COMPARISON OF DAY VERSUS NIGHT FEEDING ON PRODUCTION OF ADVANCED IMPERIAL-STRAIN CHANNEL CATFISH *Ictalurus punctatus* IN INDOOR RACEWAYS

by

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ABSTRACT

Production of advanced (229-mm) channel catfish *Ictalurus punctatus* fingerlings in indoor raceways can be problematic because of the unnatural environment and the tendency of the fish to react negatively to human presence, resulting in stress and poor growth. These problems may be remedied by maintaining low light levels and reducing human activity during feeding of the fish. We investigated the effects of two feeding regimes, {feeding in total darkness (night feeding) vs. feeding during the day under low light intensity conditions (day feeding)}, on production of advanced channel catfish in indoor raceways. We stocked six production raceways (2.4 x 24 x 1.0 m) with juvenile (98-100 mm total length) Imperial-strain channel catfish at 0.12 fish/L or 1.1-1.4 g/L and fed them commercial feed three times daily for 78 d. At the end of the study daily growth, harvest length, feed conversion ratio, growth variability, and percent return were compared. None of these measured variables was significantly different ($P > 0.05$) between feeding regimes. However, post-hoc power analyses suggested that had one feeding regime been at least 3-20% better than the other depending on the variable, we would have had 80% power to detect differences. Both feeding regimes yielded fingerlings of the desired quantities and size range within the study time frame. Therefore, either feeding regime may be used for the production of advanced Imperial-strain channel catfish fingerlings in indoor raceways.

INTRODUCTION

Catfishes *Ictalurus* spp. rank second among Texas anglers as most sought after group of sport fish in inland waters (Bohnsack and Ditton 1999). Recent programs to provide fishing opportunities to young and urban anglers have increased the need to efficiently produce larger (200-250 mm) fingerling catfish for stocking into city lakes compared to sizes (e.g., 51 mm) routinely stocked into reservoirs. The strategy of producing larger fish for urban fishing programs has become common in at least six US states including Texas (J. Warren, Dundee State Fish Hatchery, Electra, Texas, personal communication). Growing larger fish and implementing urban fishing programs require more pond space and many deliveries of small numbers of fish, respectively. From that standpoint, high-density raceway culture of catfish may be more logistically efficient for urban fishing programs.

Large-scale culture of channel catfish *Ictalurus punctatus* (CCF) has roots dating back to the 1950s when initial work, sponsored by the U.S. government, was conducted on the biology and propagation of this species (Martin 1968). In the 1960s, commercial production of catfish was started (Madewell 1971), and although pond culture was the common practice, raceway culture and research to improve this technique followed toward the end of that decade (Hill et al. 1973).

Attempts to produce 229-mm catfish indoors at Texas Parks and Wildlife Department (TPWD) hatcheries have failed in the past because of poor growth and survival. Hatchery personnel noticed that catfish fingerlings were prone to stress during feeding or raceway cleaning. To alleviate stress, tarp coverings were placed over raceways to provide refuge for fingerlings; however, light intensity was kept normal (25-35 foot candles) as part of the hatchery routine. The use of "refuge" has been explored in the culture of rainbow trout *Oncorhynchus mykiss* (Wagner and Bosakowski 1994) and channel catfish (Allen 1973) and found to be ineffective in enhancing production of these species. Our observations that supplying cover alone for indoor-cultured catfish does not seem to reduce stress or improve growth support these findings. To address the need to increase growth rate and reduce mortality in raceway culture, a pilot study was initiated during the 1999 production season at the A. E. Wood fish hatchery in San Marcos, Texas (AEW). During this study, catfish were held in raceways with 30% of the surface area shaded with tarp as cover and provided low light conditions (3-6 foot candles) during the entire production season. The results were promising in that for the first time a significant percentage (46%) of the 229-mm fingerling production came from raceways. However, these fish still lagged behind the pond-reared fish in terms of growth and feed conversion ratio (FCR).

Studies into the efficacy of feeding catfish at night in ponds have been in print for many years. Night feeding is particularly appealing when rearing catfish because they are generally considered predators of bottom and dark environments (Baras et al. 1998). Thus, feeding at night could encourage growth by reducing stress and taking advantage of the natural feeding behavior of catfish. In earthen ponds, Robinson et al. (1995) compared timed-feeding regimes (Once at 0830 hours vs. once at 1600 hours vs. once at 2000 hours vs. on demand) and found no significant differences in growth of channel catfish among these regimes, suggesting no potential benefit of night feeding. They cautioned against night feeding in ponds because of potential water quality concerns. Hastings et al. (1972) used demand feeders on channel catfish stocked in a 0.4-ha pond and found 43% of the total feeding activity of small catfish occurred between 1800 and 2400 hours, the period when normal hatchery operations are shut down. This suggests that night feeding may be advantageous for certain sizes of catfish. They also found winter feeding of large catfish more concentrated in the afternoon – perhaps due to the warmer water temperatures. Unfortunately, no specific size ranges for the fish used in that study were given.

