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Anthony B. Garrard

James A. Steeby

Craig S. Tucker

Edwin H. Robinson

John E. Waldrop

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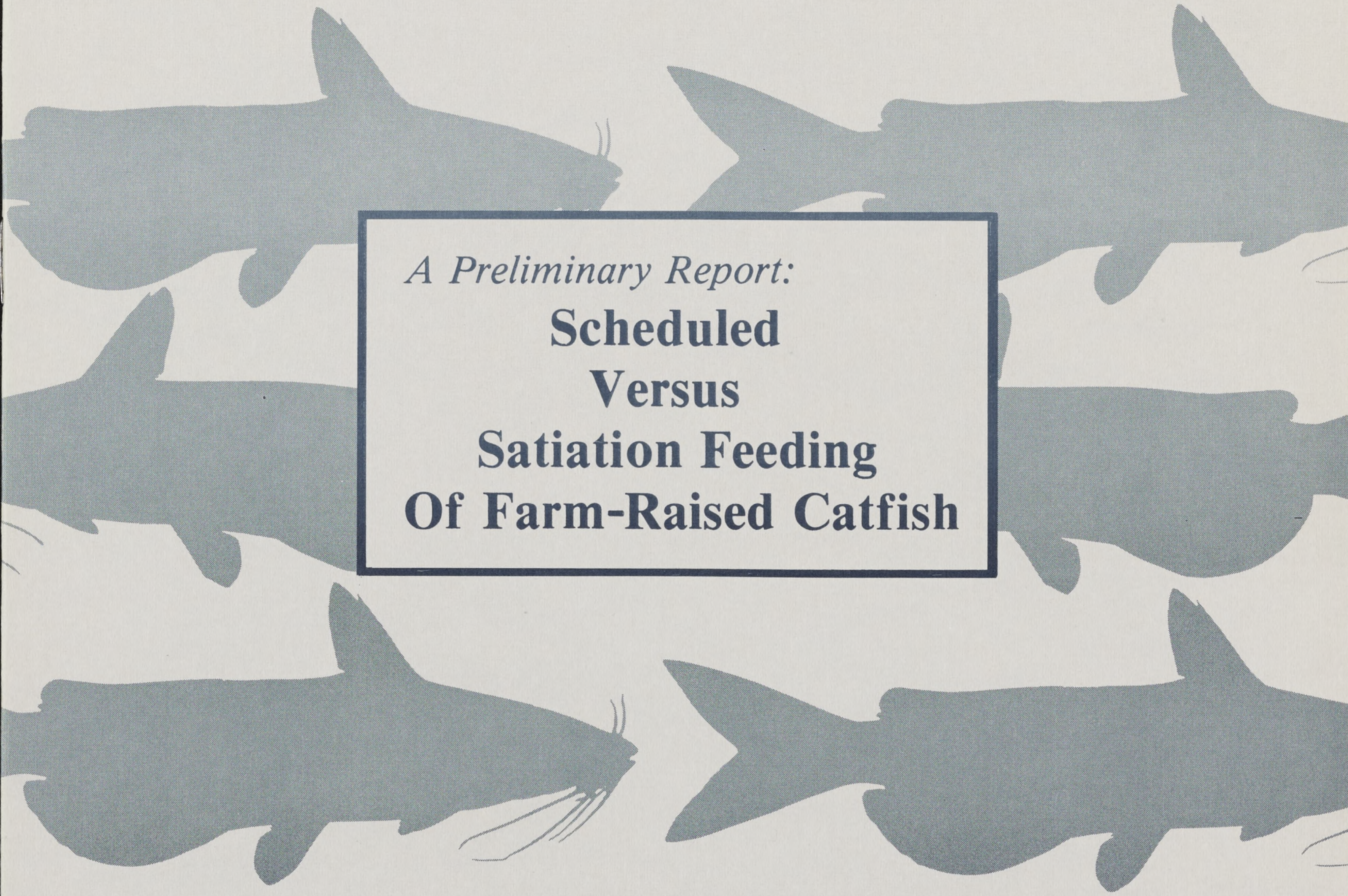

A Preliminary Report:

Scheduled Versus Satiation Feeding Of Farm-Raised Catfish

MAFES
MISSISSIPPI AGRICULTURAL & FORESTRY EXPERIMENT STATION Verner G. Hurt, Director Mississippi State, MS 39762
Donald W. Zacharias, President Mississippi State University R. Rodney Foil, Vice President

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Anthony B. Garrard
Research Assistant
Department of Agricultural Economics
Mississippi Agricultural and Forestry Experiment Station
Mississippi State University

James A. Steeby
Pond Manager, Aquaculture Department
Delta Branch Experiment Station
Stoneville, Mississippi

Craig S. Tucker
Fishery Biologist, Aquaculture Department
Delta Branch Experiment Station
Stoneville, Mississippi

