GROWING CHANNEL CATFISH, *ICTALURUS PUNCTATUS* (RAFINESQUE), IN RACEWAYS

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ABSTRACT

Techniques were investigated for growing channel catfish, *Ictalurus punctatus* (Rafinesque), from fingerlings to harvestable size fish during the summer months in a recirculation, flowing water fish culture system in South Georgia. When stocked at a density of 2,000 fingerlings per 100 ft raceway unit, mean production was more than 2,400 lb per unit with a feed conversion ratio of 1.28 to 1. Survival of the fish was 98.1%. Successful culture of 2,400 fish in one unit indicated that the carrying capacity of the raceways used in this study was greater than 2,000 fish. There was a gradual deterioration of water quality as it flowed through the raceways but, none of the water quality parameters measured were considered detrimental to the fish. Infestations of *Cleidodiscus, Scyphidia* and *Trichodina* were controlled by adding formalin to the water in the raceways at the rate of 30 ppm with the water flow stopped for 1 hr.

INTRODUCTION

Production of channel catfish, *Ictalurus punctatus* (Rafinesque), on a commercial basis in the United States has only been practiced since the 1960's (Madewell, 1971). Tremendous growth in the industry has taken place and according to the Department of Commerce (1970) more than 50,000 surface acres of water under the management of 1,600 producers was in commercial catfish production in 1970.

Several types of production systems including ponds, cages, and tanks have been utilized for culturing channel catfish. Open pond culture has been the most popular and satisfactory method but, because of the risk of fish kills from oxygen depletions in the water, Swingle (1958) recommended feeding no more than 30 lb of pelleted feed per acre per day. This factor alone imposes serious limitations on production of channel catfish in stillwater ponds.

Flowing water culture of channel catfish in earthen raceways is relatively new. This technique was first introduced in Georgia in 1969. The Department of Commerce (1970) reported that by 1970, about 70 farmers were producing catfish in 350 raceways in the United States. Since the carrying capacity of flowing water, closed fish culture systems like those in the Southeastern United States is unknown, studies in this important area should receive high priority.

The Flowing Water Research Facility at Tifton was utilized for a complete growing season with channel catfish in 1972. Objectives of the study were: (1) to determine if channel catfish fingerlings stocked at the rate of 2,000 per 100 ft raceway would grow to harvestable size in one growing season; (2) to investigate techniques for treatment of the fish in the raceways for parasite infestation; and (3) to evaluate the overall efficiency of the raceway technique for culturing channel catfish during the warm months of the year. Procedures used during and results obtained from the first year of investigation are reported in this paper.

MATERIALS AND METHODS

A closed raceway facility consisting of eight 100 ft in length raceways, a 5 acre reservoir and a 500 ft deep well was constructed at the Coastal Plain Experiment Station, Tifton, Georgia, in 1971 for the primary purpose of researching culture procedures for channel catfish. The raceways were composed of an earthen channel divided into 100 ft in length units by concrete headwalls with weir overfalls. The bottom slope of the channel was about 18 inches per 100 ft and the side slopes were one vertical to two horizontal. The bottom width of the channel was 10 ft. The depth of the water in each unit was 2.4 ft at the shallow end and 4.0 ft at the deep end.

The water supply reservoir had a surface area of 5 acres and a water holding capacity of 21 acre ft. To offset losses from evaporation and seepage, water was periodically added to the pond from the well.

The water was electrically pumped from the pond to the initial raceway at the rate of 530 gpm and flowed through the raceways by gravity containing the fish and back into the reservoir. Mechanical aerators (Chesness, et al, 1972) were used to help maintain quality in each raceway unit. A sleeve was constructed on the upstream side of each headwall forcing water flow from the bottom six inches of a raceway unit.

The raceways were stocked with channel catfish fingerlings in April, 1972. Stocking dates, rates, and total pounds per raceway of the catfish fingerlings are given in Table 1. With the exception of Raceway 8 where 2,400 fingerlings were placed, the stocking rate was 2,000 per raceway. Data from Raceway 8 are discussed in a separate section. Unless otherwise indicated data in the remainder of the paper are for Raceways 1 through 7.

Prior to stocking, the fingerlings were treated for parasites with formalin at the rate of 150 ppm for 1 hr in tanks containing mechanically aerated water. They were hauled to the raceways in water with 1 ppm acriflavin added in an aerated fiberglass tank. Tetracycline was administered to the fish on their feed at the rate of 4.5 g per 100 lb of fish per day for 10 days poststocking.

