Effects of Protein and Fish Meal Levels on Second-Year Growth of Blue Catfish, *Ictalurus furcatus*, and Associated Water Quality Variables

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ABSTRACT. Blue catfish, *Ictalurus furcatus*, juveniles (54 g) were stocked into 0.04-ha ponds at a density of 9,880/ha and fed one of four diets containing 32% or 38% protein and 4% or 8% fish meal. After 168 days, there were no significant differences ($P > 0.05$) in body weights, survival, weight gains, or other production variables. There was a significant difference ($P \leq 0.05$) in feed conversion ratios (FCR), with the FCR for fish fed the 38% protein diet with 8% fish meal being higher than for fish fed other diets. During July and August, total ammonia-nitrogen and nitrite-nitrogen concentrations were also significantly higher ($P \leq 0.05$) in ponds in which fish were fed the 38% protein diet with 8% fish meal. These data indicate that increased protein and/or fish meal does not increase weight gain in blue catfish and that blue catfish can be fed a diet with 32% protein and 4% fish meal when stocked at density < 10,000/ha. *[Article copies available from The Haworth Document Delivery Service: 1-800-342-9678.]*

INTRODUCTION

Several attributes have increased interest in the blue catfish, *Ictalurus furcatus*, as an alternative to channel catfish, *I. punctatus*, for production

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in temperate regions of the U.S. Optimum growing temperatures for blue catfish are reported to be approximately 24°C, compared to 30°C for channel catfish (Collins 1988). Such moderate temperature requirements could possibly extend the growing season of blue catfish in cooler regions of the country (Huner 1988). Also, blue catfish have a higher dress-out percentage and are easier to seine than channel catfish (Chappel 1979). Areas with little processing capacity and large pay lake markets (such as Kentucky) might find the blue catfish more marketable through these outlets. Tave et al. (1981) reported higher catch rates for blue catfish compared to channel catfish under standardized conditions, though differences were not statistically significant.

Growth comparisons between blue and channel catfishes have produced conflicting results. Huner and Dupree (1984) reported that, at sizes less than 0.5 kg, blue catfish may be inferior to channel catfish as a cultured species, due to slower growth and less efficient food conversion. Several producers, however, have reported that blue catfish grow faster than channel catfish during the first year (Collins 1988). Chappel (1979) indicated that growth of the two species is similar the first two years, with channel catfish performing slightly better. Grant and Robinette (1992) found that second-summer growth of blue catfish was slightly greater than channel catfish in Mississippi but that differences were not statistically significant. These previous studies were conducted in the deep-south states. Tidwell and Mims (1990) reported more rapid weight gain by blue catfish during second-year growth under temperate conditions in Kentucky.

In all previous studies, blue and channel catfish comparison studies have utilized feed formulations developed specifically for channel catfish. The blue catfish is, under natural conditions, considered to be more piscivorous than the channel catfish (Jones 1972), which may indicate slightly different nutritional requirements. Blue catfish may need a higher protein feed than channel catfish (Collins 1988). This could negatively bias previous species comparison studies, due to the possible use of sub-optimal diets for this species. A recent study found that blue catfish performed best when fish meal was incorporated at 13% of the total formulation (Webster et al. 1992a). Most commercial channel catfish diets currently contain 4-8% fish meal (Ed Robinson, pers. comm.). Since protein is the most expensive component, and fish meal one of the most expensive ingredients (Webster et al. 1992b), it is important to provide enough protein to support rapid growth without the expense of providing excess. Also, protein in the feed is the most important source of toxic nitrogenous waste products (i.e., ammonia and nitrite) (Robinette 1983). The accumulation of these com-

pounds is a primary constraint on production intensification and increases the importance of determining minimum protein levels required for optimum growth. The objective of this study was to evaluate the effects of dietary protein and fish meal levels on second-year growth of blue catfish and their possible impacts on water quality.