Edwin H. Robinson
Fishery Biologist, Aquaculture Department
Delta Branch Experiment Station
Stoneville, Mississippi

John E. Waldrop
Economist and Professor
Department of Agricultural Economics
Mississippi Agricultural and Forestry Experiment Station
Mississippi State University

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Preface

This Information Bulletin was the result of an interdisciplinary effort by researchers from the Mississippi Agricultural and Forestry Experiment Station (MAFES) at Mississippi State University and the Delta Branch Experiment Station, Stoneville, MS. The project was developed and planned by Craig S. Tucker, Fishery Biologist at the Delta Branch, and John E. Waldrop, Agricultural Economist at Mississippi State. In addition to developing and planning the project, Dr. Tucker was responsible for the water quality analysis and Dr. Waldrop developed the feeding schedules used in the scheduled treatment.

James A. Steeby, Aquaculture Pond Manager at the Delta Branch, was responsible for the daily management requirements associated with all the experimental ponds and determining the amount of feed fed in the satiation treatment.

Edwin H. Robinson, Fishery Biologist at the Delta Branch, analyzed the composition of the fish flesh produced in each treatment.

Anthony B. Garrard, Research Assistant in the Department of Agricultural Economics, MAFES-MSU, with the assistance of James Steeby, analyzed and summarized the data used in this Information Bulletin.

This manuscript was reviewed by James G. Dillard, Professor, and Marty J. Fuller, Associate Professor, Department of Agricultural Economics, MAFES, MSU; Robert J. Martin, Extension Economist, Mississippi Cooperative Extension Service, MSU; H. Randall Robinette, Professor, Department of Wildlife and Fisheries, MAFES, MSU; and Walter J. Drapala, Professor and Head, Department of Experimental Statistics, MAFES, MSU.

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Introduction

Farm-raised catfish is a major industry in Mississippi. In 1988, more than 90,000 acres were devoted to farm-raised catfish production. Receipts to farm-raised catfish producers amounted to slightly more than $300 million in 1988 [10], with production, processing, and feed manufacturing accounting for more than 6,000 jobs in Mississippi [3].

The Problem

Feed is the largest single cost item associated with the production of farm-raised catfish. According to research related to farm-raised catfish production, feed accounts for approximately 50 percent of the total operating cost [1, 4, 6, 9].

Accurate determination of daily feed requirements is a major problem for catfish producers, and sound financial planning requires that producers be able to estimate feed needs throughout the growing season. Excessive feeding leads to feed waste and can cause deterioration of water quality, while under-feeding can reduce fish weight gains and potential returns at harvest. The optimum feeding rate is such that the last increment of feed fed just pays for itself, i.e., its marginal value is equal to its marginal cost.

Most commercial catfish feed is manufactured to float, allowing the person feeding to observe feed consumption by the fish. Some producers feed all the fish will consume in a predetermined period of time. This is called *satiation feeding* and the total amount of feed fed depends on the judgment of the person feeding. Other producers feed the fish based on a given percentage of the estimated weight of the fish. This is called *scheduled feeding*. In scheduled feeding, the estimates are based on factors not entirely known to the producer or well-defined by research.

Development of an accurate scheduled feeding program would have many advantages for producers. Inexperienced workers could perform the task of feeding with accuracy. Harvest weights and dates could be predicted, facilitating harvest. Current computer programs also could be used to predict daily and seasonal feed requirements, which would provide information required for sound financial planning. However, the use of current computer programs for scheduled feeding requires that producers know what percentage of body weight to feed and the feed conversion values by fish size.

Objectives

The general objective of this study was to compare a scheduled feeding scheme to a satiation feeding scheme for farm-raised catfish. The specific objectives were to: (1) compare fish growth and feed conversion of fish fed from a schedule and fish fed to satiation; (2) determine the composition of the fish flesh produced with the two feeding methods; and (3) assess differences in water quality parameters associated with the two feeding methods.

Procedure

Four ponds at the Delta Branch Experiment Station in Stoneville, Mississippi were used in the study. The ponds were identified as ponds 25, 28, 29, and 30. Each pond had a surface area of approximately 4.0 acres and an average depth of about 3 feet.

All four ponds were stocked in late March 1988 with approximately 4,500 channel catfish fingerlings per water surface acre. The fingerlings ranged in stocking weight from approximately 110 pounds per 1,000 fingerlings in pond 25 to approximately 98 pounds per 1,000 fingerlings in pond 30.

After a period of orientation, feeding of the fish in each pond began April 14, 1988. Two randomly selected ponds, 28 and 30, were fed daily according to a feeding schedule that required estimation of fish weight and feed conversion. The other two ponds, 25 and 29, were fed to near satiation daily.

