The Effect of Feeding Regimen on Mixed-Size Pond-Grown Channel Catfish, *Ictalurus punctatus*

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ABSTRACT. The culture of channel catfish, *Ictalurus punctatus*, is an established industry in many areas of the southern United States. Improvements in feeding regimens would economically benefit producers. The present research was designed to evaluate the effect of feeding time (AM vs PM), feeding frequency (one vs two times a day) and intermittent fasting (6 days of feeding, 1 day of fasting) on production, feed conversion ratio (FCR), survival, weight-length relationship, percent dressout (headed and gutted carcass per unit live weight), and body composition of channel catfish reared in earthen ponds. Treatments consisted of: (1) feeding catfish once daily to satiation at 0800; (2) feeding catfish once daily to satiation at 1800; (3) feeding catfish twice daily at 0800 and 1800; and (4) feeding catfish once daily at 0800 for six consecutive days followed by one day of fasting. Twenty 0.04-ha ponds were stocked with 135 sub-market (average size: 182.6 g/fish) catfish and 600 fingerlings (average size: 18.2 g/fish) resulting in a total density of 18,375 fish/ha. Each treatment was assigned to five ponds at random.

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Fish in all treatments were offered a commercial floating catfish diet. A portion of the marketable catfish were harvested in mid- summer and the ponds completely harvested in the fall. Production parameters (e.g., biomass, weight gain, FCR, and survival), percent dressout, and weight-length relationship of catfish did not differ among the four treatments ($P > 0.05$). Percent dry matter and percent lipid of the fillet of fish fed once daily at 0800 seven days a week were significantly higher than those of fish in all other treatments ($P \leq 0.05$). The percent crude protein of the fillet of fish fed once daily at 1800 seven days a week was significantly higher than fish fasted one day a week ($P \leq 0.05$). These results indicate that as long as the fish are fed to apparent satiation there is no advantage to multiple feedings, to feeding at a specific time of day, or to intermittent fasting in earthen ponds.

KEYWORDS. Nutrition, catfish, feeding time

INTRODUCTION

Channel catfish, *Ictalurus punctatus*, production in 2001 in the United States was 271 million kilograms (Aquaculture Magazine 2002), accounting for a majority of all finfish production in the US. Since a major operating cost in catfish production is feed, proper feed management under production conditions is essential for the farmer to obtain maximum growth, feed efficiency, dressout, and economic gain. An inefficient feeding strategy is often implicated as a potential cause of poor growth, poor feed conversion, and a significant labor cost.

Given the potential economic benefits associated with improved feeding strategies, it is important to consider various regimens and how they may influence production. Earlier studies indicated that channel catfish fed twice daily had higher weight gain and consumed more feed than catfish fed once daily when grown as a single-size class (Collins 1971; Andrews and Page 1975; Greenland and Gill 1979). Noseke-Hallin (1985) reported that feeding time affected weight gain and fat deposition in channel catfish. Robinson et al. (1990) reported that channel catfish fed by demand feeder routinely feed during late afternoon near dusk or after sunset. More recent work (Robinson et al. 1995; Jarboe and Grant 1996) reported that feeding time and feeding frequency did

not significantly influence the weight gain, feed consumption, feed conversion ratio (FCR), and survival in single-size catfish production unit. Information on the influence of feeding time and frequency on catfish production under mixed-size class conditions in earthen ponds is scarce. The present research was designed to evaluate the effect of feeding time (AM, PM) and feeding frequency (one, two times per day), and intermittent fasting (6-day feeding) on growth, FCR, weight-length relationship, percent dressout, and fillet proximate composition in a mixed- size channel catfish population in earthen ponds.

MATERIALS AND METHODS

The present research was performed in 0.04-ha earthen ponds at the Auburn University Fisheries Research Unit, Auburn, Alabama. On April 17, 2001, twenty ponds were stocked with 135 sub-market (average size:182.6 g/fish) catfish and 600 fingerlings (average size:18.2 g/fish) resulting in a total density of 18,375 fish/ha each. Four feeding regimes were randomly assigned to the ponds at five ponds per treatment. Treatments were as follows: treatment 1, fish were fed once daily to satiation at 0800; treatment 2, fish were fed once daily to satiation at 1800; treatment 3, fish were fed twice daily at 0800 and 1800; and treatment 4, fish were fed once daily at 0800 for six consecutive days followed by one day of no feeding. The feed used in the present experiment was a commercial floating pellet containing no less than 32% protein and no less than 2.5% fat manufactured by Alabama Catfish Feedmill, Demopolis, Alabama. Water temperature and dissolved oxygen (DO) were measured daily after sunset and periodically in the early morning using a YSI-55 digital oxygen/temperature meter (YSI corporation, Yellow Springs, Ohio). Floating vertical pump aerators (1/4-hp) were used to maintain DO greater than 4 mg/L. Total ammonia-nitrogen was determined weekly for each pond. Temperature in ponds ranged from 20.5 C to 31.6 C, and ammonia level did not exceed 1.61 mg/L.