Baras et al. (1998) evaluated the effect of night feeding on overall growth, growth uniformity, FCR, and mortality of the vandu catfish *Heterobranchus longifilis* in indoor enclosures. Night feeding was beneficial in promoting uniform growth with less mortality than feeding under high-intensity light conditions. Also, night feeding was found to be more beneficial for smaller fish (31-101 d old). Kerdchuen and Legendre (1991) found better growth as well, yet greater heterogeneity in size for night feeding of the same species. To investigate whether channel catfish could be successfully cultured in indoor raceways by utilizing a night feeding regime, we compared several production variables (daily growth, harvest length, FCR, growth variability, and percent return) between channel catfish fed in total darkness (night feeding) and those fed during the day under low intensity light conditions (day feeding).

MATERIALS AND METHODS

This study was conducted during the 2000 channel catfish production season at the AEW. Imperial-strain channel catfish were spawned on site and reared to approximately 100 mm total length in a 0.4-ha pond before transfer into six indoor holding troughs. All fingerlings were weighed and distributed among six concrete raceways (2.4 x 24 x 1.0 m) to achieve stocking rates of 6,480-6,497 fish per raceway (Table 1). Initial mean length and weight were estimated from a sample of 100 fish from each raceway. The raceways were divided into two randomly assigned treatment groups. Group 1 contained fish fed at 0900, 1200, and 1500 hours (day feeding) and group 2 contained fish fed at 2100, 2400, and 0300 hours (night feeding). Night-feeding catfish were fed under total darkness whereas day-feeding catfish were fed under ambient light provided through windows. This illumination was measured to be 3-6 foot candles. Each raceway had a tarp over approximately 33% of the surface area to provide cover.

Feed was delivered into raceways by automatic feeders, and the feed type was1.6-, 3.2-, or 5.5-mm floating pellets depending on the mean size of fish. The amount of feed delivered into raceways daily was determined as percent of catfish total weight based on water temperature (Jensen et al. 1983). The total weight was estimated every 7-10 d. Fish samples were taken by crowding the fish and randomly dipping out 40 fish from each raceway. The fish were individually measured and weighed to estimate the total weight in each raceway. Mortality was recorded daily and subtracted from the preceding total number to obtain the actual number of fish in each raceway. The fish were cultured for 78 d, and a final fish sample was taken for length and weight estimates. The total weight of fish produced from each raceway was recorded. The amount of feed offered to fish in each raceway and the corresponding fish weight gain were used to calculate the FCR.

Water for the raceways at AEW is from a 3.2-ha storage reservoir that receives water from the San Marcos River. Water flows through the raceways were maintained at 378-1,134 LPM depending on fish health and water quality. All raceway water flows were adjusted to maintain similar flow rates. Temperatures and dissolved oxygen concentrations in the raceways (front and back) were monitored twice daily at 0500 and 1700 hours using a Yellow Spring Instrument model 610-DM dissolved oxygen meter. Ammonia levels were measured once a week with an ion-specific Accumet probe.

We used SAS statistical software (SAS Version 8.0 1999) to test for differences in percent return, FCR, daily length gain, daily weight gain, harvest length, mortality, and growth variability between treatments. We used t-tests to evaluate daily length gain, daily weight gain, FCR, harvest length, and mortality. An F-test was used to compare growth variability between groups, and the percent return data were analyzed using a logistic test. In all cases in which the null hypothesis was not rejected, a post-hoc power analysis was conducted (Peterman 1990) using PASS 2000 software (NCSS 2000). To ensure that this design had sufficient power to detect operationally significant changes (i.e., 10-20% improvement) between the two treatments, we estimated power using a post-hoc analysis.

RESULTS

Temperature, dissolved oxygen, and ammonia levels in all raceways were acceptable for the culture of Imperial-strain CCF (Warren 2002). Growth in length was sufficient in all raceways (Table 2) to produce fish that were within the target size range for the 78-d production period. Mean values of harvest length, daily length gain, and daily weight gain were statistically similar between treatments. Post-hoc power analyses suggested that had the harvest length, daily length gain, and daily weight gain differed at least 10%, 10%, and 20%, respectively, we would have had 80% power to detect that change given the current sample sizes and variances. Both treatments supported statistically similar growth variability, percent return, and mortality. Post-hoc power analysis suggested that had the percent return differed at least 3%, we would have had an 80% power to detect that change given the current sample sizes and variances. There was also no significant difference in FCR between treatments. In fact, none of the variables tested was statistically different between treatments (Table 2, $P > 0.05$); however, post-hoc power analyses suggested that the experiment had good power to detect changes within the range desired (i.e., greater than 10-20% improvement).