The feeding schedules for ponds 28 and 30 were produced weekly. These weekly schedules were developed using the computer program, FISHY [7]. The parameters used in FISHY for percentages of body weight fed and feed conversion ratios were adapted from actual parameters obtained from selected operating catfish farms and are shown Tables 1a and 1b.

Feeding procedures were the same for all ponds. Fish were fed once daily between 1:00 and 3:00 p.m. with a commercial 32 percent protein floating feed. The individual responsible for feeding each day began the process, paused after a small quantity of feed had been added to the pond, and observed the feeding activity of the fish. If the fish began to feed actively, the scheduled amount of feed was fed to ponds 28 and 30. Ponds 25 and 29 were fed to near satiation by judgment of an experienced feeder. If the fish in a pond did not actively feed, the feeding for that pond was halted for the day, regardless of feeding method. A maximum feeding rate of approximately 100 pounds of feed per acre per day was set for each pond. Ponds 25 and 29 were harvested in mid-October 1988; ponds 28 and 30 were harvested in November 1988. At the inception of the experiment, plans were not made to sample the fish for weight gain during the growing season. However, unexpected resources became available prior to the scheduled termination of the experiment and fish were sampled July 12 and September 2, 1988. The samples enabled the study to be separated into three growth rate time periods. Period 1, approximately 16 weeks, covered the number of days between initial stocking and the first sample. Period 2, approximately 7 weeks, covered the number of days between the first and second samples. Period 3, approximately 6 to 12 weeks depending on the specific pond, covered the number of days between the second sample and the final harvest.

Weight gain samples with replacements were collected on July 12 and September 2 and consisted of 100 fish from each pond. Total harvest weight for each pond was recorded at final harvest. Four fish were also selected from each pond at stocking, the first weight gain sample date, and at harvest for flesh composition analysis.

Dissolved oxygen concentrations were measured in each pond at dawn and dusk and at intervals throughout the night. Each pond was supplied with a 10-hp, electric paddlewheel aerator with a standard oxygen transfer rate of 20 pounds of oxygen per hour [2]. Emergency aeration began when nighttime dissolved oxygen concentrations fell to 2.0 mg/L

Table 1a. Percent of total body weight of fish used to calculate feeding schedules by size category, for ponds 28 and 30, scheduled versus satiation feeding study. Stoneville, Mississippi, 1988.

Size category	Starting weight	Ending weight	% Body weight fed
	(pounds per 1,000 fish)		(per feeding)
1	> 0	367	3.33
2	>367	800	2.67
3	>800	2,000	1.83

Table 1b. Feed conversion ratios used to calculate feeding schedules by size category, for ponds 28 and 30, scheduled versus satiation feeding study. Stoneville, Mississippi, 1988.

Size category	Starting weight	Ending weight	Conversion ratio
	(pounds per 1,000 fish)		(lb feed/ lb fish)
1	> 0	233	1.43
2	> 233	483	1.58
3	> 483	733	1.71
4	> 733	1,000	1.90
5	>1,000	2,000	2.17

(2 ppm) and continued until about 8:00 a.m. the following day [8].

Variables for which data were collected and recorded daily for each pond included feed consumption, observed mortality, and hours of emergency aeration. Water samples were collected from each pond at biweekly intervals during the period May 11 to October 5. Each sample consisted of four subsamples taken 12 inches beneath the surface about 5 feet from the bank in each corner of each pond [8]. Water quality parameters measured included total ammonia-nitrogen, nitrite-nitrogen, and chlorophyll a.

Results and Discussion

Total fish production (total harvest weight minus total stocking weight) per acre was 7,084 pounds in pond 28, 6,951 pounds in pond 30, 7,379 pounds in pond 25, and 7,114 pounds in pond 29 (Table 2). Mean fish production was 7,247 pounds per acre in the satiation-fed ponds and 7,018 pounds per acre in the schedule-fed ponds. The difference in fish production between the two treat-ments was not significant (P=0.05).

Ponds 25, 29, and 30 had a feed conversion of approximately 1.5 pounds of feed per pound of fish production and pond 28 had a slightly higher feed conversion of approximately 1.6 pounds of feed per pound of fish production (Table 2). It should be noted that pond 28 was harvested (Nov. 29) later in the year, and therefore more feed was applied to this pond during cooler weather when fish may not convert feed as well as in other periods of the growing season.

Total emergency aeration was 742 hours, 668 hours, 798 hours, and 715 hours for ponds 28, 30, 25, and 29, respectively (Table 2). The measures of total emergency aeration for all ponds also closely approximated measures of total emergency aeration indicated in previous research for the same size ponds [8]. Mean total emergency aeration hours were only slightly greater (less than 8 percent) in the satiation treatment than in the scheduled treatment.

