CAGE PERFORMANCE AND QUALITY COMPARISONS OF TILAPIA AND DIVERGENTLY SELECTED CHANNEL CATFISH

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Abstract: Six groups of cage-grown channel catfish (*Ictalurus punctata*) and *Tilapia aurea* were compared for body weight, total length, condition factor, carcass characteristics, and sensory quality. Catfish used in this study were the first generation progeny of brood catfish selected for increased and decreased body weight and for body weight variability at 48-week post-spawning age. A random-bred control line and a group of pond-raised catfish were also included in the experiment. Results indicated that 1 generation of divergent selection has increased body weight and body weight variability in the upward lines but no declines were observed in the downward lines. Selection for improved growth rate may also produce catfish more uniform in size. In the taste test tilapia were preferred over catfish.

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An important problem facing catfish breeders is the prediction of the future performance of a tremendously large number of fry hatched from each spawn. Performance of individual catfish hatched from the same spawn (one family), as well as those hatched from different spawns vary greatly. This provides opportunity for a catfish breeder to practice both between-and within-family selection. However, insufficient space, facilities, personnel, and funds always limit the number of families that can be raised and the duration that they can be kept. Family coefficient of variation and family mean for body weight at 40 weeks of age are currently being used in a long-term divergent selection scheme for size uniformity and growth rate of channel catfish at the Coastal Plain Experiment Station in Tifton, Georgia. Selected families are also subjected to within-family selection.

This study describes the growth and quality comparisons of various selected and unselected groups of channel catfish (*Ictalurus punctatus*) and *Tilapia aurea* grown in cages. Tilapia were included in this experiment to study their cage performance under environmental conditions similar to channel catfish and to study their market acceptability.

METHODS

Channel catfish used in this study were the first generation progeny of 5-year old brood catfish hatched from 30 families in 1974 and reared at Skidaway Island, Georgia, under warm water-high density conditions. Selection was practiced in downward and upward directions for body weight (Wt+ and Wt-) and for body weight variability (Cv+ and Cv-) at 48 weeks post-spawning age. A random-bred control line was also maintained simultaneously with the selected lines. Selected and control brood catfish were transferred to Tifton, Georgia, in 1976 when they were approximately 2 years old. Male and female catfish from each of the 4 selected groups were pair-mated in 240 x 150 cm wire-fenced spawning pens located in 0.1-ha ponds. Egg masses were artificially hatched in the summer of 1978 and the fry were kept indoors in fiberglass culture tanks for 40 weeks. Shortly after 40 weeks of age, fingerling catfish were sexed, individually weighed and measured for total length, branded, and placed in 1.3-cm plastic mesh cages (76 x 117 x 122 cm for width, length, and height, respectively) with a water depth of 91 cm in a 2-ha reservoir. Cages were arranged in sets of 2 which were fastened to a rectangular frame of 5-cm diameter PVC pipe (610 x 127 cm) for flotation.

An additional group of pond-raised channel catfish, larger in size than selected and control catfish, was also added to the test for comparisons with other groups. These catfish were hatched from the spawns accidentally left in a 0.1-ha pond and had remained in the pond with the brood catfish thereafter. Tilapia used in this study were approximately the same age as the catfish and were raised in indoor tanks under similar environmental conditions. They were the first generation progeny of a tilapia population transferred from Auburn, Alabama, to Tifton, Georgia, in 1977.

Twenty male and 20 female fish from each of the 7 groups were randomly assigned to each cage. There were 2 cages/group with a total of 560 fish for this experiment. Cages were randomly placed on the rectangular frames to account for possible location differences. The experimental fish were fed a commercial diet (40% protein) at a rate of 3 percent estimated body weight daily for a period of 18 weeks. Data were collected and fish were rebranded 8 weeks after initiation of the experiment.

Carcass information and taste data were obtained from a random sample of 10 fish per cage (5 males and 5 females). Thirty-one judges (men and women) were selected on the basis of interest and willingness to serve on a fish taste-panel to evaluate quality factors and not on the basis of their previous experience in sensory tests. Each taste-panel member was given one cleaned fish from each of the 7 groups (a total of 7 fish) to take home and was asked to cook a small sample from each fish by the method of his choice (4 of the judges mistakenly received an extra Cv+ catfish instead of a control). Judges were instructed to cook the 7 fish samples simultaneously by the same cooking method. Each judge was asked to determine the texture and aroma of each sample and to use a 7-point scale (0 for unacceptable to 6 for excellent) for overall ratings. Each panel member also ranked the 7 samples based on overall quality factors.

