Effect of Calcium Hardness on Channel, Blue, and Channel x Blue Catfish Hybrids

Eugene L. Torrans, *U.S. Department of Agriculture, Agricultural Research Service, Catfish Genetics Research Unit, Thad Cochran National Warmwater Aquaculture Center, 141 Experiment Station Road, Stoneville, MS 38776*

Terry D. Bates, *U.S. Department of Agriculture, Agricultural Research Service, Catfish Genetics Research Unit, Thad Cochran National Warmwater Aquaculture Center, 141 Experiment Station Road, Stoneville, MS 38776*

William R. Wolters, *U.S. Department of Agriculture, Agricultural Research Service, Catfish Genetics Research Unit, Thad Cochran National Warmwater Aquaculture Center, 141 Experiment Station Road, Stoneville, MS 38776*

Abstract: The aquifer that supplies water to most channel catfish *(Ictalurus punctatus)* hatcheries in the Yazoo Basin of the Mississippi River flood plain in west-central Mississippi has a hardness of <10 mg/liter as $CaCO_3$. Calcium hardness <10 mg/liter is known to reduce survival and growth of catfish sac and swim-up fry, but effects of low hardness on fingerling growth and survival have not been determined. We examined the effects of hardness (5 mg/liter and 67 mg/liter as $CaCO_3$) on survival and growth of fingerling (2.0–3.2 g initial weight) channel catfish (USDA-103 line), blue catfish (*I. furcatus*, D&B line), and channel X blue catfish hybrids (USDA-103 channel X Rio Grande blue catfish) in 80-liter aquaria. Survival was ≥99% in all treatments over the 33-day experimental period. Low calcium resulted in significantly ($P < 0.05$) reduced net weight gain in both channel (4.4±0.07 g vs. 3.6±0.08 g in high and low calcium treatments, respectively) and blue catfish (2.5±0.11 g vs. 1.9±0.11 g), but there was a significant treatment X species interaction, with hybrids growing faster (2.4±0.14 g vs. 2.8±0.09 g) in the low calcium water.

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Much of the channel catfish culture in the United States is located in the Yazoo Basin of the Mississippi River flood plain in west-central Mississippi (Tucker and Steeby 1993). Most commercial hatcheries in this region rely on water from a deep aquifer (300–400 M) with a suitable temperature (25–30 C) but low hardness (<10 mg/liter as $CaCO_3$) (Tucker 1984).

The USDA ARS Catfish Genetics Research Unit at the Thad Cochran National Warmwater Aquaculture Center, Stoneville, Mississippi, also uses this low-calcium aquifer as a hatchery water source. The hardness of our deep well averages 5 mg/liter as $CaCO_3$.

Calcium hardness below 10 mg/liter has been shown to reduce channel catfish sac fry growth, yolk utilization rate and resistance to hypoxia, with survival to swim-up significantly reduced in calcium-free water (Tucker and Steeby 1993). The effects of low calcium on eggs and fry is not limited to channel catfish (Brown and Lynam 1981).

To minimize problems associated with low hardness, all commercial catfish hatcheries using this aquifer increase the calcium hardness by injecting liquid calcium chloride into the incoming water. While commercial hatcheries operate only during the spring spawning season, we maintain large numbers of fish in the laboratory, and inject calcium chloride into the water, throughout the year.

It is not known what effect low calcium has on the growth and survival of channel catfish once they pass the swim-up stage. If low calcium does not affect the growth and survival of larger juvenile catfish, the calcium chloride injector could be turned off at our facility most of the year.

Consequences of using low calcium water for fish culture extend beyond catfish hatcheries. Calcium-deficient ground and surface water supplies are common throughout the southeastern United States (Boyd 1990), and the effects of low calcium on catfish fingerling or food fish growth and production in ponds are not known.

This study was conducted to determine the effects of low calcium on growth and survival of fingerling catfish. Since the industry produces some blue catfish and channel X blue catfish hybrids in addition to channel catfish, these species were also included in the study.

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Methods

The channel catfish were from the USDA-103 experimental line of channel catfish developed at the USDA ARS Catfish Genetics Research Unit (Li et al. 1998). This catfish line was released to the industry in 2001 under the commercial name NWAC-103 (Hanson and Killcreas 2001). They have consistently outgrown other lines of channel catfish in both tank and pond studies, due in part to their greater food consumption (Li et al. 1998, Silverstein et al. 1999). However, growth of the USDA-103 line has not yet been compared with either blue catfish or blue X channel catfish hybrids.

The blue catfish used in this study were from the D&B line (Collins 1988). The hybrids were USDA-103 ♀ channel X Rio Grande ♂ blue catfish. All test fish were spawned at our facility during the spring 2000 spawning season, and hatched and reared in indoor tanks until the study.

Thirty 80-liter glass aquaria were each stocked with 100 fish. Water volumes were maintained at 48.5 liters with PVC standpipes. Water flow during the study averaged 0.66±0.02 exchanges/hour at a temperature of 25±1 C. Oxygen was maintained near saturation with pre-aeration of the well water and diffused aeration through a 2.5 x 2.5 x 5-cm air stone in each aquarium.

Two calcium concentrations (low and high) and 3 species (channel, blue, and channel X blue catfish) were tested with 5 replications per treatment combination. High calcium aquaria were supplied with aerated well water with supplemental calcium chloride added to a final hardness of 67 mg/liter as $CaCO_3$. Low calcium aquaria were supplied well water (no calcium chloride added) with a hardness of 5 mg/liter as $CaCO_3$. Hardness was determined using an EDTA titrimetric method (Boyd and Tucker 1992).

