Effects of Selecting for Growth Rate on Reproductive Performance in Channel Catfish[1]

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Abstract: Two populations of channel catfish (*Ictalurus punctatus*) with different histories of domestication-Marion (Alabama) and Kansas—were grown in earthen ponds at 7,500/ha. The largest 10% of each population were selected when population mean weights were 500 g. The reproductive performance of these selects was compared to that of brood from random control populations. Data were analyzed for each strain then pooled and re-analyzed. No differences were found in spawning day, spawning rate, hatchability of eggs and survival of sac fry. Fecundity (eggs deposited) was increased ($P < 0.05$) in the pooled select brood fish. Fingerling output was also higher for selects ($P < 0.05$) in the Marion and pooled populations, but lower ($P < 0.05$) in the Kansas select population. Fecundity, sac fry survival, and fry survival had the largest effects on fingerling output. Selecting for growth rate did not decrease the reproductive performance (fingerling output) in channel catfish, and some improvement in reproductive performance was evident.

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Most breeding research with channel catfish concerns growth rate (Smitherman and Pardue 1974, Burnside et al. 1975, Reagan et al. 1976, Broussard 1979, Chappell 1979, Green et al. 1979, Youngblood 1980, Dunham and Smitherman 1981). Improvement in growth rate is of little utility if seed production becomes more difficult. Mass selection is one technique to improve body weight. If careful planning and selection are not implemented, inbreeding can increase. Inbreeding causes decline in reproductive perfor-

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mance (Lasley 1978). Even if inbreeding is avoided, the traits of fast growth and good reproductive performance could be antagonistic. For these reasons, the reproductive performance of channel catfish selected for increased body weight was compared to the reproductive performance of randomly selected channel catfish.

Methods

The grandparent stock of the experimental fish used in this research were collected by Green et al. (1979) during the early 1970's. The fish were propagated at Auburn University and at state and federal fish hatcheries in Marion, Alabama.

The brood populations used were from 2 domesticated strains, Marion (M) and Kansas (K). The Marion strain was developed by the U.S. National Fish Hatchery at Marion, Alabama. Originally from the Red River, Oklahoma, this group has been maintained in ponds at Marion for about 20 years (3–5 generations). Marion and Auburn hatcheries exchanged some brood stock in 1963 and 1965. A few individuals were added at this time to increase population size when brood population size was low. The Kansas strain was acquired from a private fish hatchery in Kansas. It has been maintained there for nearly 50 years (8–15 generations). The fish originated from the Ninnescha River near Pratt, Kansas in 1911.

The channel catfish parent brood used in this study were hatched from spawns of the grandparent fish in May 1976 and evaluated for growth during the summer of 1977 (Chappell 1979). From the time of hatch the parent brood have been kept in similar ponds and treated equally at Auburn University. Four to 8 spawns (20,000–30,000 eggs/spawn) of each brood population were obtained. The fry were stocked at 148,260/ha. The fingerlings were harvested at 10 months of age and 3 random samples of 300 fish of each population were stocked into 0.04 ha experimental earthen ponds at Auburn University. Production stocking rate was 7,500 catfish/ha. The fish were harvested in mid-October 1977. Mean weight was approximately 500 g. A random sample of 90 from each population was retained for the respective control populations. These were designated random (R) brood. Then, the largest 10% of the remaining fish was kept for the selected population. These were designated select (S) brood. Individual weights were recorded for the selected fish. All fish were heat branded to retain the identity of individuals and/or populations (Moav et al. 1960, Hill et al. 1970, Joyce and El-Ibiary 1977). These potential brooders were kept in communal ponds (750/ha) during the winter of 1977–78 (Dunham and Smitherman 1981) and then grown in experimental ponds (Youngblood 1980, Dunham and Smitherman

1981) to a maximum standing crop of 1,200 kg/ha during 1978, 1979 and 1980.

In June 1980, K and M select and random brood were spawned. All fish were paired in pens within 0.1-ha ponds (Table 1). Eggs were removed from spawning containers when found and were artificially incubated in paddle wheel troughs. Small egg masses have higher hatchability than large egg masses (Bondari and Joyce 1980). Egg masses were gently separated into smaller pieces to make egg mass size similar among spawns. This is a common practice in commercial catfish culture. K and M sac fry (7 days post-hatch) were stocked at 432,425/ha in recently filled ponds. There were 100,000 fry per treatment and 6 replicates per treatment. Fry survival was determined at 40 days, when the fish weighed approximately 1–2 g.

Spawning day, spawning rate, fecundity, hatchability, sac fry survival, fry survival, and fingerling output were determined in both select and random populations. Spawning day for an individual pair is the number of days after the first spawn of the season for all channel catfish. Spawning rate is the number of matings/number of pairings. Fecundity is the number of eggs deposited/kg of female body weight. Hatchability is the number of sac fry/number of eggs. Sac fry survival was the number of swim-up fry stocked/number of eggs hatched. Fingerling output (number of fingerlings/kg of female) equals spawning rate x fecundity x hatchability x fry survival.

Means for spawning day, fecundity, hatchability, and survival, of select and random populations were compared with Students t-test (Steel and Torrie 1980). Means for fingerling output and spawning rate were compared with chi-square and chi-square contingency, respectively (Steel and Torrie 1980). All comparisons were between select and random groups within a population.

