

GROWTH COMPARISON OF INBRED AND RANDOMBRED CATFISH AT DIFFERENT TEMPERATURES

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Abstract: First generation inbred channel catfish (*Ictalurus punctatus*) were produced from full brother-sister matings to be compared in growth response to various temperature regimes to a control family produced from the same base population. Temperature regimes involved: (1) constant 22 C well water for 28 weeks, (2) well water heated to 27 C for 20 weeks and not heated (22 C) for the subsequent 8 weeks, and (3) ambient temperature of a 2-ha reservoir. Results indicated that genetic divergence between 2 lines was associated with a differential response to temperature regime. Weekly weight gain and total length growth were the highest in ambient temperature, intermediate in 27C, and least in 22 C temperature. Inbred catfish gained more than the controls in all 3 temperatures.

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Fundamental information on the effects of inbreeding on production traits of channel catfish reported to date is scant. An experiment was begun at the Coastal Plain Experiment Station in 1979 to determine the effects of intense inbreeding on production traits of channel catfish. Studies with carp (Moav and Wohlfarth 1966), Atlantic salmon (Ryman 1970), and trout (Kincaid 1976) demonstrated that inbreeding results in loss of vigor as it is associated with some decrease in growth rate, body size, and fertility, and an increase in fry deformity. Crosses among inbred lines, however, regain the lost vigor as predicted by Wright (1922) and successfully tested by plant and animal breeders.

Due to the large number of fry hatched from each spawn, inbreeding is an unavoidable consequence of intensive culturing and selective breeding of channel catfish. Pure breeding, another common procedure in stock improvement, is based on interbreeding closely related individuals which increases the inbreeding coefficient. However, hybrid vigor is associated with the crossing of pure lines, and necessitates the maintenance of 2 or more pure lines (Wilkins 1981).

A study in progress at the Coastal Plain Experiment Station is designed to determine the effect of increasing level of inbreeding (full-sib matings) on growth, survival, and reproductive traits of channel catfish. The objective of the preliminary stage of the current study reported herein was to compare the growth response of 1st generation inbred ($F = 0.25$) and randombred ($F = 0$) channel catfish to different water temperatures.

METHODS

First generation inbred catfish were produced from full brother-sister matings in summer 1979. A control line (random mating) was also produced from the same base population to be used for the evaluation of the inbred fish. The parent male and female catfish from the base population were pair-mated in 240 × 150 cm

wire-fenced spawning pens located in a 0.1-ha pond. Egg masses were artificially hatched and the fry were kept indoors in fiberglass culture tanks for 40 weeks.

Shortly after 45 weeks of age, 1 full-sib family of inbred and 1 full-sib family of control were randomly selected from among all available families for this experiment. From a total of 200 inbred fish (full-sibs), reared in 1 indoor tank (122 cm in diameter), 45 males and 45 females were randomly selected, individually weighed and measured for total length, and branded. The same procedures were used to randomly select 45 males and 45 females (full-sibs) from the 200 fish in the control family. The fish were then divided into 3 groups of 60 fish each at random and were assigned to 22 C well water, 27 C well water, and ambient temperature, respectively (Rep. 1). Each group consisted of 15 males and 15 females from each of the inbred and control families. Fish for the 2nd replicate (Rep. 2) were selected from the remainder of the fish in the 2 full-sib families by an identical procedure. Four circular indoor tanks (122 cm in diameter), each supplied with a constant flow of well water at an approximate rate of 11 l/min were used for the 22 C and 27 C temperature groups. Temperature of the water in 2 of the 4 tanks was a constant 22 C; however, well water was preheated to 27 C in the remaining 2 tanks for 20 weeks. Catfish from both temperature groups were kept in 22 C well water from the 20th to the 28th week of the experimental period. The ambient temperature group involved 2 floating cages (76 × 177 × 122 cm) placed in a 2-ha reservoir. The water depth was about 90 cm in each cage. All fish were fed a commercial floating ration (about 38% protein) *ad libitum*.