DISCUSSION

We found no advantage with either the day-feeding or night-feeding regime tested for the production of advanced Imperial-strain channel catfish in indoor raceways. Both promoted a successful catfish production. Our results did not support a similar study that used vandu catfish where Baras et al. (1998) found significantly better growth, FCR, survival, and growth heterogeneity. Baras et al. (1998) compared night feeding and day feeding under normal lighting conditions. Probably, the reduced light intensity and activity in the study area during daylight hours was sufficient to keep stress in the day-fed fish at levels equivalent to those encountered by the night-fed fish. Also, Baras et al. (1998) used a catfish species which probably was behaviorally different and not as domesticated as the hatchery strain of channel catfish used in this study.

The inability to quantify uneaten feed because of the experimental design probably resulted in the higher FCR values for both treatments. This problem has been noted in other feeding studies, such as that of Cole and Boyd (1986). Although comparing the results of this study to others is probably unfair because of differences in stocking densities, strains of catfish, and environmental conditions, we found that feeding catfish in total darkness or under reduced light intensity conditions during daylight hours resulted in similar FCR to those (1.2 -1.3 FCR) reported for raceway culture by Hill et al. (1973) and better FCR than that (1.6 FCR) reported by Collins and Delmendo (1976). The FCR values (averaged 1.3 for day feeding and 1.4 for night feeding) for this study were slightly higher than those (four-year average = 1.2) for pond production at our study site (AEW). Conversely, growth rates for our study fish were better than those of catfish produced in ponds (averaged 1.4 mm/d) during the 2000 season; however, there were differences in the initial size of fingerlings used and the duration of the production period which was 113 d for ponds and 78 d for raceways.

A mistake in stocking fish into raceways resulted in raceway 7 (day-fed) being overstocked and raceway 6 being under-stocked. This created a situation where the fish in raceway 7 were fed less than the required amount of feed which may have negatively affected growth and positively affected FCR (Table 2). Conversely, fish in raceway 6 were fed more that the required amount of feed which may explain why these fish had relatively the highest growth and FCR. Evaluation of the data without these two raceways did not change the results: there were no significant differences in the measured variables between the two feeding regimes. Despite the lack of significant differences in the measured variables between the two feeding regimes, our results yielded an important conclusion: advanced channel catfish (229 mm total length) can be cultured in indoor raceways using a night-feeding strategy or a day-feeding strategy if light intensity can be managed.

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Table 1.--Initial numbers, lengths ± SD, and weights of channel catfish fingerlings stocked into six indoor raceways for day- and night-feeding comparison study during the 2000-production season at the A.E. Wood fish hatchery.

Raceway	Number of fish	Mean total length (mm)	Total weight (kg)	Mean weight (g)
		Day		
4	6,497	100.2 ± 15.2	72.2	11.1 ± 4.8
5	6,486	104.0 ± 14.5	80.3	11.8 ± 5.1
7	6,484	99.8 ± 15.5	68.3	10.5 ± 5.0
		Night		
3	6,491	102.2 ± 16.2	73.0	11.2 ±4.6
6	6,491	101.0 ± 15.2	65.6	10.1 ± 4.6
8	6,480	98.4 ± 14.7	63.0	9.7 ± 4.3

Table 2.--Mean ± SD harvest length, harvest weight, percent mortality, percent return, daily growth, and feed conversion ratio (FCR) for day- and night-fed channel catfish fingerlings cultured in indoor raceways during the 2000-production season at the A.E. Wood fish hatchery. There was no significant difference (P > 0.05) in any variable between treatments.

Raceway	Percent return	Harvest length (mm TL)	Daily length gain (mm/d)	Harvest weight (g)	Daily weight gain (g/d)	Mortality	FCR
				Day			
4	80	227.4 ± 30.9	1.60	122.2 ± 49.6	1.4	375	1.4
5	81	231.1 ± 29.6	1.60	124.1 ± 53.4	1.4	830	1.4
7	116	215.0 ± 30.4	1.50	94.8 ± 42.5	1.1	341	1.1
Mean	92	224.5 ± 30.3	1.57	113.7 ± 48.5	1.3	515	1.3
				Night			
3	91	227.6 ± 25.2	1.60	115.5 ± 49.7	1.3	350	1.2
6	70	231.8 ± 27.5	1.70	129.0 ± 52.2	1.5	379	1.6
8	91	221.0 ± 25.8	1.60	103.7 ± 41.7	1.2	401	1.4
Mean	84	226.8 ± 26.2	1.63	116.1 ± 47.9	1.3	377	1.4

Growth variability was ±30.4 for day-fed and ±26.1 for night-fed channel catfish.