The mean stocking weight per fish was 0.21 lb. They ranged in length from 7 to 9 inches. The mean weight of fish stocked per raceway was 423 lb.

Purina Trout Chow (Developers Size) was fed once daily during the culture period. Rations were calculated form growth data obtained from b-weekly samples of 100 fish taken by pulling a seine through each raceway and from estimated conversion ratios.

Water quality parameters including total hardness, dissolved oxygen, pH, CO^2, ammonia, turbidity, and visibility, were taken weekly. Maximum and minimum water temperatures (° F) were recorded daily in Raceway 1 beginning April 7 and in both Raceways 1 and 8 from May 12 until the catfish harvest was completed.

The fish were examined on 18 occasions for parasite infestations. When treatment measures were needed, formalin was added directly to the water at the rate of 30 ppm in each raceway with the flow stopped for 1 hr.

The catfish were harvested approximately 175 days after stocking with a 30 ft, nylon, tar-treated seine with a 4 ft bag. In addition, a 2 ft x 2 ft x 8 ft box constructed of 2 inch x 4 inch pine and covered with ½ inch galvenized hardware cloth was located below the drain of each raceway as it emptied.

By pulling the seine toward the drain, the fish were crowded and swept through the drain by the water current into the box where they were removed by dip nets and counted. The water flow was maintained trhough the system as the fish were harvested. After being counted, the fish were weighed, loaded into trucks and delivered to a processer.

RESULTS AND DISCUSSION

The raceways used in this study provided easily managed production units for culturing channel catfish. The 1½% slope on the bottom with the current maintained from the incoming water and the bottom water removal device in each unit caused the solid wastes to move through the raceways into the reservoir pond. As a result, no significant wastes accumulations were present in the raceways when they were drained to harvest the fish.

Mean monthly temperatures are given in Table 2. Due to the late Spring and the prolonged cool weather, water temperatures did not stabilize above 80° F until abouth the second week in June. The catfish weighed about 0.5 lb each, but they never consumed more than 2% of their body weight in feed per day. The cool water apparently affected consumption of feed.

Means and extreme variations of dissolved oxygen (DO) measurements taken during the summer within each raceway are presented in Table 3. The usual procedure was to record two DO readings at 1 ft intervals in the shallow end and four readings at 1 ft intervals in the deep end of each raceway. The mean DO content of the water was invariably less at the deep end. Also, without exception, on a given day, no matter what time the DO measurements were taken, there was a gradual decline in DO from Raceway 1 through Raceway 8. This was to be expected with the presence of such a high density of catfish.

This information emphasizes the need for good aeration capabilities of the water as it flows from raceway to raceway if high standing crops of fish are to be produced. The inclined plane aerators (Chesness, et al, 1972) utilized between raceways in this study have been rated an aeration effectiveness of 45% when operating with an 18 inch head. This means that the water did recover some DO at it passed from one unit to the next, but not to its original content.

The mean values of ammonia (NH_3) content for each raceway, also given in Table 3, showed a gradual increase as the water traveled through the system. Usually, the greatest concentrations of ammonia were present in the lower two or three raceway units.

None of the water quality paramenters measured indicated deterioration to an extent considered harmful to the fish. Table 4 contains the means and extremes of total hardness, pH, CO_2, turbidity (Jackson turbidity units), visibility (Secchi disc), and NH_3 measurements for the raceway system.

Mean weights of the fish from periodic samples are given in Table 5. The mean weight of the stocked fish was 0.21 lb and the mean harvest weight was 1.20 lb. The growth data shows vividly that the fish in Raceway 1 gained faster than those in Raceways 2 through 7. Differences in water quality already cited were the prime responsible factors which enabled the fish in the initail raceway to grow faster.

A summary of the production of channel catfish in the raceway system during 1972 is presented in Table 6. More than a ton of catfish was harvested from each of the seven raceway units. In Raceways 1, 3 and 5, the fish gained more than 2,000 lb. the mean daily gain in fish weight per raceway per day was 11.5 lb, and ranged from a low of 10.3 lb in Raceway 4 to a high of 12.8 in Raceway 1. The mean daily increase in biomass for the entire population of catfish was 78.6 lb.

The fish consumed 17,264 lb of feed while gaining 13,769 lb for a mean conversion of 1.25. Conversions ranged from 1.30 to 1.20.

Harvest data for the catfish are presented in Table 7. The fish which weiged 0.75 lb and more were considered as harvestable. The percentages harvestable and unharvestable by number were 95.7 and 4.3, respectively. When considered on the basis of weight, 98.5% of the fish were harvestable.