All aquaria were initially filled with high hardness water (hardness = 67 mg/liter as $CaCO_3$; pH = 8.8; alkalinity = 400 mg/liter as $CaCO_3$) in which the fish had been hatched and reared for the past 2–3 months. Fish were tranquilized with MS-222, counted, weighed as 100-fish batches to the nearest 0.1 g, and stocked in the aquaria. When all aquaria had been stocked and the fish had recovered from the anesthetic (approximately 4 hours after the start of the stocking process), the low hardness (hardness = 5 mg/liter as $CaCO_3$; pH = 8.8; alkalinity = 400 mg/liter) water source was turned on in 15 aquaria.

Aquaria were checked hourly for mortalities for the first 3 hours and then daily for the remainder of the study. Fish were fed to excess once daily (with the exception of 2 days when they were not fed) with a 44% protein commercial diet (Rangen, Inc., Angleton, Texas). This diet had no supplemental calcium but contained an average of 1.5% calcium from natural sources (David Brock, Rangen, Inc., Buhl, Idaho, pers. commun.). The study was terminated after 33 days, at which time the fish were removed from each aquarium, anesthetized with MS-222, counted, and weighed as a batch to the nearest 0.1 g.

Data were analyzed (P = 0.05) using ANOVA and LSMEANS/PDIFF (SAS 1999).

Results and Discussion

Although the 3 species (channel, blue, and hybrid catfish) were graded prior to stocking to minimize initial size variation, there were significant differences in initial stocking weights among the 3 species. Blue catfish were the largest (3.2 and 3.1 g in the high hardness and low hardness treatments, respectively) (Table 1), followed by channel catfish (2.3 g in both treatments), and then the hybrids (2.0 and 2.1 g). Overall survival averaged 99.8%. Most mortality occurred within an hour of stocking and was attributed to handling.

Channel catfish gained significantly more weight than either blue catfish or blue

Table 1. Average survival, initial and final weights, net weight gain, and specific growth rate, G_W[a], of channel, blue, and channel X blue catfish hybrids raised for 33 days in high hardness (67 mg/liter as $CaCO_3$) or low hardness (5 mg/liter as $CaCO_3$) water. Values $\bar{x}+SE$, $N = 5$ aquaria) in each column with different letters are significantly different ($P < 0.05$).

Treatment	Species	Survival (%)	Initial wt. (g)	Final wt. (g)	Net gain (g)	G_W
High hardness	Channel	100	2.3±0.02 B	6.7±0.07 D	4.4±0.07 E	3.2±0.04 F
	Blue	100	3.2±0.03 C	5.6±0.11 C	2.5±0.11 B	1.7±0.06 B
	Channel X blue	100	2.0±0.03 A	4.4±0.14 A	2.4±0.14 B	2.4±0.10 C
Low hardness	Channel	100	2.3±0.03 B	5.8±0.11 C	3.6±0.08 D	2.9±0.03 E
	Blue	99	3.1±0.05 C	5.1±0.14 B	1.9±0.11 A	1.4±0.06 A
	Channel X blue	100	2.1±0.02 A	4.8±0.08 A	2.8±0.09 C	2.6±0.07 D

a. G_W is the specific growth rate, expressed as $\log_e W_t - \log_e W_o * 100/t$, where W_o is weight at time 0, W_t is weight at time t, and t is time in days (Jobling 1983).

X channel catfish hybrids in both high and low hardness treatments (Table 1). Channel catfish and blue catfish grew significantly faster in high hardness water than in low hardness water, averaging 4.4 and 2.5 g weight gain, respectively, in the high hardness water, versus 3.6 and 1.9 g in the low hardness water. A significant treatment X species interaction ($P < 0.05$) was observed with the channel X blue catfish hybrids gaining more weight in the low hardness treatment than in the high hardness treatment (2.8 g weight gain versus 2.4 g, respectively).

The reason for the treatment X species interaction is not known, but channel X blue catfish hybrids have been shown to exhibit genotype X treatment interactions in other studies (Dunham et al. 1990). It was noted in this study that hybrid catfish exhibited a different spatial orientation within aquaria in the 2 treatments. In the low hardness treatment, hybrid catfish tended to concentrate toward the rear of the aquaria. The hybrid catfish in the high hardness treatment, and channel and blue catfish in both treatments, appeared to have a more uniform distribution throughout the aquaria. The cause of this behavior and the effects on growth are being explored.

Although hybrids gained significantly more weight than blue catfish in low hardness water (2.8 g weight gain versus 1.9 g for the blues), there was no significant difference in high hardness water (2.4 g weight gain for the hybrids versus 2.5 g for the blues) (Table 1). Since there was a significant difference in the initial weights of blue and hybrid catfish (the blues were 50% larger than the hybrids when stocked), growth differences were also assessed using specific growth rate, G_w (Jobling 1983). Hybrid catfish had a significantly higher specific growth rate than blue catfish in both treatments (Table 1).

Results of this study demonstrated that growth but not survival of fingerling (2–3 g) catfish was affected by calcium hardness. Pending further studies examining a range of calcium concentrations and fish sizes, the existing recommendation for calcium hardness in catfish hatcheries (>10 mg/liter as $CaCO_3$, Tucker and Steeby 1993) should be applied through the fingerling stage as well.

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