Statistical procedures involved least-squares analysis of variance and mean comparisons using SAS-76 package (Barr et al. 1976). Sources of variation were replication, line, sex, and line x sex interaction. Additional least-squares analyses were performed for each sex independently. Body weights were adjusted to a common total length by including the total length as a covariate term in the model.

RESULTS

Cage performance of 4 divergently selected and control lines of channel catfish are presented in Table 1. According to these results, line and sex effects were significant for body weight and total length at the beginning, after 8 weeks, and at the end of the experiment. Line x sex interaction was not significant for any of the traits at any period. Means for body weight, total length, and condition factor of pond-raised catfish and tilapia are shown in Table 2. Weekly gain and total length increase and the coefficients of variation for body weight of all 7 groups are presented in Table 3.

The results (Table 1) show substantial variation among different lines of channel catfish in the response of the growth to divergent selection. Catfish from the accelerated growth line (Wt+) were approximately 46 percent heavier than the control line at the beginning and 8 weeks after the initiation of the experiment. The total length advantages at the beginning and after 8 weeks were 13.4 percent and 11.3 percent, respectively. Body weight and total length superiority of the Wt+ line over the control were 33.2 percent and 10.1 percent, respectively, at the termination of the experiment. All these differences were statistically significant ($P < 0.01$). However, when body weight means adjusted for equal total length (Wt_a) were considered (Table 1), Wt+ and control catfish were similar after 8 weeks and at the end of the experiment. The 2 lines were also similar with regard to condition factor ($Wt \times 10^2/TL^3$, where body weight (Wt) is expressed in g and total length (TL) in cm). These results indicate that Wt+ catfish possess the genetic potential to gain and increase in length more rapidly than the control group but the weight-length relationships are similar for the 2 groups.

Table 1. Least-squares means, number of fish (N), and coefficient of variation (Cv) for body weight (Wt), total length (TL), body weight adjusted for total length variation (Wt_a), and condition factor (CF) at the beginning, after 8 weeks, and at the end of the experiment.

		Initial				After 8 weeks				After 18 weeks				
		N	Wt	TL	Wt_a	N	Wt	TL	Wt_a	N	Wt	TL	Wt_a	CF
Line			**	**	**		**	**	**		**	**	**	**
	Ctl	80	41 c	171 c	55 a	80	111 d	240 d	152 b	66	301 c	316 c	369 bc	0.96 b
	Wt+	80	60 a	194 a	50 b	80	162 b	267 ab	148 bc	80	401 b	348 a	365 c	0.93 bc
	Wt-	80	50 b	185 b	50 b	79	130 c	253 c	144 c	80	327 c	329 b	353 c	0.87 c
	Cv+	80	59 a	189 ab	55 a	79	162 b	265 b	151 b	73	409 ab	345 a	384 b	0.93 bc
	Cv-	80	57 a	185 b	56 a	79	195 a	272 a	168 a	76	439 a	345 a	412 a	1.03 a
Sex			**	**	NS		*	*	NS		**	**	**	*
	♀	200	48	179	53	198	145	255	153	190	349	332	365	0.92
	♂	200	59	190	53	199	158	262	152	185	401	341	388	0.97
Overall														
	Mean[1]	400	53	185	53	397	153	260	153	375	375	337	375	0.94
	Cv(%)	400	45.8	12.2	15.4	397	38.3	9.6	16.3	375	30.0	8.8	15.4	23.0

a,b,c,d Column means for the 5 lines of catfish with no letters in common are significantly ($P < 0.05$) different.

*, **Significant line or sex effects ($P < 0.05$ or $P < 0.01$).

NS Not significant

[1]All body weight and total length measurements are in grams and millimeters, respectively.

Table 2. Least-squares means for body weight (Wt), total length (TL), and condition factor (CF) of pond-raised channel catfish and tilapia at the beginning, after 8 weeks, and end of the cage experiment.

		Initial			After 8 weeks			After 18 weeks			
		N[1]	Wt	TL	N	Wt	TL	N	Wt	TL	CF
Catfish											
	Female	40	275[2]	318	40	617	393	40	1048	452	1.11
	Male	40	283	321	38	678	402	38	1240	478	1.12
	Combined	80	279	319	78	647	397	78	1144	465	1.12
Tilapia											
	Female	40	116	184	37	255	233	37	363	265	1.92
	Male	40	187	213	40	534	287	40	676	318	2.07
	Combined	80	152	199	77	395	260	77	519	292	2.00

[1]Number of fish.