Table 1. Number of Pairings, Spawns and Mean Spawning Days for Select and Random Populations of Marion and Kansas Channel Catfish

Population[a]		Pairings	Spawns	Days
Marion	(S)	13	8	3.9
	(R)	19	8	2.6
Kansas	(S)	20	8	7.1
	(R)	19	10	5.0
pooled	(S)	33	16	5.5
	(R)	38	18	3.8

[a] S = select, R = random

Results and Discussion

Spawning day

Catfish fry that are spawned at early dates may be larger at harvest than those spawned at later dates. Synchrony in spawning may reduce labor in the hatchery operation. For these reasons, early spawning may be advantageous. In addition, if selection for growth rate were successful but correlated to late spawning, practical gains made through selection for growth rate would be reduced. However, there were no differences in spawning day between select and random brood fish in this experiment ($P > 0.05$, Table 1).

Spawning rate

There were no significant differences ($P > 0.05$) in spawning rate between select and random brood fish (Table 2). The development of the secondary sexual characters did not appear different between select and random brood fish.

Fecundity

M and K select and random egg production was not statistically different (Table 2). However, pooled egg production of select brood fish, 8,370 eggs/kg, was higher ($P < 0.05$) than that of random brood fish, 7,807 eggs/kg. Strain differences were apparent and the fecundity difference was caused by the Kansas strain. The data indicates that by selecting for growth rate egg production may be improved. Eisen (1981) also found increased fecundity in mice selected for large body weight.

Hatchability and Fry Survival

Early vigor of eggs and fry may be due to maternal effects. This early vigor and survival may also be important determinants for predator avoidance. No statistical difference was found in hatchability of eggs from select and random brood fish (Table 2). No statistical differences were found in the fry survival of select and random M, K, and pooled channel catfish (Table 2). However, fry survival was consistently lower in the M random. This strain has a history of disease problems (Smitherman and Pardue 1974, Chappell 1979, Green et al. 1979) and selection for growth rate appears to have increased viability. Conversely, selection for growth rate appeared to decrease viability in the Kansas strain.

Table 2. Spawning Rate, Fecundity, Hatchability, 10-Day Swim-Up Fry Survival, Fry Survival in Ponds, and Fingerling Output for Select and Random Populations of Marion and Kansas Channel Catfish

	Spawning Rate	Fecundity (eggs/kg)	Hatchability	10-Day Swim-Up Fry Survival	Fry Survival in Ponds	Fingerling Output (fingerlings/kg female)
Marion (S)	0.62	7,865	0.75	0.85	0.66	2,051[b]
(R)	0.42	8,226	0.69	0.73	0.50	870
Kansas (S)	0.42	8,875	0.67	0.84	0.71	1,489
(R)	0.53	7,388	0.78	0.87	0.76	2,019[b]
Pooled (S)	0.49	8,370[a]	0.71	0.85	0.69	1,688[b]
(R)	0.47	7,807	0.74	0.80	0.63	1,388

[a] Significantly different ($P < 0.05$).
[b] Significantly different ($P < 0.005$).

Fingerling Output

Total fingerling output is determined by the multiplicative effects of spawning rate, fecundity, hatchability, and fry survival. Thus fingerling output should be the best measure of total reproductive performance. Fingerling output/kg of female was higher ($P < 0.005$) in M, and pooled select brood fish than in their corresponding random brood fish (Table 2), but not in the K strain. Selecting for greater body weight generally increased total reproductive performance and fingerling output. Preliminary data with Rio Grande strain (Dunham 1981) also indicated increased fecundity, fry survival, and fingerling output in select populations. There may be a trend of less difference in reproductive performance between select and random populations with increased length of domestication. This trend is also evident for growth rate and disease resistance (Dunham 1981). One might expect less difference between select and random catfish if selection had taken place during the domestication process in the hatchery environment.

Of the factors involved in total fingerling output, fecundity and fry survival were the most important (Table 3). Spawning rate also had a significant effect ($P < 0.05$) on fingerling output. Fecundity had a significant negative effect ($P < 0.01$) on hatchability. Either splitting egg masses was not wholly effective in eliminating the environmental effect of egg mass size or there is true inverse genetic relationship between fecundity and hatchability. Environmental effects of egg mass size could be elicited shortly after deposition or could be a result of mean egg quality reduction in large egg masses. Sac fry survival and fry survival in ponds were highly correlated ($P < 0.01$). All other factors of fingerling output were not significantly correlated with each other.

Table 3. Correlations Between Spawning Rate, Egg Production, Hatchability, 10-Day Swim-Up Fry Survival, Fry Survival in Ponds, and Fingerling Output in Select and Random Channel Catfish Brood Stock

	Spawning Rate	Fecundity	Hatchability	10-Day Swim-Up Fry Survival	Fry Survival in Ponds
Fingerling output	.74[a]	.83[b]	.04	.88[b]	.87[b]
Spawning rate		.50	.38	.60	.55
Fecundity			−.84[a]	−.02	.62
Hatchability				.46	.39
10-day swimup fry survival					.91[b]
Fry survival in ponds					

[a] Significant ($P < 0.05$).
[b] Significant ($P < 0.01$).

The data on the Marion and Kansas strains, and the preliminary data on the Rio Grande strain indicate that selection for growth rate is not detrimental to reproductive performance. In fact, there appears to be some increase in total fingerling output in select populations and we could recommend selection for growth rate (Dunham and Smitherman 1983) as a general hatchery practice. Fecundity and fry survival were the most important factors determining total fingerling output.

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