At the initiation of the experiment, feed was offered at 5% of biomass per day. Subsequently, satiation feeding was achieved in each pond by allowing the fish to eat until feeding activity stopped (about 30 minutes), after which the amount of remaining feed was estimated. If the amount of remaining feed was over 5% of feed offered, the ration was decreased by 100 to 200 g for the subsequent day. If the amount of remaining feed was less than 5% of feed offered, the ration was increased by 100 to 200 g for the subsequent day. The weight of feed offered daily

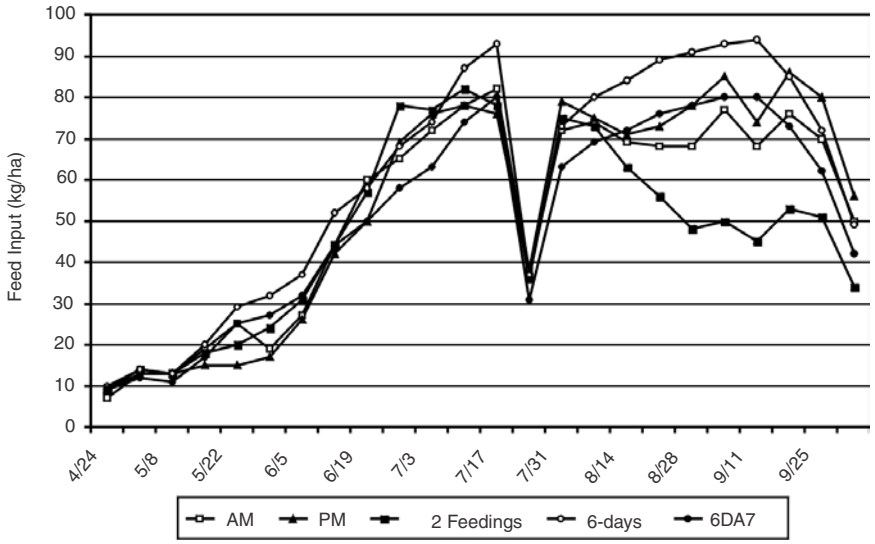
was recorded for each pond. For the fish receiving two feedings per day, half of the ration was offered in the morning and the other half in the afternoon. Feed intake was evaluated only after the afternoon feeding.

On July 23 and 24, 2001, approximately 80 market-size (> 450 g) catfish were removed from each pond by partial harvest using a seine and a grading live-car with 4.4-cm^2 mesh. A sub- sample of 15 of the marketable catfish were randomly collected from each pond to estimate a weight-length relationship, and dressout percentage. On October 9 and 10, 2001, all ponds were drained and completely harvested. A minimum of 25 fish were randomly collected from each pond to estimate weight-length relationship, and dressout percentage. Dressout percentage was calculated as the relative weight of fish with head and viscera removed to weight of whole fish. Six fish from each pond were randomly collected for determination of proximate composition of fillets. Fillets of fish from individual samples were pooled, and homogenized. Ash and dry matter of fish fillets were determined in duplicate by methods described by the Association of Official Analytical Chemists (1990). Crude protein of fish fillets was determined in duplicate by micro-kjeldahl analysis (Ma and Zuazago 1942). Lipid of fish fillets was determined in duplicate after chloroform-methanol extraction (Folch et al. 1957). Statistical analyses were performed using SAS (V 8e, SAS Institute Inc. Cary, North Carolina). Data was analyzed by one-way analysis of variance and Student-Newman-Keuls test to determine significant (P 0.05) differences. Data from one replicate pond in treatment 2 and one in treatment 4 were excluded from statistical analysis due to aerator failure and/or initial stocking problems.