MATERIALS AND METHODS

Fish were fed one of four diets which were mixed and extruded into floating pellets by a commercial feed mill (Delta Western, Indianola, Mississippi[1]) to contain either 32% or 38% protein and either 4% or 8% fish meal (Table 1). Diets were based on a model commercial formulation for channel catfish (Ed Robinson, pers. comm.). Blue catfish fingerlings (D&B strain; average weight: 53.9 g) were stocked on 26 April 1993 into twelve 0.04-ha earthen ponds at the Aquaculture Research Center, Kentucky State University, at a density of 9,880 fish/ha. Ponds were approximately 1.5 m deep and were supplied with water from a reservoir which was filled by rain runoff. Water levels in ponds were maintained at a constant depth by periodic additions.

Fish were fed daily (at 1400 h) all the diet they could consume in 40 minutes for 168 days. Each treatment (diet) was replicated in three ponds. Diets were placed inside a 3.0-m diameter floating feeding ring in each pond. Rings were made from 1-cm diameter plastic pipe and had a 0.58-cm plastic mesh skirt extending 20 cm below the water surface.

Dissolved oxygen (DO) and temperature of all ponds were monitored twice daily (0800 and 1430 h) with a YSI Model 57 oxygen meter (Yellow Springs Instruments, Yellow Springs, Ohio). When the DO level of any pond was predicted (graphically) to decline to below 4.0 mg/L, emergency aeration was provided. Total ammonia nitrogen (TAN) and nitrite were measured twice weekly (at 1300 h) with a Hach DREL/5 spectrophotometer, and pH was measured twice weekly (at 1300 h) with an electronic pH meter (Accumet 900, Fisher Scientific). Morning DO, afternoon temperature, and afternoon pH averaged ($\pm$ SE) 6.9 ± 0.7 mg/L, 25.1 ± 4.7°C, and 8.5 ± 0.3, respectively, over the duration of the study.

Blue catfish in all ponds were sampled monthly. Samples of $\geq$ 40 fish per pond were captured by seine, group weighed, and individually counted back into the pond. Fish were harvested by seine on 11 October 1993. Fish were not fed 24 hours prior to harvest. Total number and weight of fish in

1. Use of trade or manufacturer's name does not imply endorsement.

TABLE 1. Formulations of experimental diets containing different percentages of protein and fish meal fed to blue catfish in ponds.

	Diet (% protein × % fish meal)			
Ingredients	32 × 4	32 × 8	38 × 4	38 × 8
Soybean meal (44% protein)	35.00	29.00	53.50	48.60
Ground corn	22.38	24.38	21.88	21.88
Wheat flour	20.00	20.00	20.00	3.00
Cottonseed meal	12.00	12.00	12.00	12.00
Meat and bone meal (54.1% protein)	4.00	4.00	4.00	4.00
Menhaden fish meal (67% protein)	4.00	8.00	4.00	8.00
Catfish oil	1.50	1.50	1.50	1.50
Dicalcium phosphate	1.00	1.00	1.00	1.00
Vitamin mix[1]	0.10	0.10	0.10	0.10
Mineral mix[2]	0.03	0.03	0.03	0.03

[1]Vitamin mix contains (per kg of diet): biotin, 0.20 mg/kg; choline, 1792.6 mg/kg; folic acid, 2.68 mg/kg; niacin, 113.15 mg/kg; pantothenic acid, 45.47 mg/kg; B_6, 16.65 mg/kg; riboflavin, 16.48 mg/kg; thiamin, 13.92 mg/kg; B_{12}, 20.76 mg/kg; E, 76.77 mg/kg; K, 4.48 mg/kg; A, 4401.34 IU/kg; D, 2200.00 IU/kg; ascorbic acid, 580 mg/kg.
[2]Mineral mix contains (per kg of diet): potassium, 1.20%; choride, 0.08%; magnesium, 0.20%; sodium, 0.06%; sulfur, 0.31%; copper 19.38 mg/kg; iron, 380.08 mg/kg; manganese, 126.83 mg/kg; selenium, 0.36 mg/kg; zinc, 245.27 mg/kg, iodine, 0.0002%.

each pond were determined 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 centimeter. Feed conversion ratio (FCR) was calculated as total diet fed (kg) divided by total wet weight gained (kg).

