among means. All percentage and ratio data were transformed to arc sin values prior to analysis (Zar 1984).

RESULTS AND DISCUSSION

Water Quality

Average monthly morning water temperatures (±SE) ranged from 18.9°C for October to 28.2°C for July; they averaged 23.3°C for the duration of the study. Average monthly afternoon water temperatures ranged from 20.5°C for May and October to 29.3°C for July; they averaged 24.0°C for the entire study. Morning DO levels averaged 6.1, 5.5, 7.3, and 8.2 mg/liter for June, July, August, and September, respectively; afternoon values were 7.6, 7.6, 9.4, and 10.8 mg/liter for those months. These values were within acceptable values for growth of channel catfish (Boyd 1979).

Growth, Survival, and Feed Conversion

No significant differences ($P > 0.05$) in final individual weight, percentage weight gain, survival, and specific growth rate (SGR) were found among dietary treatments; these parameters averaged 127 g, 227%, 97%, and 0.85%/day, respectively (Table 2) Blue catfish fed a diet containing 38% protein had significantly ($P < 0.05$) lower FCR (2.06) than fish fed a diet containing 33% protein (2.72), but FCR was not different ($P > 0.05$) from fish fed a diet with 29% protein (2.18). This difference might be an artifact from feeding methods rather than a difference in diet utilization. All fish fed rather non-aggressively, and it took great care not to overfeed them. It may be that fish were overfed and this resulted in higher FCRs than would have been calculated for fish that feed aggressively.

The fish we used were a non-domesticated strain from Kentucky. Channel catfish have been selected for rapid growth, aggressive feeding behavior, and tolerance of culture conditions. Blue catfish, which have not had much genetic selection for aquaculture purposes, tend to feed non-aggressively and, compared to channel catfish, do not grow as rapidly when grown in cages. The non-aggressive feeding of blue catfish in cages is especially evident when a "wild" strain is used, as in our study. Careful feeding methods must be used to ensure that fish are consuming the diet; however, overfeeding is better than underfeeding since optimal growth cannot occur unless the fish are being offered all they will consume.

Protein, the most expensive component in catfish diets, is a primary concern in diet formulation. Feed producers desire to provide the minimum level of protein that will supply

essential amino acids to give acceptable growth in fish. Data from previous studies indicate that optimal levels of protein for channel catfish were between 25% and 45% (Brown and Robinson 1989; Gatlin et al. 1986; Hastings and Dupree 1969; Reis et al. 1989). Li and Lovell (1992a, 1992b) reported that a diet with a lower protein level (26%) could be fed to pond-grown channel catfish if fed to satiation. Webster et al. (1994) stated that a diet with 27% protein could be fed to cage-grown channel catfish reared without adversely affecting growth and body composition.

Reis et al. (1989) reported that channel catfish reared in ponds had higher weight gains when fed diets containing 35% and 39% protein than fish fed a diet containing 26% protein. Further, fish fed the 26% protein diet had higher fat levels in the dressed carcass than fish fed diets containing 35% and 39% protein. However, Li and Lovell (1992a) found that weight gains of channel catfish fed to satiation on a diet with 26% protein were similar to fish fed a diet containing 38% protein. According to Garling and Wilson (1976), a diet with 28% protein gave similar weight gains to catfish as a diet with 36% protein. These conflicting results may be due to previous studies not feeding diets in sufficient quantity for fish to achieve optimum growth. When fish are fed a restricted ration, a diet with higher protein levels may be required (Li and Lovell 1992a; Lovell 1972; Prather and Lovell 1971). Li and Lovell (1992b) suggested that a possible reason for high-protein diets (36% and 40% protein) not producing higher weight gains in channel catfish than fish fed a low-protein (26%) diet might be higher concentrations of ammonia and nitrite in the ponds fed the high-protein diets. However, in our study, all fish were reared in the same body of water and water quality parameters remained within acceptable limits (Boyd 1979).

Although fish eat to satisfy an energy requirement (Lovell 1989), environmental temperature and stomach volume are also important factors. Maximum weight gain for channel catfish has been reported to occur between 27 and 30°C (Andrews and Stickney 1972; Helfrich et al. 1981). In our study, water temperature averaged between 23 and 24°C, and fish may not have had as aggressive a feeding response as they might have had if water temperature had been higher. Dietary protein had no effect on food consumption and feed conversion. Feed conversion values in our study were somewhat higher than for channel catfish reared in cages (Newton and Robinson 1981; Webster et al. 1992a, 1993) and may be due to the non-aggressive feeding nature of this strain of blue catfish.

Body Composition

No significant differences ($P > 0.05$) were found in body composition of fish fed diets containing 29%, 33%, or 38% protein (Table 2). Percentage of whole-body protein averaged 49.5%; percentage body fat, 36.6%; and percentage moisture, 69.7% among treatments. Our data suggest that body composition of blue catfish was not affected when fish were fed diets containing different protein levels. This is in agreement with the findings in channel catfish by Webster et al. (1992b), who reported protein and fat percentages of 41.5% and 41.4%, respectively.

The level of digestible energy in a diet affects the amount of food consumed by fish, and the ratio of energy to protein in the diet will influence conversion efficiency. An excessively high ratio may increase fat deposition, whereas when the ratio is too low, protein will be used as an energy source. Webster et al. (1993) reported that channel catfish fed diets containing 127 mg to 130 mg of protein/kcal of digestible energy had increased carcass fat levels when grown in cages; however, subsequent data indicate that a diet with between 120 mg and 135 mg of protein/kcal of digestible energy does not significantly affect body composition of cage-grown channel catfish (Webster et al. 1994).

Our study suggests that increasing protein level to 38% in a blue catfish diet does not significantly reduce body fat and does not increase weight gains compared to fish fed a diet containing 29% protein. This is of importance to producers who can feed a diet with a lower percentage of protein. Since protein is the most expensive component in a diet, lowering protein levels may reduce costs and increase profits for producers of blue catfish in Kentucky.

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