Statistical Procedure

Data were analyzed by the general linear model of the Statistical Analysis System (Barr et al. 1979). Individual catfish were considered as the experimental unit for body weight and total length. Weekly gain and weekly increase in total length were determined on a group basis and were not subjected to statistical analysis. Also, data from tank-cultured and cage-cultured catfish were analyzed independently since the 2 measurements were taken at different ages. The statistical model used for the analysis of tank data included: replication, temperature, line, sex, and all possible interactions. An identical model with the exception of temperature effect was used to analyze the cage data. Residual mean square was used to test the significance of each effect.

RESULTS AND DISCUSSION

Tank-grown Catfish

The effects of temperature, line, and sex, included in the model for the analysis of body weight and total length of the tank-grown catfish, were highly significant ($P < 0.01$) after 20 and 28 weeks of the experimental period (Table 1). The effect of temperature × line interaction on body weight and total length was also significant (Table 1), whereas the replicate effect and the effects of all interactions involving sex were not.

Catfish assigned to 22 C and 27 C temperature groups were similar in body weight and total length at the beginning of the experiment (Table 1). After 20

Table 1. Effects of water temperature on body weight (Wt) and total length (TL) of tank-grown inbred and control channel catfish.

Category	Initial			After 20 weeks			After 28 weeks		
	N	Wt	TL	N	Wt	TL	N	Wt	TL
<u>Temperature (T)</u>									
22 C	120	113	226	119	302A ^a	309A	119	395A	337A
27 C	120	108	227	119	385B	352B	117	507B	376B
% ^b		96	100		127	114		128	112
<u>Line (L)</u>									
Control	120	66A	202A	119	249A	304A	118	348A	333A
Inbred	120	115B	251B	119	437B	356B	118	553B	380B
% ^c		174	124		176	117		159	114
<u>T×L interaction</u>									
Control									
22 C	60	62	198	59	189A	277A	59	258A	305A
27 C	60	70	206	60	309B	332B	59	438B	361B
% ^b		113	104		163	120		170	118
Inbred									
22 C	60	165	254	60	413C	342C	60	531C	369C
27 C	60	146	248	59	461D	371D	58	579D	392D
% ^b		88	98		112	108		109	106
Sex									
♀	120	102A	223C	119	288A	317A	119	383A	343A
♂	120	119B	230D	119	403B	344B	117	518B	370B
% ^d		117	103		140	109		135	108

^a Means, within a main effect or interaction, with different letters differ (A or B, $P < 0.01$; C or D, $P < 0.05$).

^b Mean body weight (g) and total length (mm) of catfish grown in 27 C well water expressed as percentages of those grown in 22 C well water.

^c Mean body weight (g) and total length (mm) of inbred catfish expressed as percentages of control catfish.

^d Mean body weight (g) and total length (mm) of male catfish expressed as percentages of female catfish.

weeks, however, the catfish grown in preheated well water (27 C) were 27% heavier and 14% longer than those grown in 22 C well water. These differences were highly significant ($P < 0.01$). Results summarized in Table 2 indicated that an increment of 5 C in water temperature increased the weekly rate of gain and total length growth of channel catfish by 46 and 50%, respectively. When well water was no longer heated from the 20th to the 28th weeks of the experimental period, the catfish previously grown in preheated water for 20 weeks continued to gain 32% more weight per week than those grown in 22 C water during both periods (Table 2). Conversely, the weekly rate of increase in body length of the catfish previously

grown in 27 C well water was 0.5 mm less than those of the 22 C temperature group in this period. When the 2 periods were combined, catfish from the 27 C temperature group were 28% heavier and 12% longer (Table 1) than those grown in 22 C. The weekly length growth of the 27 C catfish during the 20th to the 28th weeks of the experimental period (Table 2) was less than 50% of the growth during the 1st 20 weeks (3.0 vs. 6.3 mm). These results indicated that the effect of 5 C reduction in water temperature is more pronounced on length growth than on weight gain of channel catfish.

