Effects of Density and Feeding Regimen on the Overwintering of Channel Catfish

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ABSTRACT. Two feed regimens were evaluated at two densities of market-sized (> 0.5 kg) channel catfish, *Ictalurus punctatus*, in a factorial experiment. Reducing density from 7,410 to 4,940/ha produced significant ($P < 0.05$) increases in weight gain, while low temperature feeding (below 10°C) did not. There were no significant ($P > 0.05$) interactions between density and feeding regimen in fish production variables. Fish overwintered at low density without low-temperature feeding gained more weight than fish overwintered at high density and fed during the winter.

INTRODUCTION

Market-size channel catfish, *Ictalurus punctatus*, must frequently be overwintered due to market constraints, off flavor problems, to address seasonal markets, or to produce large fish for speciality markets such as pay lakes. Pay lakes have historically served as significant outlets for fish producers in regions where aquacultural development is in its early stages (Ivers 1981). Channel catfish is the most common species stocked in Kentucky pay lakes and large catfish (0.9-1.8 kg) are preferred (Cremer et al. 1984). Peak fish needs for the pay lake industry are in the spring, making marketing

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potential especially good for producers overwintering large fish (Cremer et al. 1984). Demand for processed catfish is also often highest during the late winter and early spring months (Dixon et al. 1982), and producers in some regions receive higher prices in April and May (Ivers 1981). However, relatively few studies have examined methods for overwintering market-size catfish.

Lovell and Sirikul (1974) found that market-size catfish (> 0.45 kg) overwintered in ponds lost 9% body weight if not fed, but gained 18% if fed at 1% of body weight when the water temperature was above 12°C. However, overwintering temperatures have been reported to significantly affect the benefit provided by feeding (or not feeding) the fish during the winter (Lovell 1988). Reagan and Robinette (1978) found that increased feeding frequency increased weight gain in catfish fingerlings during a mild winter in Mississippi (12.8°C average temperature) but had no effect during a severe winter (7.7°C average temperature). Mims and Tidwell (1989) found that when fingerling catfish were not fed at temperatures below 7.2°C, the feed conversion ratio was significantly improved (from 7.4 to 3.4) without significant decreases in survival, mean harvest weight, or total yield. Because of the variation imposed by temperature differences, optimum winter feeding schedules could vary at different latitudes. In addition, the effects of catfish density and its interaction with winter feeding have not been reported. Third-year grow-out is conducted at lower densities than second-year grow-out (Busch 1986) and thinning before or after overwintering could affect allocation of pond space, fish growth, and feed requirements.

The objective of this study was to evaluate the effects of density, feeding regimen, and interactions between density and feeding regimen on overwintering market-size channel catfish.

MATERIALS AND METHODS

Adult catfish were stocked 12 October 1987; average weight was 544 g. Winter feeding schedule was based on that described by Dupree and Huner (1984), except when water temperatures fell below 10°C. Feeding schedules at temperatures below 10°C varied according to treatment. A 2 × 2 factorial design (4 treatments) with three replications each, was chosen: (1) catfish stocked at 4,940/ha and not fed below 10°C (temperature restricted feeding); (2) catfish stocked at 4,940/ha and fed 0.5% of standing crop weight three days per week below 10°C (temperature unrestricted feeding); (3) catfish stocked at 7,410/ha and not fed below 10°C; and (4) catfish stocked at 7,410/ha and fed 0.5% of body weight three days per week below 10°C. Fish were fed a 30% crude protein sinking commercial catfish feed (Purina,[1] Richmond, IN).

Twelve 0.04-ha ponds used in this study were approximately 1.5 m deep and were supplied with water from a reservoir filled by rain runoff. Water levels in ponds were maintained at a constant depth by periodic additions. Water temperature and dissolved oxygen (DO) were monitored daily, in mid-afternoon, at a depth of 0.5 m. Ponds were aerated if DO levels were predicted (by graph) to go below 5.0 mg/l during the night. Ammonia and pH were determined weekly and nitrite was determined twice weekly.

Total culture days were 180. Fish were harvested on 11 April 1988. Data were analyzed by factorial analysis of variance using the general linear models procedure of the statistical analysis system (SAS Institute, Inc. 1985). If significant interactions between main effects were indicated, sub-class means were separated by Fisher's protected least significant difference (LSD) at the 5% level (Steel and Torrie 1980).

RESULTS AND DISCUSSION

Water Quality

There were no significant interactions ($P > 0.05$) and no significant differences ($P > 0.05$) in means temperatures, pH's, and unionized ammonia levels between the main effects of density and feeding regimen (Table 1). These variables averaged 7.8°C, 7.9, and 0.015 mg/l, respectively, during the culture period. Density had a significant effect ($P < 0.01$) on mean DO and total ammonia concentrations. Feed regimen significantly ($P < 0.01$) affected total ammonia and nitrite levels. There was significant interaction

1. Use of trade name does not imply endorsement.

TABLE 1. Summary of water quality analyses[a] for ponds containing two densities of market-size channel catfish fed according to two feed regimens.