[2]All body weight and total length measurements are in grams and millimeters, respectively.

Table 3. Weekly gain, weekly increase in total length (TL), coefficient of variation (Cv) for body weight at the beginning and at the end of the cage experiment.

	Weekly gain (g)			Weekly growth in TL (mm)			Cv (%) at the start			Cv (%) at the end		
	Female	Male	Combined	Female	Male	Combined	Female	Male	Combined	Female	Male	Combined
Control	13.9	14.6	14.3	8.1	7.8	8.0	46.6	47.7	49.7	26.6	27.3	27.2
Wt+	18.2	19.6	18.9	8.6	8.6	8.6	37.5	36.7	37.8	25.7	29.8	28.7
Wt-	15.1	15.6	15.3	8.1	7.9	8.0	42.1	49.3	45.7	34.3	40.8	38.0
Cv+	16.5	22.6	19.5	8.3	9.0	8.7	51.3	56.1	55.8	38.5	44.5	42.9
Cv-	19.8	22.7	20.8	9.1	8.7	8.9	34.8	58.3	53.3	34.8	46.5	42.2
Pond	42.9	53.2	48.1	7.4	8.7	8.1	29.3	37.4	33.5	23.8	21.1	23.7
Tilapia	13.7	27.2	20.4	4.5	5.8	5.2	32.3	27.6	37.3	20.6	21.9	37.7

The Wt- catfish included in this study were approximately 22 percent heavier and 8 percent longer than the control catfish at the beginning of the experiment (Table 1). These advantages were reduced to 17 percent for body weight and 5.4 percent for total length after 8 weeks. All these differences were statistically significant ($P < 0.01$). The 2 lines did not differ significantly in final body weight but Wt- catfish were 4.1 percent longer ($P < 0.05$) than the control line at the end of the experiment. Although the results confirm a decreasing trend in body weight and total length of the Wt- vs control, the 2 lines did not diverge in the expected direction during the 18-week experimental period. Results indicate that the 2 lines were similar in adjusted body weight but significantly ($P < 0.05$) different in regard to condition factor (Table 1) which confirms that Wt- catfish are capable of growing in length more rapidly than the control line but not in gaining weight.

When the 2 sexes were combined, Wt+ catfish exceeded the control and Wt- catfish in weekly rate of gain by approximately 32 percent and 24 percent, respectively (Table 3), and were significantly ($P < 0.05$) heavier than both groups at the termination of the experiment (Table 1). The rate of weekly increase in total length of Wt+ catfish also exceeded both control and Wt- catfish by 7.5 percent (Table 3), and the Wt+ catfish were significantly ($P < 0.05$) longer than control and Wt- catfish throughout the experimental period (Table 1). These results suggest that 1 generation of divergent selection for body weight has been effective in changing body weight and total length of catfish in the expected direction in the upward line but not in the downward line.

One generation of selection for size uniformity (Cv+ vs Cv-) was not effective in changing the coefficient of variation for body weight in 2 directions as evident from Table 3 (sexes combined). Selection for increased coefficient of variation, however, did increase the coefficient of variation by 57.7 percent as compared to control catfish. Comparisons of the coefficients of variation at the beginning and at the end of the experiment (Table 3) indicate that an increase in body weight of male and female catfish and tilapia is associated with a decrease in coefficient of variation for body weight. This was also evident from the lowest coefficient of variation for body weight (23.7%) produced by the largest of all 6 catfish groups (pond-raised in Table 2). These results also suggest that selection for improved growth rate may reduce the coefficient of variation (Cv for Wt+ vs Cv for Wt- in Table 3) as selection for increased and decreased family coefficient of variation of body weight has significantly increased body weight and total length (Table 1).

Pond-raised catfish (the 2 sexes combined) were over 5 times heavier than all other catfish combined (279 g in Table 2 vs 53 g in Table 1) and 1.7 times longer (319 mm in Table 2 vs 185 mm in Table 1) at the beginning of the experiment. Corresponding values at the termination of the experiment were 3.1 and 1.4 times, respectively. These differences were highly ($P < 0.01$) significant and were displayed even after the body weight measurements were adjusted for the variation in total length. Pond-raised catfish had a substantial size advantage over other groups of catfish at the beginning of the experiment but also performed well during the 18-week cage test with the most rapid growth rate and weekly total length increase of all catfish groups (Table 3). These results show that in a selection program or a performance test with catfish, initial weight will influence the subsequent weights and total length substantially.