RESULTS AND DISCUSSION

A complete and nutritious diet offered in sufficient quantities and under a proper feeding regimen are important factors in successful aquaculture. Results of the present study indicate that feeding time and frequency had no significant impact on biomass, weight gain, feed consumption, survival rate, weight-length relationship, FCR, and dressout percentage of channel catfish in treatments 1, 2, and 3. Individual weight gain among the four treatments ranged from 244.8 g to 279.8 g, survival from 74.8% to 89.3%, total feed consumed from 302.6 kg to 348.1 kg, and FCR from 1.68 to 2.02, without any significant difference being observed among treatments (Table 1). Despite the use of different feeding strategies, average feed consumption by the fish was similar among treatments (Figure 1). Similar results were obtained with catfish

FIGURE 1. Average daily feed inputs for mixed-size catfish offered single feedings (AM, PM), two feedings per day or 6 days of feeding with 1 day of fasting (6 days). The 6 -day feeding treatment is presented as daily feed inputs (open circle) and as daily feed input averaged over 7 days (6DA7, filled circle).



stocked as a single size class by Lovell (1979), Webster et al.(1992a), Robinson et al.(1995), Jarboe and Grant (1996; 1997). Webster et al. (1992b) reported that no significant differences were found in length, weight gain, survival, and feed conversion for catfish reared in floating cages offered one or two feedings daily.

The findings of the aforementioned researchers contradict with some earlier findings that suggested that feeding time and feeding frequency affected the weight gain and feed conversion of catfish (Collins 1971; Andrews and Page 1975; Greenland and Gill 1979; Noeske-Hallin et al.1985). The differences between the present study and some earlier research may have been due to differences in environmental conditions, fish size, and feeding rate among studies. Results of studies by Collins (1971), Andrews and Page (1975), and Greenland and Gill (1979) differ from those of the present study possibly because they were conducted with same size fish in tanks, rather than ponds. Similarly, differences between results by Noeske-Hallin et al. (1985) and results of the present study might be due to their restriction of feeding rate to 2.5% of body weight as opposed to the present study, where fish were fed to satiation. Moreover, because the catfish has a relatively large stomach (Andrews and Page 1975), a single meal daily might provide enough feed for maximal growth. Similarly, Kono and Nose (1971) postulated that since fish with smaller stomachs required more frequent feedings for maximal growth, feeding frequency requirements are related to stomach size.

Although no significant difference in biomass, weight gain, survival, weight-length relationship, FCR, feed consumption, dressout percentage, and ash percentage of fillet for the various treatments were found, some trends are suggested (Table 1, 2, and 3) . Feeding twice a day caused a depression in feed uptake during the late summer and early fall (Figure 1). A similar response was also reported by Lovell (1979). Such behavior may be due to the fact that fish in treatment 3 did not feed as aggressively during the afternoon feeding as they did during the morning feeding, thus lowering total daily consumption. Feed rates were adjusted based on afternoon appetite of fish that might not have completely digested the morning feed. Conversely, daily feed intakes were generally higher for fish fed on a 6 day schedule. However, when weekly feed consumption was averaged over seven consecutive days, feed intakes in all treatments were similar.

The present study indicated that biomass, weight gain, survival, weight-length relationship, FCR, and dressout percentage of fish fasted 1 day a week were not significantly different from the results for fish fed everyday. Kim and Lovell (1995) observed that weight gain, mean survival, feed efficiency, and dressout percentage over an 18 week period were the same for

fish placed on restricted feeding for 3 weeks and fish fed continuously. Similar results were found by Dobson and Holmes (1984) with rainbow trout, *Salmo gairdneri*, Rueda et al. (1998) with red porg, *Pagrus pagrus* , and Gaylord and Gatlin (2000) with channel catfish.

No significant difference in total amount of feed consumed between fish fasted one day a week and fish fed everyday was found. The total amount of feed consumed by fish maintained on the six day feeding protocol was about 98% of that consumed by fish offered feed daily in the morning, and 94% of the consumption of fish offered feed daily in the afternoon. Such results are corroborated by Samford (1995) working with channel catfish, and Rueda et al. (1998) working with red porgy. In the present study, the response to a one day fasting period followed by six days of satiation feeding seems to be hyperphagy and compensatory growth. Note that the poor FCR for the 6-day treatment is biased due to results from one pond, which had a diseases problem. If this pond is excluded from the analysis, the average FCR is 1.86, which is in line with the other treatments.