Estimates of the number of fish stocked, harvested, and lost due to mortality are presented in Table 3. The average estimated loss due to mortality in the satiation treatment was greater than that estimated for the scheduled treatment. The difference in fish loss did not appear to be related to the differences in feeding methods and the estimated loss for all ponds was well within expected fish loss in farm-raised catfish production.

Daily observed mortality was recorded for each pond. In pond 30, observed mortality accounted for approximately 83 percent of estimated total mortality, but in ponds 25, 28, and 29, observed mortality accounted for less than 1 percent of estimated total mortality.

Estimates of average fish size and fish growth by period are presented in Table 4. At stocking, estimated average fish size for the scheduled treatment was 104 pounds per 1,000

Table 2. Total stocking weight, harvest weight, fish production, feed applied, feed conversion, and emergency aeration for four ponds, scheduled versus satiation feeding study. Stoneville, Mississippi, 1988.

		Scheduled feeding			Satiation feeding		
Variable	**Unit**	**Pond 28**	**Pond 30**	**Mean**	**Pond 25**	**Pond 29**	**Mean**
Stocking weight [a]	lb/1,000 fish	109	98	104	110	103	107
	lb/pond	1,964	1,776	1,870	1,983	1,868	1,926
	lb/acre[d]	491	444	468	496	467	482
Harvest weight	lb/1,000 fish	1,720	1,644	1,682	1,834	1,753	1,794
	lb/pond	30,300	29,580	29,940	31,497	30,323	30,910
	lb/acre[d]	7,575	7,395	7,485	7,874	7,580	7,727
Fish production[b]	lb/pond	28,336	27,804	28,070	29,514	28,455	28,985
	lb/acre[d]	7,084	6,951	7,018	7,379	7,114	7,247
Feed applied (fed)	lb/pond	44,890	40,680	42,785	43,735	41,945	42,840
	lb/acre	11,223	10,170	10,697	10,934	10,486	10,710
Feed conversion[c]	lb feed/lb fish	1.58	1.46	1.52	1.48	1.47	1.48
Emergency aeration	hr/pond	742	668	705	798	715	757

[a]Fish stocked approximately 4,500 per water acre.
[b]Harvest weight minus stocking weight.
[c]Total feed applied divided by net fish production.
[d]Based on 4.0 acres per pond.

fish and 107 pounds per 1,000 fish for the satiation treatment. On July 13, 1988, the estimated average fish size for the scheduled treatment was 795 pounds per 1,000 fish and 885 pounds per 1,000 fish for the satiation treatment. By September 2, 1988, estimated average fish size in all four ponds had more than reached harvest weight (approximately 1.25 pounds), averaging 1,295 pounds per 1,000 fish for the scheduled treatment and 1,410 pounds per 1,000 fish in the satiation treatment. At harvest, the average estimated fish size for the scheduled treatment was 1,682 pounds per 1,000 fish and 1,794 pounds per 1,000 fish in the satiation treatment.

The estimated average fish sizes represent estimated fish growth of 3,132 pounds per acre, 2,264 pounds per acre, and 1,622 pounds, per acre in periods 1, 2, and 3, respectively for the scheduled treatment, and 3,528 pounds per acre, 2,378 pounds per acre, and 1,341 pounds per acre in periods 1, 2, and 3, respectively in the satiation treatment. Fish growth from stocking to harvest represented approximately a fifteen-fold increase in weight for both treatments.

Average fish weight, fish production, feed applied, feed conversion, and emergency aeration by period for each pond are presented in Table 5. During periods 1 and 2, fish in the scheduled treatment had a slightly lower feed conversion than in the satiation treatment. In period 3, fish in the satiation treatment had a slightly lower feed conversion than those in the scheduled treatment, but it should be noted again that ponds in the scheduled treatment were harvested later in the year, therefore more feed was applied during a period of growing season in which feed was not converted as efficiently. Overall, there was no statistical difference in the feed conversion for both treatments (P=0.05).

Emergency aeration hours were highest in period 3 for all ponds. Aeration hours increased through the growing season as a result of higher community respiration rates as fish grew and plankton density increased in response to higher feeding rates [8].

The scheduled feeding began for ponds 28 and 30 on April 14, 1988 and ended on October 5, 1988 (25 weeks or 175 total days). During this period, 41,465 pounds and 37,645 pounds of feed were applied (fed) in ponds 28 and 30, respectively. Also, during the same period, 42,825 pounds and 39,635 pounds of feed were applied in ponds 25 and 29, respectively. Weekly feed consumption by pond from April 14 to October 5 is presented graphically in Figures 1 and 2. The graphs clearly illustrate more variation in weekly feed consumption for the satiation-fed ponds (Figure 2) than for the schedule-fed ponds (Figure 1).

Table 3. Estimated number of fish stocked, harvested, and lost due to mortality for four ponds, scheduled versus satiation feeding study. Stoneville, Mississippi, 1988.