Tilapia included in this study were approximately the same age as the selected and control catfish shown in Table 1 and were treated similarly in this cage test. Male tilapia were approximately 61 percent heavier and 16 percent longer than female tilapia prior to the start of the cage test (Table 2). Corresponding values after 18 weeks were 86 percent for body weight and 20 percent for total length. These differences were statistically significant ($P < 0.01$). Weekly rate of gain (Table 3) indicate that both male and female tilapia are well adaptable for cage-rearing with satisfactory performance. When age, feed, water condition, cage density, etc. were the same, the weekly gain of female tilapia were comparable to unselected female catfish but the male tilapia outgained the male catfish

(Table 3). Weekly rate of growth in total length of female and male tilapia were 4.5 mm and 5.8 mm, respectively, compared to approximately 8 mm/week for channel catfish. Condition factor for tilapia was approximately 2.0 (Table 2) compared with 1.0 or less (Table 1) for channel catfish which is due to a marked difference in the growth pattern of the 2 species with regard to weight-length relationship.

Number of fish (N) shown in Tables 1 and 2 indicates that survival rates were similar for all 7 groups. A few fish were lost due to mishandling (mainly from Ctl and Cv + lines) but no important fish loss occurred during the 18-week cage test.

Male fish from both species were significantly heavier and longer than female fish (Tables 1 and 2). The condition factor for male of both species was also higher than for females. Relative variability, measured by coefficient of variation (Table 1), was over 3 times greater for body weight than total length. However, when body weight was considered on a common total length basis, coefficient of variation was reduced considerably (Table 1).

Carcass data and correlation coefficients between the traits are shown for each sex in Tables 4 and 5, respectively. Although carcass weight (cleaned weight) varied significantly among the groups and between the sexes, no significant differences in dressing percentage (carcass weight expressed as percentages of body weight) were observed among the groups (Table 4). Body weight, total length, and carcass weight of male and female from both species were significantly ($P < 0.01$) correlated at the termination of the experiment (Table 5). Changes in dressing percentage of tilapia or pond-grown catfish were not associated with the changes in body weight or total length. However, when the remaining 5 groups of catfish were combined (for simplicity of presentation and to increase the sample size), correlation between dressing percentage and body weight, total length, and carcass weight were significant for both sexes (Table 5). Head weight constituted approximately 25 percent of the body weight ranging from 24 percent to 27 percent for males and 20 percent to 29 percent for females (Table 4). Female fish of both species showed significant variation in head weight when expressed as percentages of body weight; however, male fish were more uniform in this regard.

In the sensory evaluations (Table 6), all the fish scored above average (3.0) in overall rating and the mean scores for the 7 groups were not significantly different from each other. The 6 groups of catfish were also similar in aroma but varied with regard to texture. Except for the control catfish which 50 percent of the panelists evaluated as having mushy texture, the majority of the judges determined desirable texture for the remaining 5 groups of catfish. Although none of the panel members detected a tilapia with undesirable texture, approximately 20 percent indicated an unfavorable aroma for tilapia. In overall ranking, however, 17 of the 31 judges (55%) indicated first or second preference for tilapia as compared to 14.8 percent for control, 16 percent for the pond-raised, 24 percent for Cv+ and Cv-, and 21 percent for WT+ and Wt- catfish. The respective percentages for the last 2 choices ranked by the same judges were 23 percent, 19 percent, 39 percent, 15 percent, and 23 percent. These results indicate a preference for cage-grown tilapia over cage-grown catfish. Panel members also showed least preference for the pond-raised catfish.

DISCUSSION

Although the cage culture of tilapia has not been extensively studied, several investigators (Schmittou 1969, Collins 1970, Hill 1974, Konikoff and Lewis 1974) have reported on the feasibility of rearing catfish in cages. Results of the present study also demonstrate that both species are well adapted for intensive cage culture.

The results summarized in Table 3 indicate significant variation in growth rate between different selected and control catfish but also clearly demonstrate that relative variability

Table 4. Carcass information obtained from cage-grown tilapia and channel catfish.

