Effects of Stocking Density on Growth of Juvenile Channel Catfish Overwintered in Ponds

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ABSTRACT. Channel catfish, *Ictalurus punctatus*, juveniles (mean weight 78.0 ± 3.5 g) were stocked into nine 0.04-ha earthen ponds at three rates (4,940 fish/ha, 12,350 fish/ha, and 24,700 fish/ha) and fed a prepared diet (32% protein) according to a fish size/water temperature-dependant feeding chart for 160 days during the winter. Morning water temperatures averaged 5.8°C during the study. No significant differences ($P > 0.05$) were found in individual fish length, survival, and percentage weight gain among treatments and averaged 19.4 cm, 96.2%, and −13.0%, respectively. No significant differences ($P > 0.05$) in whole-body composition were found among treatments. Percentage moisture, protein, and fat averaged 12.4, 50.8, and 28.4%, respectively. Stocking juvenile channel catfish at the lower rate, 4,940 fish/ha, did not significantly increase winter growth compared to growth of fish stocked at higher rates (12,350 and 24,700 fish/ha).

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INTRODUCTION

Since the metabolism of fish is directly correlated with water temperature, fish do not feed as actively in cool/cold weather months compared to summer months. Thus, fish culturists often limit feeding of channel catfish, *Ictalurus punctatus*, during the winter. Research on winter feeding practices for channel catfish has been limited and has mostly been conducted in southern states (e.g., Alabama and Mississippi). Lovell and Sirikul (1974) reported that market-size channel catfish (> 450 g) overwintered in ponds lost 9% of their body weight if not fed. Reagan and Robinette (1978) stated that increased feeding frequency increased weight gain in juvenile channel catfish when water temperature averaged 12.8°C, but did not increase weight gain when water temperature averaged 7.7°C, during the winter. This is in agreement with Mims and Tidwell (1989). Tidwell and Mims (1991) reported that there were no differences in weight gain between large channel catfish (> 500 g) not fed below 10°C and fish fed 3 times per week when water temperature was below 10°C.

More northernly states (e.g., Kentucky, Indiana, and Illinois) have a shorter summer growing season than more southernly states, thus requiring stocking of larger (40-80 g) fingerlings in the spring for fish to be able to reach market-size (Mims and Tidwell 1989). This requires overwintering fingerlings in ponds. Stocking density may affect weight gain of channel catfish overwintered in ponds. Natural food organisms present in ponds may supplement the feeding of prepared diets during the winter, thereby allowing for greater growth in fish stocked at lower rates. Tidwell and Mims (1991) found that large catfish (540 g) stocked at 4,940 fish/ha had significantly higher individual weight gains (33 g) than fish stocked at 7,410 fish/ha (0.5 g).

Little research has been reported on the effect of stocking rate on growth of juvenile channel catfish overwintered in ponds. The objective of the present study was to determine if growth in juvenile channel catfish could be increased by stocking lower numbers of fish (4,940 and 12,350 fish/ha) compared to fish stocked at a higher rate (24,700 fish/ha).

MATERIALS AND METHODS

Culture Conditions

Juvenile channel catfish (average weight 78.0 ± 3.5 g) were stocked on 21 October 1991 into nine 0.04-ha earthen ponds at the Aquaculture Research Center, Kentucky State University, Frankfort, Kentucky. 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 from the reservoir. Fish were stocked at one of three rates: Low (4,940 fish/ha), Medium (12,350 fish/ha), or High (24,700 fish/ha). There were three replications per treatment (density). Fish were fed according to a feeding chart (Dupree and Huner 1984) for 160 days. Every two weeks, feeding rates were adjusted based upon an assumed 3:1 feed conversion ratio (Robinette et al. 1982). Fish were fed a total of 40 days with an average of 3.7, 9.4, and 16.4 kg of diet/pond offered to fish stocked at 4,940, 12,350, and 24,700 fish/ha, respectively.

Dissolved oxygen (DO) and water temperature in all ponds were measured twice daily (0800 and 1430) using a YSI Model 57 oxygen meter. When the DO level of any pond was predicted (graphically) to decline to below 6.0 mg/L, aeration was provided by an electric aerator. Total ammonia nitrogen (TAN) and nitrite were measured weekly in each pond at 1300 using a Hach DREL/5 spectrophotometer, and pH was measured weekly at 1300 using an electronic pH meter (Accumet 900, Fisher Scientific, Cincinnati, Ohio).