Table 2. Average weekly gain (g) and total length increase in mm (TL+) of control and inbred channel catfish grown in 2 different water temperatures.

		20 weeks		20-28 weeks		28 weeks	
		Gain	TL+	Gain	TL+	Gain	TL+
<u>Temperature (TL)</u>							
	22 C	9.5	4.2	11.6	3.5	10.1	4.0
	27 C	13.9	6.3	15.3	3.0	14.3	5.3
	% ^a	146	150	132	86	142	133
<u>Line (L)</u>							
	Control	9.2	5.1	12.4	3.6	10.1	4.7
	Inbred	14.1	5.3	14.5	3.0	14.2	4.6
	% ^b	153	104	117	83	141	98
<u>T×L</u>							
Control							
	22 C	6.4	4.0	8.6	3.5	7.0	3.8
	27 C	12.0	6.3	16.1	3.6	13.1	5.5
	% ^a	188	158	187	103	187	145
Inbred							
	22 C	12.4	4.4	14.8	3.4	13.1	4.1
	27 C	15.8	6.2	14.8	2.6	15.5	5.1
	% ^a	127	141	100	76	118	124
<u>Sex</u>							
	♀	9.3	4.7	11.9	3.3	10.0	4.3
	♂	14.2	5.7	14.4	3.3	14.3	5.0
	% ^c	153	121	121	100	143	116

^a Average weekly gain and total length increase of channel catfish grown in 27 C well water expressed as percentages of those grown in 22 C well water.

^b Average weekly gain and total length increase of inbred catfish expressed as percentages of control catfish.

^c Average weekly gain and total length increase of male catfish expressed as percentages of female catfish.

The inbred catfish, randomly selected for this study, were superior in body weight and total length to the control group at the beginning of the experiment and remained superior throughout the 28-week experimental period (Table 1). Inbred

catfish were in a generally more favorable condition when preheated well water was used during the 1st 20 weeks. They gained 53% more per week (14.1 vs. 9.2 g) and increased in length 4% more per week (5.3 mm vs. 5.1 mm) than the control group during this period (Table 2). However, when heated water was not used during the last 8 weeks, the rate of weekly weight gain of inbred catfish exceeded the control by 17% but the rate of length increase was 17% less per week than the control group (Table 2).

Inasmuch as the line superiority for body weight and total length is concerned, it appears that the inbred family was superior to control at the beginning and remained superior throughout the 28-week experimental period (Table 1). Since only 1 family from each line was randomly selected for this study, the inbred superiority in this instance is probably due to chance. Interest in this study centers on the relative growth performance of inbred and control catfish in different temperature regimes.

Control catfish grown in 27 C water for 20 weeks were 63% heavier and 20% longer than their full-sibs grown in 22 C water. Corresponding differences for the inbred catfish were 12 and 8%, respectively (Table 1). These differences were statistically significant ($P < 0.01$). The weekly rate of increase in body weight and total length (Table 2) indicated that control catfish from the 27 C temperature group gained 88% more weight per week and grew 58% more in length per week than their full-sibs grown in 22 C water for 20 weeks. Corresponding values for the inbred fish were 27 and 41%, respectively. Control and inbred catfish grown in 27 C well water for 20 weeks and then shifted to 22 C well water for 8 weeks were significantly heavier and longer than their respective full-sib counterparts grown at a constant temperature of 22 C (Table 1). The weekly weight gain and length growth advantages of the control fish over their full-sibs in 22 C water were 87 and 3%, respectively. When the inbred catfish from both temperature groups were grown in 22 C well water for 8 weeks, the 2 groups were equal in the rate of weekly gain. The weekly length growth of the catfish from 27 C group was, however, 24% less (2.6 mm vs. 3.4 mm) than those of the 22 C group (Table 2).

