# Effects of Protein Level and Feeding Frequency on Growth and on Body Composition of Third-Year Channel Catfish Cultured in Ponds

Carl D. Webster
James H. Tidwell
Laura S. Goodgame
Julia A. Clark
Daniel H. Yancey

**ABSTRACT.** Channel catfish, ***Ictalurus punctatus,*** adults were stocked at 3,705 fish/ha in twelve 0.04-ha earthen ponds and fed to satiation either once or twice daily with diets containing either 32 or 38% protein for 170 days. Experimental diets with the appropriate levels of essential amino acids, vitamins, and minerals were formulated by a commercial feed mill. There were no significant differences ($P > 0.05$) in growth and body composition of channel catfish when analyzed by protein level, feeding frequency, or their interaction. Average individual fish weight at harvest was 1,600 g. Average net production was 3,125 kg/ha. Dry-weight percentages of protein, fat, and ash in the carcass were 55.5, 38.1, and 6.7%, respectively, and in the waste (head, skin, and viscera) were 40.5, 43.2, and 12.5%, respectively. Third-year channel catfish may be able to utilize a diet with lower (<32%) protein levels and a reduced energy:protein ratio.

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Carl D. Webster, James H. Tidwell, Laura S. Goodgame, Julia A. Clark, and Daniel H. Yancey, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601 USA.

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## INTRODUCTION

The majority of research on production of channel catfish, *Ictalurus punctatus*, concerns growth of second-year fish to marketable size (400-500 g) (Dupree et al. 1970; Lovell et al. 1974; Robinson 1991; Webster et al. 1991). Little information is available concerning growth of third-year channel catfish (Busch 1986). Commercial catfish diets used for grow-out of channel catfish usually contain 32% crude protein and 3.0 kcal digestible energy (DE)/g of diet, for a digestible energy:protein ratio (DE/P) of 9.4 kcal/g of protein (Reis et al. 1989). This digestible energy:protein ratio and feeding to satiation allows fish to grow faster and larger during a production season than diets that were used a decade ago. However, excess fat in cultured channel catfish has become a concern in recent years (Lovell 1983). Excess fat results in decreased dress-out and a shorter shelf-life of processed fish. Increased fattiness may be influenced by diet composition (Kamarundin 1984), feeding practices (Lovell 1979), and fish size (Tidwell and Robinette 1990).

In some regions of the United States (e.g., Kentucky), larger channel catfish are preferred for the pay-lake industry (Cremer et al. 1984). Limited data are available on growth, food conversion, and body composition for fish grown for a third year (>500 g). Lovell (1989) stated that growth rate and food conversion values decrease as fish increase in size. However, little information on the nutritional requirements of third-year channel catfish exists.

There are conflicting opinions about the most appropriate diet formulation for channel catfish. Two possible diet formulations have been discussed in the literature. The first formulation would reduce the percentage of dietary protein to a level that does not sacrifice weight gain, dressout percentage, or body composition (Brown and Robinson 1989). The second formulation would increase the percentage of dietary protein, thereby possibly reducing the DE/P ratio of the diet and reducing fat deposition in the fish (Lovell 1979; Kamarundin 1984). The objective of this study was to evaluate the effects of two dietary protein levels, with different energy:protein ratios, at two feeding frequencies on growth and on body composition of third-year channel catfish.

## MATERIALS AND METHODS

### Diets

Fish were fed one of two extruded diets formulated by a commercial feed mill (Delta Western,[1] Indianola, Mississippi) to contain either 32 or 38% protein. Diets were analyzed for crude protein, fat, and moisture. Crude protein was determined using the macro-Kjeldahl method; crude fat was determined by the acid-hydrolysis method; and moisture was determined by placing 2 g of the diet in a drying oven until a constant weight was obtained (Association of Official Analytical Chemists 1990). Digestible energy values were calculated from the diet ingredients (NRC 1983). Chemical analysis of the diets indicated that the 32% protein diet had 33.2% protein and 4.4% lipid (dry-matter basis), as well as 2.96 kcal of digestible energy (DE)/g of diet and a DE/P ratio of 8.92 kcal/g of protein, while the 38% protein diet had 37.8% protein and 3.4% lipid (dry-matter basis), along with 3.05 kcal of DE/g of diet and a DE/P ratio of 8.07 kcal/g of protein. Diets were stored at -30°C in plastic-lined bags until fish were fed.