Treatment factors							
Density (fish/ha)	Feed Regimen Below 10°C	Temperature (°C)	D.O. (mg/l)	pH	Total Ammonia (mg/l)	Un-ionized Ammonia (mg/l)	Nitrite (mg/l)
4940	Restricted	7.9(0.1)	11.6(0.5)x	7.9(0.2)	0.41(0.11)x	0.017(0.018)	0.01(0.0)x
4940	Unrestricted	7.8(0.2)	11.9(0.3)x	8.0(0.3)	0.42(0.20)x	0.014(0.009)	0.02(0.0)x
7410	Restricted	7.6(0.2)	11.3(0.3)x	7.8(0.2)	0.47(0.11)x	0.013(0.012)	0.01(0.0)x
7410	Unrestricted	7.7(0.2)	10.9(0.1)y	7.9(0.2)	1.04(0.11)y	0.015(0.004)	0.03(0.0)y
Analysis of variance							
Density		NS[b]	0.0020[c]	NS	0.0004	NS	NS
Feed		NS	NS	NS	0.0008	NS	0.0001
Density X feed regimen		NS	0.0274	NS	0.0011	NS	0.0070

a Means of three replicate ponds (SE): means within a column followed by the same letter are not significantly different P = 0.05).

b NS = Not significant.

c Probability of significance.

tween density and feed regimen ($P < 0.01$) in mean DO, total ammonia, and nitrite concentrations. This indicated that these water quality variables reacted differently to feed input in ponds stocked at 4,940/ha than they did in ponds stocked at 7,400/ha.

Separation of sub-class means demonstrated no significant differences ($P > 0.05$) in these water quality variables between the low density-temperature restricted, low density-temperature unrestricted, and high density-temperature restricted feeding treatments. However, mean DO (10.9 mg/l) was significantly lower ($P < 0.05$), mean total ammonia (1.04 mg/l) was significantly higher ($P < 0.05$), and mean nitrite (0.03 mg/l) was significantly higher ($P < 0.05$) in the high density-temperature unrestricted feeding treatment. These levels should not have been detrimental to the fish, although some studies have shown un-ionized ammonia toxicity may be increased at reduced temperatures (Meade 1985).

Fish Production

There were no significant interactions ($P > 0.05$) in measured fish production variables between stocking density and feed regimen (Table 2). Therefore, the main effects of density and feed regimen may be analyzed separately (Steel and Torrie 1980).

There were no significant differences ($P > 0.05$) in average individual weight gain, average feed conversion ratio (FCR), or average survival between fish not fed below 10°C and those fed 3 times per week below 10°C (Table 3). Fish in the temperature restricted feeding regimen were fed significantly fewer days than fish in the temperature unrestricted regimen (27 d vs. 63 d; $P < 0.01$) and received significantly less feed (36.3 kg vs. 63.8 kg; $P < 0.01$). Lack of significant differences in FCR between treatments was at least partially due to large variation within treatments. As a ratio, FCR can become extremely large as the denominator (gain) approaches zero. Relatively small changes in feed amounts or gains can cause large differences in FCR under these circumstances.

Fish stocked at low density demonstrated significantly ($P < 0.05$) higher individual mean weight gain (33.0 g) than those fish stocked at high density (0.5 g) (Table 3). There was no significant difference in survival due to density ($P > 0.05$). Feed conversions

TABLE 2. Sub-class means[a] of performance variables for market-size channel catfish overwintered at two densities and fed according to two feed regimens.

Treatment factors				
Density (fish/ha)	Feed Regimen Below 10°C	Individual Gain (g)	Feed Conversion	Survival (%)
4940	Restricted	26.2 (20.6)	40.6 (58.7)	98.7 (1.0)
4940	Unrestricted	39.8 (7.6)	11.3 (6.9)	97.7 (1.5)
7410	Restricted	-2.0 (33.3)	c	98.0 (1.2)
7410	Unrestricted	2.9 (29.5)	c	99.5 (0.7)
Analysis of Variance				
Density x feed regimen		NS[b]	NS	NS

a Means of three replicate ponds (SE).

b NS = Not significant ($P > 0.05$)

c Could not be calculated due to weight losses in some replicates.

TABLE 3. Main effect means of performance variables for market-size channel catfish overwintered at two densities and fed according to two feeding regimens[a].

Main effect	Individual gain (g)	Survival (%)
Density (fish/ha)		
4,940	33.0 (15.8)x	98.2 (1.3)
7,410	0.5 (28.3)y	98.8 (1.2)
Feed regimen (Below 10°C)		
Restricted	12.1 (29.2)	98.3 (1.1)
Unrestricted	21.4 (28.0)	98.6 (1.5)
Analysis of variance		
Density	0.0393[b]	NS
Feeding regimen	NS[c]	NS
Density X feeding regimen	NS	NS

a Means of the six replicate ponds (SE), means within a column followed by the same letter are not significantly different ($P = 0.05$).

b Probability of significance.

c NS = Not significant.

could not be calculated, due to weight loss in two replicates of the high density/temperature restricted feeding treatment and one replicate of the high density/temperature unrestricted feeding treatment.

Previous studies have demonstrated the positive benefits of winter feeding. Results from this study indicate that overwintering density may influence weight gain more than low temperature feeding in large channel catfish. Low temperature (< 10°C) feeding produced a 9.3 g increase in body weight, while reduced density produced a 32.5 g increase. When overwintering density is reduced, low temperature feeding does not appear to be as important. Fish stocked at low density and not fed below 10°C gained more weight than fish overwintered at high density and provided with feed below 10°C. This not only produced larger (and presumably healthier) fish but represents substantial savings in labor (36 feeding days) and feed (111 kg/ha).

Since third-year grow-out of catfish requires density reduction from second-year growth (Busch 1986), producers desiring large fish may benefit from reducing densities before, rather than after, overwintering. Producers addressing spring markets, such as pay lakes, could increase gains, reduce feeding days and feed amounts, and produce healthier fish by reduction of overwintering density. If low temperature feeding is practiced its benefit may also be increased by density reduction.

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