Treatment pond number	Estimated number of fish stocked	Estimated number of fish harvested	Estimated mortality (number)	Estimated mortality (% of stocked)
Scheduled Feeding				
28	18,100	17,616	484	2.7
30	18,122	17,993	129	0.7
Mean	18,111	17,805	306	1.7
Satiation Feeding				
25	18,088	17,174	914	5.1
29	18,156	17,298	858	4.7
Mean	18,122	17,236	886	4.9

Table 4. Estimated average fish weight and fish growth by period, by pond, scheduled versus satiation feeding study. Stoneville, Mississippi, 1988.

Variable	Unit	Scheduled feeding			Satiation feeding		
		Pond 28	Pond 30	Mean	Pond 25	Pond 29	Mean
Estimated average fish weight at stocking	lb/1,000 fish	109	98	104	110	103	107
Estimated average fish weight end period 1[a]	lb/1,000 fish	840	750	795	890	880	885
Estimated fish growth during period1[a]	lb/acre[d]	3,310	2,954	3,132	3,529	3,527	3,528
Estimated average fish weight end period 2[b]	lb/1,000 fish	1,370	1,220	1,295	1,490	1,330	1,410
Estimated fish growth during period 2[b]	lb/acre acre[d]	2,398	2,129	2,264	2,713	2,043	2,378
Estimated cumulative growth for period 1 and 2	lb/acre[d]	5,708	5,083	5,396	6,242	5,570	5,906
Estimated average fish weight end period 3[c]	lb/1,000 fish	1,720	1,644	1,682	1,834	1,753	1,794
Estimated fish growth for period 3[c]	lb/acre[d]	1,376	1,868	1,622	1,137	1,544	1,341
Estimated fish growth from stocking to harvest	lb/acre[d]	7,084	6,951	7,018	7,379	7,114	7,247

[a]Period 1 corresponds to the time elapsed between stocking (March 22, 1988) and the first weight gain sample (July 13, 1988).
[b]Period 2 corresponds to the time elapsed between the first weight gain sample (July 13, 1988) and the second weight gain sample (Sept. 2, 1988).
[c]Period 3 corresponds to the time elapsed between the second weight gain sample (Sept. 2, 1988) and harvest.
[d]Based on 4.0 acres per pond.

Table 5. Estimated average fish weight, fish production, feed applied, feed conversion, and emergency aeration by period for four ponds, scheduled versus satiation feeding study, Stoneville, Mississippi, 1988.

Variable	Unit	Scheduled Feeding			Satiation Feeding		
		Pond 28	Pond 30	Mean	Pond 25	Pond 29	Mean
Average fish weight at stocking	lb/fish	0.11	0.10	0.11	0.11	0.10	0.11
Average fish weight end of period 1[a]	lb/fish	0.84	0.75	0.80	0.89	0.88	0.89
Estimated fish production for period	lb/acre	3,310	2,954	3,132	3,529	3,527	3,528
Total feed applied for period	lb/acre	3,482	3,145	3,314	4,058	3,614	3,836
Feed conversion for period	lb feed/lb fish	1.05	1.06	1.06	1.15	1.02	1.09
Total emergency aeration for period 1	hr/pond	129	129	129	186	145	166
Average fish weight end of period 2[b]	lb/fish	1.37	1.22	1.30	1.49	1.33	1.41
Estimated fish production for period 2	lb/acre	2,398	2,129	2,264	2,713	2,043	2,378
Total feed applied for period 2	lb/acre	3,968	3,635	3,802	4,226	3,921	4,074
Feed conversion for period 2	lb feed/lb fish	1.65	1.71	1.68	1.56	1.92	1.74
Total emergency aeration for period 2	hr/pond	239	243	241	301	245	273
Estimated fish production for periods 1 and 2	lb/acre	5,708	5,083	5,396	6,242	5,570	5,906
Total feed applied for periods 1 and 2	lb/acre	7,450	6,780	7,115	8,284	7,535	7,910
Feed conversion for periods 1 and 2	lb feed/lb fish	1.31	1.33	1.32	1.33	1.35	1.34
Total emergency aeration for periods 1 and 2	hr/acre	368	372	370	487	390	439
Average fish weigth end of period 3[c]	lb/fish	1.72	1.64	1.68	1.83	1.75	1.79
Estimated fish production for period 3	lb/acre	1,376	1,868	1,622	1,137	1,544	1,341
Total feed applied for period 3	lb/acre	3,773	3,390	3,582	2,650	2,951	2,801
Feed conversion for period 3	lb feed/lb fish	2.74	1.81	2.28	2.33	1.91	2.12
Total emergency aeration for period 3	hr/acre	373	296	335	310	326	318
Estimated fish production from stocking to harvest	lb/acre	7,084	6,951	7,018	7,379	7,114	7,247
Total feed applied from stocking to harvest	lb/acre	11,223	10,170	10,697	10,934	10,486	10,710
Feed conversion from stocking to harvest	lb feed/lb fish	1.58	1.46	1.52	1.48	1.47	1.48
Total emergency aeration from stocking to harvest	hr/acre	741	668	705	797	716	757