Of the 16,400 fingerling stocked in the eight raceways, 16,103 survived to be harvested. Total natural mortality was only 1.9% in Raceway 3 where only eight fish died to 94.0% in Raceway 7. the months of May and June each accounted for more than 27% of the total mortalities. Less than 1% of the total mortalities occurred in September when harvest was imminent. Only 297 catfish of the 16,400 stocked experienced natural mortality.

The catfish were parasitized by *Cleidodiscus*, *Scyphidia* and *Trichodina* during the summer. Table 9 gives the examination dates, number of fish examined, kinds of parasites found, the degree of infestation and treatment used. The degree of infestation was an arbitrary term used to describe the results of microscopic examination of gill filaments from the fish in a sample. In some instances 30 ppm formalin added to the water in the raceways seemed to do an excellent job of eliminating parasites from the fish, whereas at other times reinfestation occurred in a short time.

More investigations are needed to determine the proper amounts of required treatment material. Length of time that the water can be safely turned off without stressing the fish needs investigation. No stress symptoms were evidenced with water flow stopped for 1 hr. If the fish could stay in the water with the parasiticide for a longer period of time, treatment might be more effective. Also, it should be determined if it is necessary to treat every raceway when they are in tandem.

Raceway 8

The higher stocking rate of 2,400 fish was used in Raceway 8 in order to establish if 2,000 fish was less than carrying capacity for a raceway. Data in Table 6 show that survival in Raceway 8 was 98.3% and that an acceptable feed conversion of 1.61 was obtained. The related factors of less desirable water quality and offering the fish more feed than they consumed on some occasions were responsible for the higher conversion in Raceway 8.

The catfish in Raceway 8 were larger than the others used in the study when stocked (Table 1). As a result, they reached a mean weight of one pound before the fish in the other seven raceways. When sampling procedures showed that the mean weight of the fish in Raceway 8 was more than one pound, they were harvested. Data in Table 7 show that 96.7% of the fish attained harvestable size.

CONCLUSIONS

Every objective which was set forth for the study, of growing channel catfish in flowing water, was realized. Growing catfish in raceways is a biologically sound and feasible technique. When stocked at a density of 2,000 fingerlings per 100 ft raceway, mean production was more than 2,400 lb per unit and 95.9% of the fish had a harvest weight of at least 0.75 lb. The mean feed conversion ratio was 1.28:1. The successful culture of 2,400 fish in Raceway 8 indicated that the carrying capacity of the raceways used in this study was greater than 2,000 fish and that future investigations should include higher fish densities.

There was a gradual deterioration of water quality as it flowed through the raceways but none of the water quality parameters measured were considered detrimental to production of catfish. The mechanical aerators performed well with a minimum of maintenance.

Infestations of parasites on the catfish were effectively treated and controlled during the summer. Further investigations are needed before recommendations are made.

Even though a measure of success was realized in 1972 for development of the techniques needed for growing channel catfish in raceways during warm months of the year, many questions remain to be answered. Further research on stocking rates, flow rates, feeds and feeding, grading, harvesting, improvement of water quality, and control of parasites is needed.

LITERATURE CITED

Chesness, J. L, J. L. Stephens, and T. K. Hill. 1972. Gravity flow aerators for raceway fish culture systems. Univ. of Ga. Coll. of Agri. Exp. Sta., Res. Rep. 137. 21p.

Madewell, Carl E. 1971. Historical development of catfish farming. Conference Proceedings: Producing and Marketing Catfish in the Tennessee Valley. Tennessee Valley Authority. Bulletin Y-38. 96p.

Swingle, H. S. 1958. Experiments on growing fingerling channel catfish to marketable size in ponds. Proc. Ann. Conf. S. E. Assn. Game and Fish Comm. 12: 63-72.

U.S. Department of Commerce. 1972. A statistical reporting system for the catfish farming industry, methodology and 1970 results. 233p.

Table 1. -Stocking Data for Channel Catfish Grown in Flowing Water 1972, Coastal Plain Experiment Station, Tifton, Georgia.

	Raceway	Number Fish	Pounds	Mean Weight
4/4/72	1	2,000	537	0.27
4/5/72	2	2,000	446	0.22
4/6/72	3	2,000	411	0.20
4/7/72	4	2,000	397	0.20
4/7/72	5	2,000	411	0.20
4/10/72	6	2,000	408	0.20
4/10/72	7	2,000	353	0.18
4/12/72	8	2,000	838	0.34

Table 2. -Mean Maximum and Minimum Temperatures of Water in °F in Raceways during Catfish Culture Season, 1972, Coastal Plain Experiment Station, Tifton, Georgia.