### Grow-out

Adult channel catfish (average weight 546 ± 30 g) were stocked on 23 April 1991 into twelve 0.04-ha earthen ponds at the Aquaculture Research Center, Kentucky State University, Frankfort, at 3,705 fish/ha. Ponds were approximately 1.5 m deep and were supplied with water from a reservoir that was filled by rain runoff. Water levels in ponds were maintained at a constant depth by periodic additions from the reservoir.

Fish were fed all they would consume either once (0900) or twice (0900 and 1530) daily for 170 days. Each treatment combination in the 2 × 2 factorial arrangement (protein level × feeding frequency) was replicated in three ponds. Diets were placed inside a 3.0-m diameter floating feeding ring in the pond. Rings were made from 1-cm diameter plastic pipe and had a 0.58-mm plastic mesh skirt extending 20 cm below the water surface.

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1. Use of company or trade names does not imply endorsement.

Dissolved oxygen and water temperature in all ponds were monitored twice daily (0800 and 1430) by means of a YSI Model 57 oxygen meter. When the dissolved oxygen level of any pond was predicted (graphically) to decline to below 4.0 mg/1, aeration was provided by an electric aerator. Total ammonia nitrogen (TAN) and nitrite were measured twice weekly in each pond at 1300 by means of a Hach DREL/5 spectrophotometer, and pH was measured twice weekly at 1300 using an electronic pH meter (Accumet 900, Fisher Scientific).

### *Harvest Data*

Fish were not fed 24 hours prior to harvest and were harvested by seine on 9 October 1991. Total number and weight of fish in each pond were recorded at harvest. Twenty-five fish were randomly sampled from each pond and were individually weighed to the nearest gram and measured (total length) to the nearest 0.5 cm. Ten fish were randomly sampled from each pond to determine dressing percentage and percent abdominal fat. Three of these fish were randomly sampled for analysis of body composition. Fish were skinned by machine and dressed by removing the head and viscera. Abdominal fat was removed, weighed, and reported as a percentage of the whole fish. Carcass and waste (head, skin, and viscera) were homogenized separately in a blender and analyzed for percentage moisture, protein, fat, and ash. Protein was analyzed using the macro-Kjeldahl method; fat was analyzed by ether extraction; moisture was determined by drying a 6-g sample in a convection oven until a constant weight was reached; and ash was determined by placing a 3-g sample in a muffle furnace at 600°C for 2 hours (Association of Official Analytical Chemists 1990).

Food conversion ratio (FCR) and specific growth rate (SGR) were calculated as follows: FCR = total diet fed (kg)/total wet weight gain (kg); SGR (%/day) = $(\ln W_t - \ln W_i/T) \times 100$, where $W_t$ is the weight of fish at time t, $W_i$ is the weight of fish at time 0, and T is the culture period in days.

### *Statistical Analysis*

Data were analyzed using the SAS General Linear Models procedure (Statistical Analysis Systems 1988) as a 2×2 factorial for significance between two protein levels, between two feeding frequencies, and among their interaction (Zar 1984). All percentage and ratio data were transformed to arc sin values prior to analysis (Zar 1984).

## *RESULTS AND DISCUSSION*

### *Water Quality*

Throughout the duration of the study, water quality parameters were not significantly different ($P > 0.05$) among treatments and were (±SE): morning water temperature, 24.3±0.3°C; afternoon water temperature, 25.6±0.3°C; morning dissolved oxygen, 6.8±0.5 mg/l; afternoon dissolved oxygen, 10.5 ± 1.0 mg/l; TAN, 0.2±0.1 mg/l; nitrite, 0.1±0.1 mg/l; pH, 8.8 ± 0.2.