Diets

Fish were fed a pelleted (sinking) diet, using ingredients found in commercial catfish diets. Diet was made by a commercial feed mill (Farmers Feed Mill, Lexington, Kentucky) and had a pellet size of 6.0 mm (Table 1). Diet was evenly distributed over the deepest area of each pond. Diets were analyzed for crude protein, fat, and moisture. Crude protein was determined using a LECO FP-228 nitrogen determinator (Sweeney and Rexroad 1987); crude fat was determined by ether extraction and moisture was determined by placing 2 g of the diet in a drying oven (95°C) until a constant weight was

obtained (Association of Official Analytical Chemists 1990). Diets were stored (10°C) in plastic-lined bags until fish were fed.

Harvest Data

Fish were not fed 24 hours prior to harvest and were harvested by seine on 30 March 1992. Total number and weight of fish in each pond were recorded at harvest. Percentage weight gain was calculated from the total pond weight. Fifty fish were randomly sampled from each pond and were individually weighed to the nearest gram and measured (total length) to the nearest 0.5 centimeter for individual weights and lengths. Five fish from each pond were randomly sampled for analysis of whole body composition. Whole fish were homogenized in a blender and analyzed for moisture, protein, and fat. Protein was analyzed using a LECO FP-228 nitrogen determinator; fat was analyzed by ether extraction; and moisture was determined by drying in a convection oven (95°C) until a constant weight was reached.

Statistical Analysis

Data were analyzed using the SAS ANOVA procedure (Statistical Analysis Systems 1988). Duncan's multiple range test was used to determine differences among means (Zar 1984). Percentage data was transformed to arc sin values prior to analysis.

RESULTS AND DISCUSSION

Water quality parameters are presented in Table 2. All measured water quality values were within accepted limits for culture of channel catfish (Boyd 1979).

Individual fish weight was significantly higher ($P < 0.05$) for fish stocked at 12,350 fish/ha (medium stocking rate) compared to fish stocked at the higher stocking rate (24,700 fish/ha) (Table 3). This may be due to the higher initial stocking weight of fish used in the medium stocking rate compared to fish stocked at the high stocking rate (Table 3). No explanation for this difference can be offered since all fish were randomly stocked into the ponds. However, no

TABLE 1. Composition of diet fed to juvenile channel catfish, stocked in ponds at three different rates, during the winter.

Ingredient	% of diet
Menhaden fish meal	8.00
Soybean meal (44%)	48.50
Corn grain	40.35
Dicalcium phosphate	1.40
Vitamin mix[1]	0.10
Mineral mix[2]	0.10
Cod liver oil	1.50
Ascorbic acid	0.05
Proximate Analysis (dry-matter basis)	
% Moisture	8.69
% Protein	31.34
% Fat	4.65

[1]Vitamin mix provided the following (IU or mg/kg of diet): biotin, 0.20 mg; choline, 1792.6 mg; folic acid, 2.68 mg; niacin, 113.15 mg; pantothenic acid, 45.47 mg; B_6, 16.65 mg; riboflavin, 16.48 mg; thiamin, 13.92 mg; B_{12}, 20.76 mg; E, 76.77 mg; K, 4.48 mg; A, 4401.34 IU; D, 2200 IU.
[2]Mineral mix provided the following (% or mg/kg of diet): potassium, 1.20%; chloride, 0.08%; magnesium, 0.20%; sodium, 0.06%; sulfur, 0.31%; copper, 19.38%; iron, 380 mg; manganese, 127 mg; selenium, 0.36 mg; zinc, 245.3 mg; iodine, 0.0002%.

significant difference ($P > 0.05$) in individual fish weight between low and high stocking rates was found. No significant differences ($P > 0.05$) were found in individual fish length, survival and percentage weight gain among treatments and averaged 19.4 cm, 96.2%, and −13.0%, respectively. Pond yield was 343, 818, and 1450 kg/ha for fish stocked at the low, medium, and high stocking rates, respectively. Pond yield for fish stocked at the high rate (24,700 fish/ha) was consistent with winter production values for the region (Mims and Tidwell 1989). Percentage moisture, protein, and fat were not significantly different ($P > 0.05$) among treatments and averaged 72.4, 50.8, and 28.4%, respectively (Table 3).