	Raceway 1		Raceway 8	
Date	Maximum	Minimum	Maximum	Minimum
April	76	74	-	-
May	79	76	80	74
June	83	80	84	80
July	87	85	89	84
August	88	85	88	83
September	85	81	85	81

Table 3. -Means and Extreme Variations of Dissolved Oxygen and Ammonia Content of Water in Raceways During Catfish Culture Season, 1972, Coastal Plain Experiment Station, Tifton, Georgia.

Dissolved Oxygen (PPM)				Ammonia (PPM)		
Raceway	Mean	High	Low	Mean	High	Low
1	7.4	9.6	4.9	0.63	1.10	0.24
2	7.0	9.0	4.6	0.91	1.93	0.48
3	6.7	8.5	4.6	1.02	1.93	0.48
4	6.6	9.2	4.6	1.06	2.06	0.36
5	6.4	9.4	4.0	1.16	1.69	0.47
6	6.3	9.5	4.0	1.24	2.48	0.54
7	6.5	9.6	4.2	1.46	2.84	0.54
8	6.3	9.6	3.5	1.51	2.76	0.44

Table 4.- Means and Extremes of several Water Quality Paramenters Measured in Raceways During Catfish Culture Season, 1972, Coastal Plain Experiment Station, Tifton, Georgia.

	Mean	High	Low
Total hardness (ppm)	79	95	70
pH (ppm)	6,8	8.3	6.0
CO_2	(ppm)	5.8	1.5
Turbidity (JTU)	35	100	4
Visibility (Secchi disc-inches)	22	30	10
NH_3 (ppm)	1.1	2.8	0.2

Table 5.- Mean Weights from Periodic Samples of Channel Catfish Grown in Flowing Water, 1972, Coastal Plain Experiment Station, Tiftion, Geogria.

	Raceway								Overall Mean Weight	Cumulative Days
	1	2	3	4	5	6	7	8*		
4/5/72	0.27	0.22	0.20	0.20	0.20	0.20	0.18	0.34	0.23	
5/10/72	0.33	0.33	0.30	0.32	0.33	0.35	0.28	0.52	0.35	30
5/23/72	0.40	0.39	0.41	0.42	0.42	0.38	0.34	0.62	0.41	48
6/21/72	0.63	0.45	0.50	0.46	0.52	0.47	0.39	0.68	0.50	77
7/5/72	0.68	0.58	0.58	0.53	0.57	0.61	0.45	0.80	0.60	91
7/17/72	0.83	0.63	0.63	0.66	0.62	0.65	0.62	0.87	0.69	103
8/2/72	0.98	0.69	0.80	0.76	0.65	0.79	0.80	0.92	0.80	119
8/17/72	1.15	0.88	0.88	0.88	0.87	0.91	0.92	0.96 Harvested	0.93	134
8/31/72	1.16	0.96	0.97	0.98	0.97	0.96	0.99	1.06	0.99	148
9/15/72	1.34	1.00	1.08	1.00	1.00	1.09	1.18	---	1.10	163
Harvest 9/25-28/72	1.41	1.16	1.25	1.11	1.23	1.17	1.19	---	1.20	172-176

Table 6.- Summary of Production of Channel Catfish in Flowing Water, 1972, Coastal Plain Experiment Station, Tifton, Georgia.

	Raceway							
	1	2	3	4	5	6	7	8
Number Stocked	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,400
Number Recovered	1,988	1,981	1,992	1,961	1,969	1,972	1,880	2,360
Percent Survival	99.4	99.0	99.6	98.0	98.4	98.6	94.0	98.3
Weight Stocked (lbs)	537	446	411	397	411	408	353	838
Weights Recovered	2,803	2,298	2,490	2,176	2,421	2,307	2,237	2,501
Weight Gained	2,266	1,852	2,079	1,779	2,010	1,899	1,884	1,663
Days on Feed	176	176	174	173	172	169	168	131
Avg. Daily Gain (lbs)	12.8	10.5	11.9	10.3	11.7	11.2	11.2	12.7
Feed Consumed	2,959	2,330	2,510	2,287	2,469	2,397	2,312	2,693
"C" Conversion	1.30	1.25	1.20	1.28	1.22	1.26	1.22	1.61
Mean Wt. Fish Stock	0.27	0.22	0.20	0.20	0.20	0.20	0.18	0.34
Mean Wt. Fish Harv.	1.40	1.16	1.25	1.10	1.22	1.17	1.19	1.06
Mean Wt. Increase/fish	1.13	0.94	1.05	0.90	0.98	0.97	1.01	0.72

*Not included in totals because of higher stocking rate.