[a]Period 1 corresponds to the time elapsed between stocking (March 22, 1988) and the first weight gain sample (July 13, 1988).
[b]Period 2 corresponds to the time elapsed between the first weight gain sample (July 13, 1988) and the second weight gain sample (May 2, 1988).
[c]Period 3 corresponds to the time elapsed between the second weight gain sample (Sept. 2, 1988) and harvest.

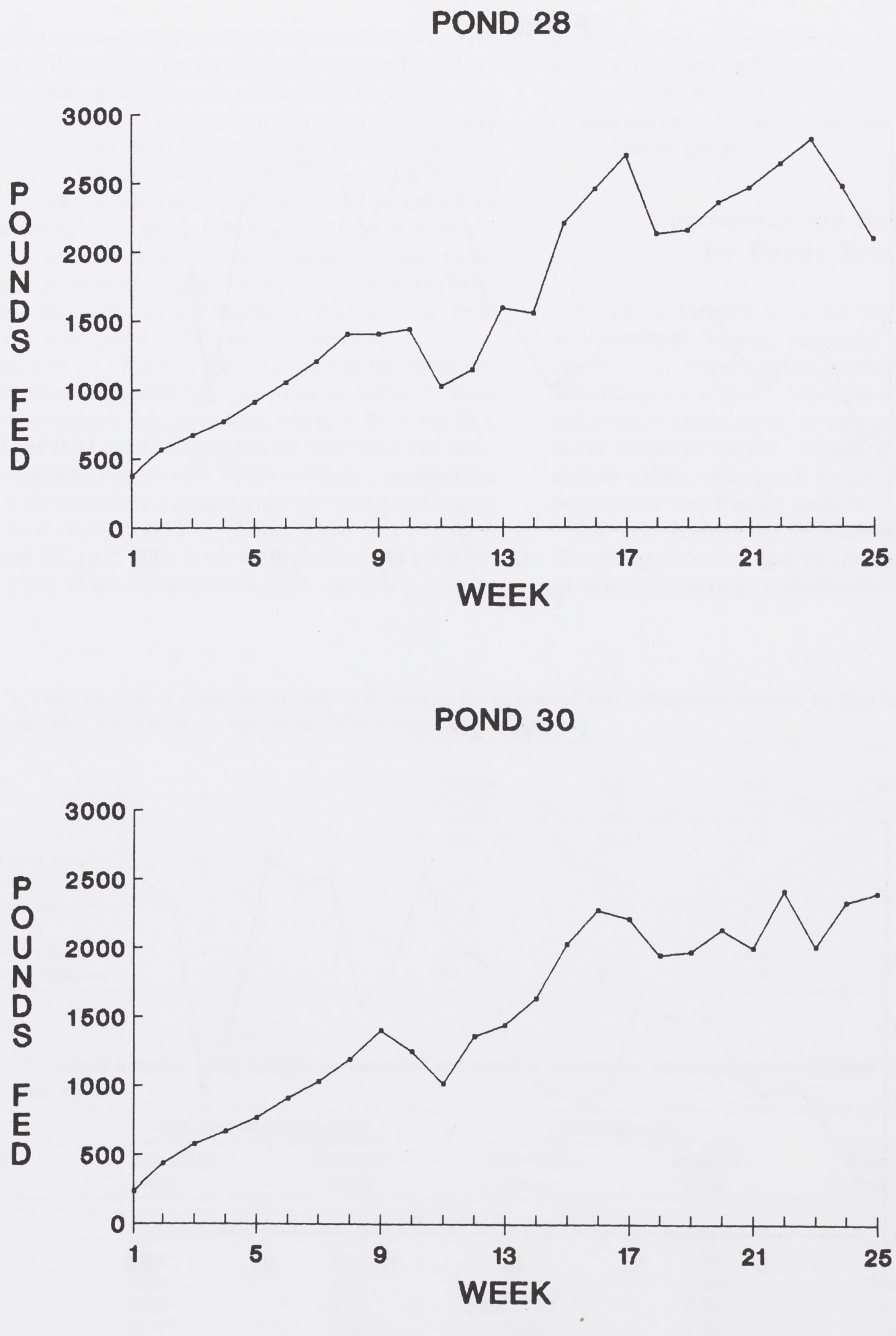
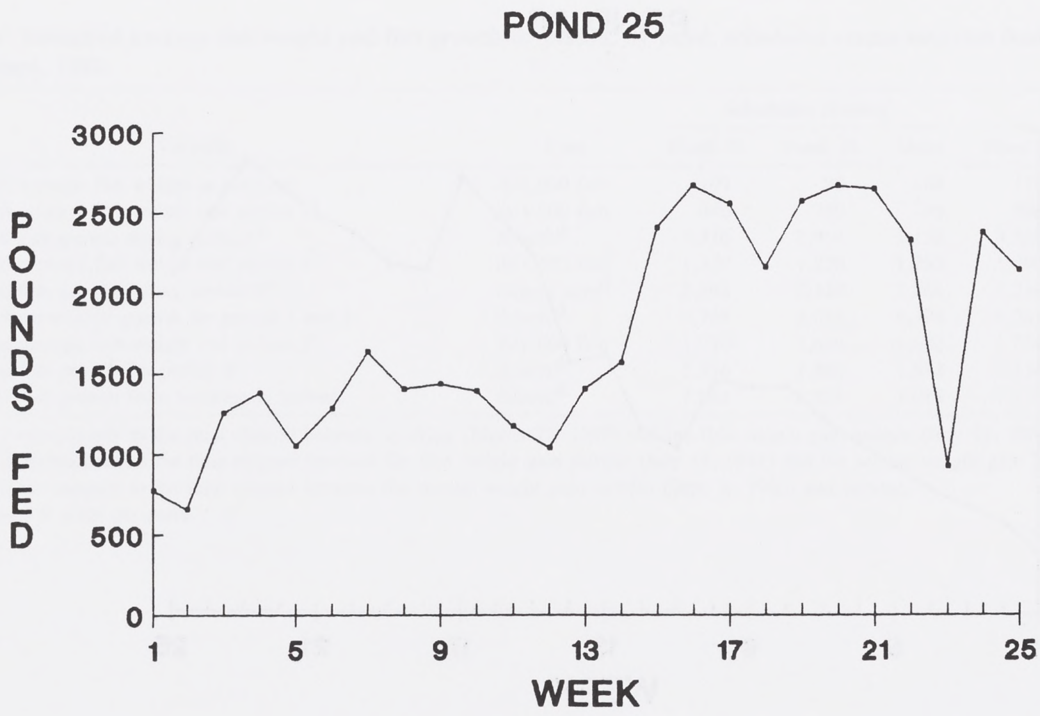