Data were analyzed using the SAS General Linear Models procedure (Statistical Analysis Systems 1988) for significant differences among the four treatments (Zar 1984). All percentage and ratio data were transformed to arcsin values prior to analysis (Zar 1984).

RESULTS AND DISCUSSION

There were no significant differences ($P > 0.05$) in average harvest weight, individual weight gain (%), total harvest weight, or survival among blue catfish fed the four diets (Table 2). These variables averaged 334.1 g, 530.3%, 3,249.3 kg/ha, and 98.2%, respectively and are in agreement with Grant and Robinette (1992) and Tidwell and Mims (1990) for second-year growth of blue catfish. Data indicate that blue catfish can be successfully fed diets with levels of fish meal as low as 4%. This is in agreement with Webster et al. (in press) who found that in aquaria, fish meal could be totally replaced with soybean meal in blue catfish diets without adversely affecting growth, but different from Webster et al. (1992a), who reported that blue catfish fed a diet containing 13% fish meal were significantly larger than fish fed diets containing 9%, 4%, or 0% fish meal. Conflicting results between these studies may be due to differences in stocking sizes, practical ingredients, and other experimental conditions.

Although growth and survival were not affected by protein or fish meal level, there was a significant effect on feed conversion. Blue catfish fed a diet containing 38% protein with 8% fish meal had an FCR (1.80) that was significantly higher ($P \leq 0.05$) than the FCR for blue catfish fed other diets. There was no significant difference ($P > 0.05$) in FCR of blue catfish fed the 32% × 4% feed (1.60), 32% × 8% feed (1.62), or 38% × 4% feed (1.67).

Water quality data largely reflect differences in FCR of fish fed the different diets. During July and August (periods of high feeding rates), ponds in which blue catfish were fed the 38% protein diet with 8% fish meal had significantly higher ($P < 0.05$) total ammonia (Figure 1) and nitrite (Figure 2) levels than ponds in which fish were fed the other diets.

In summary, results indicate that commercial channel catfish diets, as currently formulated, contain adequate levels of protein and fish meal for production of blue catfish at densities ≤ 9,880/ha. This indicates that previous comparisons of blue catfish with channel catfish were not compromised by feeding diets that had been formulated for channel catfish.

TABLE 2. Final individual fish weight, total harvest weight, individual weight gain, survival, and feed conversion ratio (FRC) for blue catfish fed diets containing either 32% or 38% protein and 4% or 8% fish meal at each of the protein levels. Values are means ± SE of three replicates. Means in the same row with different letters are significantly different ($P < 0.05$).

	32% Protein		38% Protein	
	4% Fish meal	8% Fish meal	4% Fish meal	8% Fish meal
Final individual weight	336.4 ± 36.7	331.1 ± 25.4	347.7 ± 12.3	321.0 ± 40.3
Total harvest weight (kg/ha)	3316.1 ± 385.3	3195.9 ± 315.0	3308.8 ± 116.5	3176.3 ± 364.8
Individual weight gain (%)	544.5 ± 40.6	530.1 ± 40.4	519.3 ± 18.3	527.1 ± 36.0
Survival (%)	99.0 ± 1.12	97.8 ± 2.5	96.4 ± 1.8	99.5 ± 0.87
FCR	1.59 ± 0.11b	1.62 ± 0.11b	1.67 ± 0.05b	1.80 ± 0.05a

FIGURE 1. Monthly means of total ammonia-nitrogen (mg/L) in ponds stocked with blue catfish at 9,880/ha and fed diets containing 32% or 38% protein and 4% or 8% fish meal. Each point represents three replicate ponds and four weekly samples per pond. An asterisk indicates a significant difference among treatments ($P < 0.05$).