	Totals
Number Stocked	14,000
Number Harvested	13,743
Percent Survival	98.1
Wt. Stocked (lbs.)	2,963
Wt. Harvested (lbs.)	16,732
Wt. Gained	13,769
Culture Period (Days)	172-176
Feed Consumed	17,264
"C" Conversion	1.25
Mean Wt. Stocked	0.21
Mean Wt. Harvested	1.20
Percent Harvested	95.7
Percent Unharvested	4.3

Table 7.- Harvest Data (lb) for Channel Catfish Grown in Flowing Water, 1972, Coastal Plain Experiment Station, Tifton, Georgia.

Raceway	Weight* Harvest-able	Number Harvest-able	Percentage Harvest-able	Weight* Unharvest-able	Number Un-harvestable	Percentage Unharvest-able	Harvest Weight	Total Number	Mean Harvest Weight
1	2,779	1,930	97.1	24.0	58	2.9	2,803	1,988	1.40
2	2,264	1,891	95.5	34.0	90	4.5	2,298	1,981	1.16
3	2,454	1,900	95.4	36.0	92	4.6	2,490	1,992	1.25
4	2,140	1,879	95.8	36.0	82	4.2	2,176	1,961	1.10
5	2,397	1,915	97.3	24.0	54	2.7	2,421	1,969	1.22
6	2,275	1,904	96.6	32.0	68	3.4	2,307	1,972	1.17
7	2,180	1,739	92.5	57.0	141	7.5	2,237	1,880	1.19
8	2,462	2,282	96.7	39.0	78	3.3	2,501	2,360	1.06
	18,951	15,440	95.9	282.0	663	4.1	19,233	16,103	1.20

*Fish weighing 3/4 lb and more were considered harvestable.

Table 8.- Mortalities of Channel Catfish Grown in Flowing Water, 1972, Coastal Plain Experiment Station, Fifton, Georgia.

	Raceway								
	1	2	3	4	5	6	7	8	Percentage
April	2	4	3	4	4	3	30	0	16.8
May	4	4	1	9	8	16	22	19	27.9
June	3	6	1	18	8	4	29	12	27.3
July	3	4	2	5	7	3	24	9	19.2
August	0	1	1	2	4	2	14	0	8.1
Septembei	0	0	0	1	0	0	1	0	0.7
Total	12	19	8	39	31	28	120	40	

Table 9. Parasites found and treatments given to Catfish grown in Raceways, 1972, Coastal Plain Experiment Station, Tifton, Georgia.

Date	Number Fish Examined	Parasites Present	Degree of Infestation	Treatment
April 4	10	*Cleidodiscus*	Slight	150 ppm Formalin
		Trichodina	Slight	as transported
April 19	6	*Cleidodiscus*	Slight	
	Trichodina	*Slight*	Slight	
April 26	2	*Cleidodiscus*	Slight	
		Trichodina	Medium	
		Scyphidia	Slight	
May 3	3	*Cleidodiscus*	Heavy	30 ppm Formalin
		Trichodina	Heavy	with water flow
		Scyphidia	Heavy	stopped for 1 hr.
May 10	6	None		

May 17	3	*Trichodina*	Medium	
May 24	6	*Trichodina*	Heavy	30 ppm Formalin with water flow stopped for 1 hr.
May 31	3	None		
June 7	5	None		
June 14	3	*Trichodina*	Slight	
June 21	3	*Cleidodiscus*	Slight	
		Trichodina	Slight	
June 28	5	*Cleidodiscus*	Medium	
		Trichodina	Medium	
		Scyphidia	Medium	
July 11	1	*Cleidodiscus*	Heavy	30 ppm Formalin with water flow stopped for 1.5 hr.
		Trichodina	Heavy	
		Scyphidia	Heavy	
July 17	6	*Cleidodiscus*	Slight	
August 2	4	*Cleidodiscus*	Medium	30 ppm Formalin with water flow stopped for 1 hr.
August 16	4	*Cleidodiscus*	Slight	
		Trichodina	Slight	
August 31	4	*Trichodina*	Slight	
September 12	4	*Trichodina*	Slight	

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