Figure 1. Weekly feed consumption for the schedule-fed ponds from April 14, 1988 to October 5, 1988.



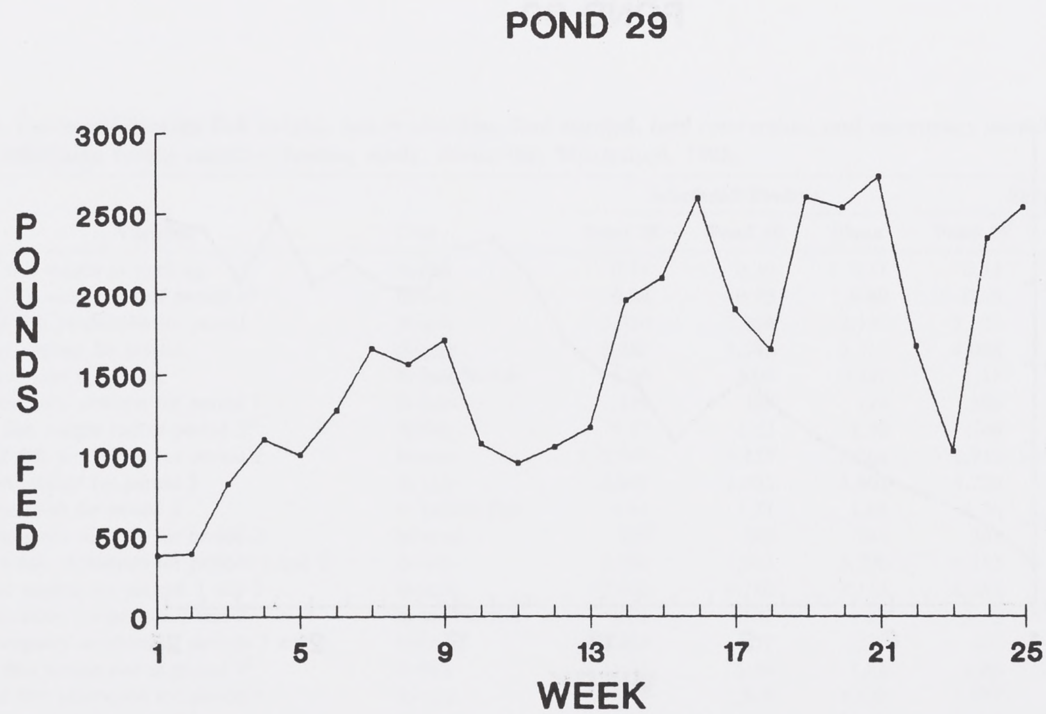


Figure 2. Weekly feed consumption for the satiation-fed ponds from April 14, 1988 to October 5, 1988.