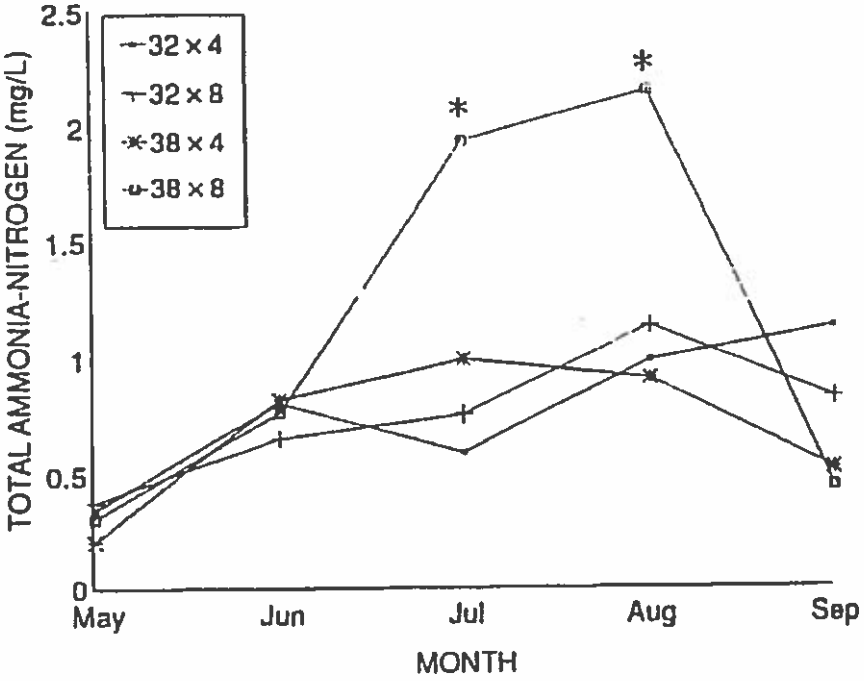
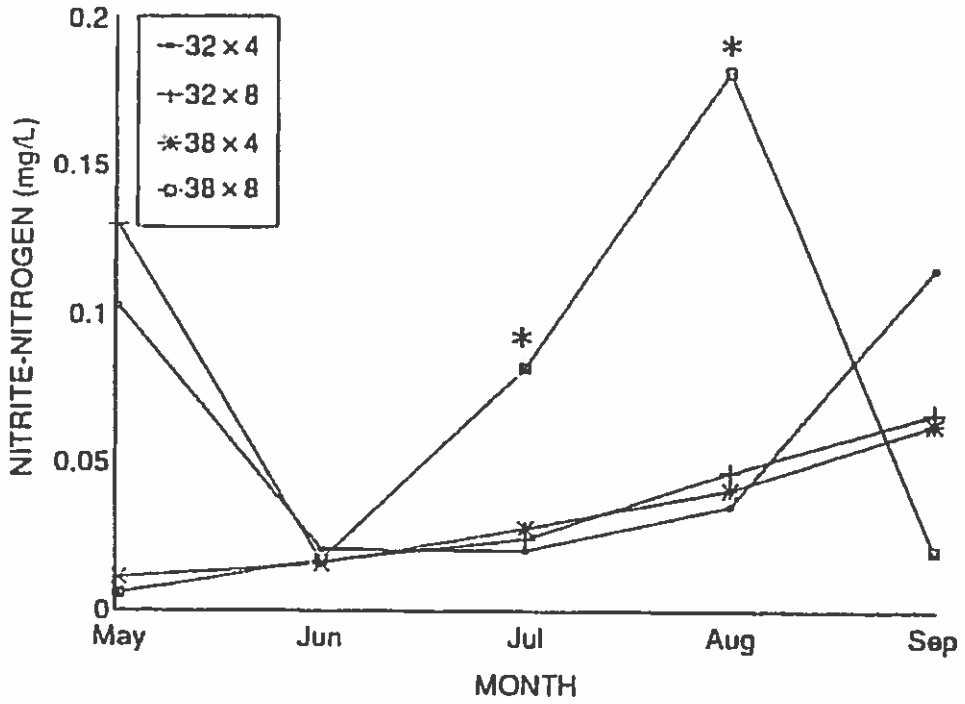


FIGURE 2. Monthly means of nitrite-nitrogen (mg/L) in ponds stocked with blue catfish at 9,880/ha and fed diets containing 32% or 38% protein and 4% or 8% fish meal. Each point represents three replicate ponds and four weekly samples per pond. An asterisk indicates a significant difference among treatments ($P < 0.05$).



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