### *Fish Growth*

There were no significant differences ($P > 0.05$) in individual fish length, individual fish weight, survival, food conversion ratio (FCR), specific growth rate (SGR), or net production (kg/ha) for channel catfish fed either a 32 or a 38% protein diet either once or twice daily (Table 1). Body weights reported in this study are in agreement with those found by Tidwell and Robinette (1990) for third-year channel catfish. Percentage survival was high (>90%) and was not significantly different ($P > 0.05$) among treatments.

Food conversion averaged 1.95 for the study. This is in agreement with that found by Busch (1986), who reported food conversion values of 2.2 for adult channel catfish. Contrary to reports by Dupree (1984) and Busch (1986), channel catfish fed actively on the floating diet in the present study and did not appear reluctant to feed at or near the water surface. The decrease in percentage growth rate and food conversion in third-year channel catfish, compared to those of second-year fish (Webster et al. 1991), are in agreement with values reported by Lovell (1989).

Protein is the most expensive dietary component in catfish diets and is a primary concern in diet formulation, which means that feed

TABLE 1. Mean ± SE net production, individual weight, individual length, survival, food conversion ratio (FCR), specific growth rate (SGR), dressing percentage, dressed carcass weight, abdominal fat weight, and abdominal fat percentage for channel catfish fed diets containing either 32 or 38% protein, either once or twice daily. Means in the same row followed by different letters were significantly different ($P < 0.05$).

| | 32% Protein | | 38% Protein | |
|---|---|---|---|---|
| | Once/day | Twice/day | Once/day | Twice/day |
| Net production (kg/ha) | 2,979.6±260.3a | 2,946.7±322.2a | 3,392.1±377.9a | 3,183.0±183.7a |
| Individual weight (g) | 1,581.2±50.1a | 1,569.1±53.1a | 1,602.7±39.2a | 1,648.9±12.6a |
| Individual length (cm) | 50.9±0.3a | 51.2±0.6a | 51.1±0.3a | 51.9±0.2a |
| Survival(%) | 91.33±4.54a | 91.78±4.9a | 95.33±3.06a | 94.22±1.90a |
| FCR | 1.92±0.05a | 2.04±0.11a | 1.85±0.04a | 2.00±0.13a |
| SGR (%/day) | 0.71±0.02a | 0.68±0.27a | 0.72±0.04a | 0.70±0.04a |
| Dressing percentage | 53.3±2.8a | 52.5±1.7a | 52.4±2.8a | 54.7±0.1a |
| Dressed carcass (g) | 829.0±45.6a | 833.9±76.8a | 832.6±54.3a | 884.9±39.1a |
| Abdominal fat (g) | 42.0±6.1a | 33.9±5.1a | 41.5±6.5a | 36.6±5.8a |
| Abdominal fat (%) | 2.6±0.4a | 2.2±0.4a | 2.6±0.4a | 2.2±0.2a |

producers desire to provide the minimum level of dietary protein that will supply essential amino acids for acceptable weight gain in fish. These results indicate that of the two protein levels evaluated (32 or 38%), the lower percentage protein diet should be used. Increasing the protein level neither improved weight gain nor reduced percentage of fat in fish. A diet with a lower protein level, e.g., 26%, should be evaluated in future studies to determine the minimum level of protein that a diet can contain for third-year channel catfish without reducing growth or adversely affecting body composition (Brown and Robinson 1989).

Feeding frequency had no effect on growth or food conversion. These results are similar to those found by Lovell (1979) and Webster et al. (1991). This indicates that feeding adult channel catfish to satiation once daily is as effective as feeding twice daily. This result may be due to insufficient time between feedings for twice-fed fish to completely digest the first meal or perhaps to changes in food consumption during the growing season. Rate of stomach evacuation decreases with decreasing water temperatures (Lovell 1979), which results in less food being consumed at cooler temperatures, due to the presence of diet in the gut. In the present study, ponds had water temperatures higher than 26°C for only two of five months. Lovell (1979) reported that when water temperatures declined below 26°C, fish fed twice daily consumed less diet than fish fed once daily. Webster et al. (1991) observed the same response.