These results strongly confirm the differential response of inbred and control catfish to water temperatures. Exposure of control catfish to a temperature of 27 C for 20 weeks influenced their subsequent growth rate in 22 C temperature for 8 weeks. However, this was not the case with the inbred catfish since the group exposed to 27 C exhibited no growth advantage during the 8-week period in 22 C well water over the group grown at a constant temperature of 22 C. When the 2 periods were combined, control catfish from the 27 C temperature group gained 87% more per week and grew 45% more in length than their full-sibs in 22 C temperature. Corresponding values for the inbred group were 18 and 24%, respectively (Table 2). These results indicate some degree of genetic divergence among lines at the current level of inbreeding ($F = 0.25$). They also suggest that any increase in homozygosity may be associated with a differential response to temperature regime and possibly other components of the environmental condition.

Male catfish were 17% heavier and 3% longer than females at the beginning, 40% heavier and 9% longer after 20 weeks, and 35% heavier and 8% longer after 28 weeks (Table 1). These differences were statistically significant. The weekly gain of the male catfish exceeded the weekly gain of the female catfish by 53% during the 1st 20 weeks when heated water was also used. The respective value

was 21% during the subsequent 8 weeks in 22 C temperature (Table 2). Male and female catfish from control and inbred lines did not respond differently to the change in water temperature.

Cage-grown Catfish

Inbred catfish assigned to ambient temperature (21-33 C) were also heavier and longer than control catfish at the beginning and remained heavier and longer at the termination of the experiment (Table 3). Differences in body weight and total length were, however, twice as large after 25 weeks than they were initially. Inbred catfish gained 56% more per week in weight and grew 16% more per week in length than did the control catfish. The weekly rates of gain of control catfish were 6.4, 12.0, and 15.6 g in 22 C, 27 C, and ambient temperature, respectively (Tables 2, 3). Corresponding values for the inbred catfish were 12.4, 15.8, and 24.4 g, respectively. These results confirmed that inbred catfish performed better than control in all 3 temperatures and that all fish performed better in the ambient temperature than did their full-sibs in the controlled temperatures of the indoor tanks. Weekly gain and increase in total length of the cage-grown male catfish were 29 and 14% more than females (Table 3). These differences were not as large as those obtained from tank-grown catfish (Table 2).

Table 3. Effects of ambient water temperatures on body weight (Wt), total length (TL), weekly gain (g), and weekly increase in total length (TL+) of channel catfish grown in cages.

Line	Intital ^a			After 25 weeks			Weekly growth ^b	
	N	Wt	TL	N	Wt	TL	Gain	TL+
Control	60	98A ^c	223C	59	488A	383A	15.6	6.4
Inbred	60	122B	232D	58	732B	417B	24.4	7.4
% ^d		124	104		150	109	156	116
Sex								
♀	60	102A	223C	59	539A	384A	17.5	6.4
♂	60	117B	233D	58	681B	416B	22.6	7.3
% ^e		115	104		126	108	129	114

^a All body weight measurements in g and total length in mm.

^b Test of significance was not performed.

^c Means within a main effect with different letters differ (A or B, $P < 0.01$; C or D, $P < 0.05$).

^d Inbred means expressed as percentages of control means.

^e Male means expressed as percentages of female means.

CONCLUSION

Conclusions reached for catfish breeding experiments concerned with response of inbred and control catfish to different water temperatures are as follows: (1) One generation of brother-sister mating has created genetic diversity associated

with differential response to temperature regimes. (2) Comparisons of growth and survival of 1 inbred and 1 control family in different environmental conditions indicated no decreasing effect of inbreeding depression after 1 generation, but the small number of full-sib families involved makes this conclusion uncertain. More research is needed to determine if inbreeding of channel catfish is useful in obtaining genetic improvement. (3) An increment of 5 C temperature of 22 C well water for 20 weeks increased the weekly gain of control and inbred channel catfish by 88 and 27%, respectively. Both inbred and randombred catfish performed better under the ambient temperature regime of a 2-ha reservoir than did their full-sibs under controlled temperatures of 22 C and 27 C in indoor tanks.

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