Fillet dry matter and lipid percentage in treatment 1 (23.04% and 4.56%, respectively) were significantly higher than in the treatment 4 (21.66% and 3.28%, respectively) (Table 3). The crude protein percentage of the fillet in treatment 2 (16.81%) was significantly higher than in treatment 4 (15.30%), but similar to treatments 1 and 3 (Table 3). These results may be due to the fish utilizing stored energy for metabolic process during fasting. Machado et al. (1988) concluded that most of the energy utilized during starvation were derived from catabolism of muscle lipid and protein. This could explain the low percent lipid and percent protein of fillet of fish fasted one day a week.

No clear preference of feeding time and feeding frequency for catfish fed to satiation was observed during the present study. Given the logistics on large catfish farms, the observed results do not warrant strict adherence to a specific feeding regimen (i.e., feeding all ponds in the afternoon or feeding twice daily). Hence, the farmer is encouraged to allocate manpower and equipment in a reasonable manner. Also, the feeding of fish in the evening should be discouraged as the catfish's physiological maximum demand for oxygen is six hours after feeding (Robinson and Li 1996), and would correspond to low night-time DO levels in the pond, potentially contributing to DO stress. When DO levels are low and metabolic oxygen demand is high, mortality can result (Roberts and Bullock 1989). Since photosynthetic activity in pond water supplies oxygen during daylight hours, we suggest that catfish be fed once daily in the morning after dissolved oxygen level reaches 4 mg/L or greater.

TABLE 1. Performance of mixed-size channel catfish offered a commercial feed in the morning (AM), afternoon (PM), morning and afternoon (Twice), and 6 days per week (6 days).

		Middle Harvest			Final Harvest			Total			
Treatment	Initial biomass (Kg)	Number of fish	Biomass (kg)	Mean weight (g)	Number of fish	Biomass (kg)	Mean weight (g)	Individual weight gain (g)	Feed (kg)	FCR3	Survival(%)
AM 1	35.1	82	47.2	573.7	467	177.7	382.3	279.8	336.4	1.79	74.8
PM 2	35.1	87	46.1	533.2	570	195.1	339.5	244.8	348.1	1.70	89.3
Twice 1	35.1	87	50.6	571.0	492	166.8	324.8	265.0	302.6	1.68	82.2
6 days 2	35.1	81	44.0	550.0	469	158.9	339.5	262.8	329.7	2.02*	74.8
PSE 4			2.28	21.57		17.03	18.57	31.09	22.82	0.115	5.92
Pr > F			0.254	0.529		0.524	0.162	0.887	0.541	0.206	0.31

1 Means of five replicates.
2 Means of four replicates
3 FCR, feed conversion ratio=feed offered/weight gain.
4 Pooled standard error.
* If one diseased pond is excluded from the analysis, the average FCR for treatment 4 becomes 1.86.

TABLE 2. Dressout and weight-length relationship of mixed-size channel catfish offered a commercial feed in the morning (AM), afternoon (PM), morning and afternoon (Twice), and 6 days per week (6 days)

Treatment	Middle Harvest		Final Harvest	
	Dressout percentage (%)	Weight/length (g/cm)	Dressout percentage (%)	Weight/length (g/cm)
AM 1	65.0	15.3	66.3	14.6
PM 1	64.0	15.0	67.9	14.1
Twice daily 1	64.8	15.1	66.9	14.7
6 days 2	64.5	14.4	70.4	15.0
PSE 3	0.489	0.379	1.434	0.432
Pr > F	0.459	0.456	0.246	0.546

1 Means of five replicates.
2 Means of four replicates.
3 Pooled standard error.

TABLE 3. Proximate analysis (% wet weight) of mixed-size channel catfish offered a commercial feed in the morning (AM), afternoon (PM), morning and afternoon (Twice), and 6 days per week (6 days). Values within the same column with different letters are significantly different ($P < 0.05$).

Treatment	Dry Matter (%)	Crude Protein (%)	Lipid (%)	Ash (%)
AM 1	23.04 a	16.50 ab	4.56 a	1.02 a
PM 2	22.11 b	16.81 a	2.85 b	0.81 a
Twice daily 1	21.71 b	15.78 ab	2.97 b	0.97 a
6 days 2	21.66 b	15.30 b	3.28 b	0.94 a
PSE 3	0.255	0.35	0.196	0.102
Pr > F	0.001	0.024	0.001	0.565

1 Means of five replicates.
2 Means of four replicates.
3 Pooled standard error.

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