### *Body Composition*

No significant differences ($P > 0.05$) in dressing percentage, dressed carcass weight, abdominal fat weight, and percentage abdominal fat were found among treatment groups (Table 1). Average dressing percentage was 53.3%, and average percentage abdominal fat was 2.4%. This latter value is in agreement with that found by Tidwell and Robinette (1990) who reported that third-year channel catfish had approximately 2.0% abdominal fat as a percentage of whole body weight. Composition (dry-weight basis) of dressed carcass did not differ significantly ($P > 0.05$) among treatment groups (Table 2), averaging 70.9, 55.5, 38.1, and 6.7%, respectively, for moisture, protein, fat, and ash. Composition (dry weight basis) of

TABLE 2. Mean ± SE percentage moisture, protein, fat, and ash (on a dry–weight basis) of carcass and waste (head, skin, and viscera) for channel catfish fed diets containing either 32 or 38% protein once or twice daily. Means in the same row followed by a different letter are significantly different ($P < 0.05$).

| | 32% Protein | | 38% Protein | |
|---|---|---|---|---|
| | Once/day | Twice/day | Once/day | Twice/day |
| **Carcass** | | | | |
| Moisture | 72.54±1.76a | 70.54±2.12a | 70.04±0.60a | 70.64±0.76a |
| Protein | 57.46±2.93a | 56.83±4.79a | 53.81±3.31a | 53.68±0.39a |
| Fat | 36.63±1.10a | 38.57±4.92a | 38.15±4.84a | 39.01±2.33a |
| Ash | 5.15±1.10a | 5.00±1.04a | 8.50±3.30a | 7.85±3.13a |
| **Waste** | | | | |
| Moisture | 66.03±0.58a | 66.19±1.56a | 64.54±0.75a | 64.52±0.50a |
| Protein | 42.42±3.25a | 39.94±2.08a | 42.00±1.37a | 37.96±1.12a |
| Fat | 41.91±1.49a | 45.32±2.84a | 40.76±4.42a | 43.77±2.66a |
| Ash | 10.72±1.69a | 12.48±0.81a | 12.00±2.95a | 14.63±1.67a |

waste (head, skin, and viscera) did not differ significantly ($P > 0.05$) among treatment groups. Percentage moisture, protein, fat, and ash averaged 65.5, 40.5, 43.2, and 12.5%, respectively.

This study suggests that growth and body composition of third-year channel catfish were not affected by percent protein or feeding frequency that were examined. No differences in abdominal fat and carcass fat levels were found among treatment groups. Percentage protein in carcass and waste and percentage fat in waste are in agreement with those reported in other studies (Conrad et al. 1988; Reis et al. 1989; Webster et al. 1991). However, percentage of fat in dressed carcasses was higher in the present study than in those studies on market-size (450 g) channel catfish (Lovell 1983; Reis et al. 1989; Tidwell and Robinette 1990). Ash values for carcasses are higher in this study (5.0-8.5%) than the reported range of 3.3-6.6% (Conrad et al. 1988); however, this is probably because the fish frame (skeleton) was included in analysis in the present study, and ash values in other studies generally pertain to smaller, second-year fish.

The level of digestible energy in a diet affects the amount of food consumed by fish and the energy:protein ratio of the diet will influence conversion efficiency of the diet (Reis et al. 1989). A high ratio may increase fat deposition while a low ratio will cause protein to be used as an energy source. The high percentage of fat in the dressed carcass indicates that the energy:protein ratios of the diets used in this study may have been too high for third-year channel catfish.

Fattiness is undesirable in a fish fillet. Consumers consider fish to be a low-fat food, and excessive fat can reduce marketability. Excess fat in the fillet is also more susceptible to oxidative rancidity, which reduces storage time. Results from the present study indicate that a diet with a reduced energy:protein ratio (<8.0 kcal/g of protein) should be fed to third-year channel catfish if fish are to be marketed. However, a fattier fish may be desirable if the fish is for the pay-lake market. Fat deposits serve as energy reserves during winter months and periods of reduced food supply. Growth and body composition of third-year channel catfish fed diets with lower protein levels (26-30%) or lower energy:protein ratios should be evaluated in future studies.

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