	Carcass weight (g)			Dressing percent			Head weight (as % of body weight)		
	Female	Male	Combined	Female	Male	Combined	Female	Male	Combined
Control	182 b	191 e	187 d	62.6 a	60.2 a	61.4 a	24.4 b	27.6 a	26.0 ab
Wt+	240 b	283 cd	261 c	62.8 a	60.5 a	61.7 a	24.0 b	24.2 a	24.1 bc
Wt-	229 b	255 d	242 c	63.1 a	63.5 a	63.3 a	22.7 b	25.1 a	23.9 bc
Cv+	238 b	335 c	287 bc	63.0 a	63.5 a	63.3 a	24.3 b	24.1 a	24.2 bc
Cv-	246 b	299 cd	272 c	63.5 a	62.0 a	62.7 a	27.9 a	26.5 a	27.2 a
Pond	621 a	721 a	671 a	61.0 a	62.2 a	61.6 a	19.9 c	24.3 a	22.1 c
Tilapia	224 b	442 b	333 b	62.3 a	64.0 a	63.1 a	29.5 a	26.9 a	28.2 a

a,b,c,d Means in the same column with different letters differ significantly ($P < 0.05$).

Table 5. Correlations between body weight, total length, carcass weight, and dressing percent of cage-grown tilapia and channel catfish.

		Female			Male		
	Characteristic	Body wt.	Total length	Carcass wt.	Body wt.	Total length	Carcass wt.
Tilapia:	Total length	0.92 a			0.82 a		
(N=10)	Carcass wt.	0.99 a	0.88 a		0.97 a	0.80 a	
	Dressing percent	0.23	0.03	0.36	0.33	0.30	0.54
Pond-raised							
(N=10)	Total length	0.91 a			0.99 a		
	Carcass wt.	0.85 a	0.81 a		0.99 a	0.99 a	
	Dressing percent	-0.57	-0.45	-0.05	0.41	0.43	0.48
Wt+, Wt-, Cv+, Cv- & control combined							
(N=50)	Total length	0.83 a			0.91 a		
	Carcass wt.	0.99 a	0.83 a		0.99 a	0.91 a	
	Dressing percent	0.28 b	0.28 b	0.37 a	0.38 a	0.44 a	0.45 a

a $P < 0.01$.

b $P < 0.05$.

Table 6. Taste results of cage-grown catfish and tilapia.

	Overall rating		Aroma		Texture			Rank	
	N[1]	Score	Favorable	Unfavorable	Desirable	Tough	Mushy	First 2	Last 2
Control	27	3.5	12	0	7	0	7	4	5
Wt+	31	3.6	17	0	14	1	3	6	8
Wt-	31	4.0	17	0	11	0	7	7	6
Cv+	35	4.1	21	0	20	0	2	8	4
Cv-	31	3.7	18	2	13	0	7	8	6
Pond	31	3.2	16	3	12	2	6	5	12
Tilapia	31	4.4	15	4	18	0	0	17	7

[1]Number of judges.

in body weight will decrease with age. Body weight and total length were highly correlated in both sexes (Table 5); however, coefficient of variation for body weight was 30.0 percent vs 8.8 percent for total length (Table 1). Significant correlation between body weight and total length of catfish at the same age has also been reported by El-Ibiary et al. (1978). Condition factor differences between tilapia and catfish (Tables 1 and 2) were indicative of natural differences in weight-length relationships between the 2 species. According to the results shown in Table 3, female tilapia were comparable in weekly rate of growth to control catfish while kept in cages, but the male tilapia grew almost twice as much as the male catfish from the control line.

A major objective of the present study was to examine the response of channel catfish to divergent selection in body weight. The experimental results suggest that 1 generation of such selection has not created growth variability in both directions and should be continued for several more generations. The results also suggest that asymmetrical response to selection for body weight found in mice (Falconer 1960) may also exist in channel catfish.

Results of the sensory evaluations indicated that tilapia and various selected and non-selected catfish groups included in this experiment will be acceptable to the consumer. Although the overall scores for the 7 groups of catfish and tilapia were not significantly different, judges clearly indicated a preference for tilapia in overall ranking. Since the majority of the panel members had not previously tasted tilapia, such preference strongly suggests a market potential for tilapia. A preference was also noted for the small catfish as opposed to very large catfish in overall ranking. Baldwin et al. (1961) has also reported differences in trends among species of fish with regard to their size and flavor relationship.

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