Another measure used to compare the treatments was the number of days where feed consumption declined drastically (feed consumption 50 percent lower than the previous day feed consumption). Feed consumption declined drastically approximately six times in the satiation treatment and approximately 10 times in the scheduled treatment. The number of days in which feed consumption declined drastically does not appear to be related to differences in feeding methods. Virtually no differences were indicated in the results of the fish flesh proximate analysis for the two treatments (Table 6). Also, the results for both treatments did not deviate from expected farm-raised catfish flesh composition.

Results of the biweekly water samples in the scheduled and satiation treatments are presented in Table 7. Total ammonia-nitrogen concentrations averaged 0.71 mg N/L (ppm) and 0.93 mg N/L (ppm) in the scheduled and satiation treatments, respectively. Nitrite-nitrogen concentrations were well below levels considered detrimental to the production of channel catfish. Chlorophyll α concentrations averaged 222 μg/L (ppb) in the scheduled treatment and 309 μg/L (ppb) in the satiation treatment, indicating slightly greater phytoplankton densities and respiration rates in the satiation treatment. All concentration levels measured in the water samples for both treatments were considered typical of concentration levels encountered in commercial farm-raised catfish ponds.

Conclusions and Implications for Future Research

Results of this study indicated that there were practically no differences between scheduled and satiation feeding schemes with respect to fish production, feed conversion, and emergency aeration. Mortality for both treatments was well within levels normally encountered in commercial farm-raised catfish production. Results of the flesh composition analysis and the water quality samples showed little difference between the two feeding methods.

Fish growth by period yielded some interesting results. The feed conversion and percentage of body weight fed parameters used to generate the feeding schedules differed

Table 6. Fillet proximate composition and fat in viscera for scheduled and satiation treatments by fish flesh samples, scheduled versus satiation feeding study. Stoneville, Mississippi, 1988.

Sample	Protein	Fat	Ash	Moisture	Viscera fat
	(% of dr y wt.)			(% of body wt.)	
Initial	73.9	16.0	4.7	77.1	3.8
Weight gain sample					
Scheduled treatment	73.0	17.4	4.6	77.3	5.2
Satiation treatment	74.0	15.4	4.6	77.9	4.8
Harvest					
Scheduled treatment	71.3	21.7	4.2	74.8	4.0
Satiation treatment	68.0	27.8	4.6	75.5	3.6

Table 7. Results of biweekly water samples in scheduled and satiation treatments, scheduled versus satiation feeding study, Stoneville, Mississippi, 1988.

Selected date	Total ammonia-nitrogeneno Scheduled mean	Total ammonia-nitrogeneno Satiation mean	Nitrite-nitrogen Scheduled mean	Nitrite-nitrogen Satiation mean	Chlorophyll a Scheduled mean	Chlorophyll a Satiation mean
	(ppm)				(ppb)	
05-11	0.23	0.09	0.003	0.001	59	94
05-25	0.08	0.07	0.001	0.000	187	460
06-08	0.05	0.09	0.000	0.000	266	548
06-22	0.70	0.83	0.000	0.001	235	254
07-06	0.76	1.42	0.001	0.005	218	201
07-20	1.20	0.75	0.013	0.017	177	377
08-03	0.57	0.51	0.002	0.004	292	355
08-17	0.55	0.19	0.009	0.043	215	337
09-01	0.38	0.08	0.000	0.000	233	631
09-14	1.86	1.72	0.002	0.001	95	194
09-28	0.88	2.75	0.102	0.007	447	135
10-05	1.23	2.66	0.055	0.056	244	118
Average	0.71	0.93	0.016	0.011	222	309

from those actually attained by the fish. Feed conversions, based on the fish weight samples, were lower than the feed conversion parameters used to develop the feeding schedule. Average fish weights in the samples were greater than the average fish weights predicted in the feeding schedule. The actual percentage of body weight fed was lower than the parameter used for this variable in the scheduled feeding. Although the parameters used for feed conversion and percentage of body weight fed variables were apparently incorrect, the effect of these two incorrect parameters were offsetting and resulted in a "reasonable" feeding schedule.

Further research is needed to develop more creditable parameters (coefficients) to use in feeding schedules. Research is also needed to evaluate the coefficients with respect to various stocking densities and "clean" versus "topped" harvest methods. The fact that, on the average, fish in all four ponds had reached market weight well before the harvest date signifies the need for additional alternative stocking density research.

If these results are confirmed by future research, they will serve as a sound basis for recommendations that will increase profits from catfish production.

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