TABLE 2. Winter water quality parameters of ponds where juvenile channel catfish were stocked at three different rates during the winter. Values are means ± SE of three replicate ponds. Means with different letters are significantly different ($P < 0.05$). TAN = total ammonia nitrogen.

Parameter	Stocking Rate (fish/ha)		
	Low (4,940)	Medium (12,350)	High (24,700)
DO (am, mg/L)	13.6 ± 0.1a	11.6 ± 0.4b	12.3 ± 0.2b
DO (pm, mg/L)	14.6 ± 0.1a	12.5 ± 0.5b	13.2 ± 0.2b
Water temp. (am. °C)	5.0 ± 1.1a	6.2 ± 0.1a	6.1 ± 0.1a
Water temp. (pm. °C)	6.9 ± 0.0a	7.0 ± 0.1a	6.9 ± 0.1a
pH	8.50 ± 0.05a	8.18 ± 0.06b	8.24 ± 0.02b
Nitrite(mg/L)	0.001 ± 0.001b	0.009 ± 0.003a	0.004 ± 0.002ab
TAN (mg/L)	0.30 ± 0.07a	0.64 ± 0.31a	0.40 ± 0.13a

One possible reason for the loss in body weight reported in our study was the low water temperatures during the study period. Andrews and Stickney (1972) reported that as water temperature decreases, so too does growth and food conversion. It has been suggested that juvenile channel catfish should not be fed when water temperatures were below 7-8°C, since fish do not appear to consume much diet at these temperatures (Lovell and Sirikul 1974; Felts 1977; Reagan and Robinette 1978; Tackett et al. 1987). This is in agreement with Mim and Tidwell (1989) who reported no difference in growth of juvenile channel catfish that received feed throughout the winter and fish not fed when the water temperature was below 7°C. Robinette et al. (1982) reported weight gains of 14-38% when channel catfish were fed during the winter; however, water temperatures were higher (9-12°C) than reported in our study.

These results suggest that natural foods may not be an important

TABLE 3. Initial individual fish weight, final individual fish weight, individual fish length, percentage survival, percentage weight gain, pond yield, and whole body composition (percentage moisture, protein, and fat) of juvenile channel catfish overwintered in ponds at three different stocking rates. Means with the same letters are not significantly different ($P > 0.05$).

	Stocking Rate (fish/ha)		
	Low (4,940)	Medium (12,350)	High 24,700)
Init. indiv. weight (g)	80.9 ± 4.0a	81.1 ± 2.2a	71.0 ± 1.3b
Final indiv. weight (g)	67.56 ± 1.52ab	72.32 ± 1.57a	63.00 ± 1.63b
Individual length (cm)	19.76 ± 0.15a	19.63 ± 0.15A	18.85 ± 0.16a
Survival (%)	98.50 ± 0.87a	94.73 ± 1.37a	95.43 ± 1.86a
Weight gain (%)	−12.17 ± 6.39a	−13.71 ± 1.99a	−13.25 ± 0.94a
Pond yield (kg/ha)	342.7 ± 5.9c	818.0 ± 20.8b	1450.3 ± 17.8a
Chemical analyses (dry-matter basis)			
Moisture (%)	71.43 ± 0.58a	72.55 ± 0.85a	73.19 ± 0.32a
Protein (%)	49.33 ± 1.50a	51.18 ± 3.97a	51.19 ± 2.03a
Fat (%)	29.08 ± 2.92a	22.56 ± 3.18a	25.51 ± 3.30a

source of supplemental diet during winter months for juvenile channel catfish at the water temperatures reported during this study. This is in contrast to Tidwell and Webster (1993) who reported that hybrid bluegill (*Lepomis cyanellus* × *L. macrochirus*) stocked at 12,350 fish/ha had higher growth rates than fish stocked at 24,700 fish/ha. Tidwell and Mims (1991) reported that decreasing stocking rates (from 7,410 to 4,940 fish/ha) increased weight gain during the winter in larger (540 g) channel catfish. Decreasing stocking rates of juvenile channel catfish, from 24,700 to 12,350 and 4,940 fish/ha, in the fall does not increase winter weight gains when water temperatures do not average higher than 7°C.

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