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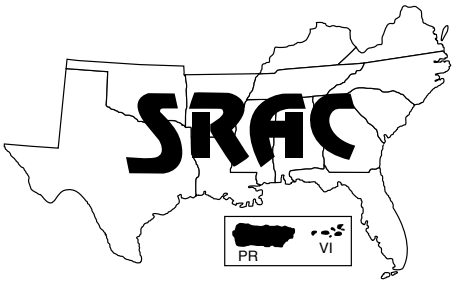

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Production of Hybrid Catfish

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The mating or crossing of two different species is a process called hybridization,with the offspring known as hybrids. Probably the best recognized animal hybrid is the mule,which is a cross between a female horse and a male donkey. Hybrids can have some characteristics of both parents. Breeding hybrids with selected or favored characteristics of each parent is one of the goals of animal husbandry. When a hybrid has characteristics superior to both parents it is said to have hybrid vigor or positive heterosis which, of course, is the ultimate breeding goal.

Hybrids between different species of North American catfish (ictalurids) have been researched for more than 30 years. Of all these interspecific catfish hybrids (crosses between two distinct species) only one hybrid has characteristics that would favor commercial application. That hybrid is the channel catfish (*Ictalurus punctatus*) x blue catfish (*I. furcatus*) hybrid (denoted as the CxB hybrid). More specifically, it is the hybrid produced by crossing the female channel catfish with the male blue catfish. It is important to note that the reciprocal cross, crossing the male channel catfish with the female blue catfish, does not have the same superior production characteristics of the CxB hybrid.

Research on CxB hybrids has demonstrated that they exhibit many commercially desirable characteristics. Compared to most commercially cultured strains of channel catfish, the CxB hybrid exhibits superior characteristics for the following traits:

- faster growth;
- better feed conversion;
- tolerance of low oxygen;
- increased resistance to many diseases;
- tolerance to crowded growth conditions in ponds;
- uniformity in size and shape;
- higher dressout percentages;
- increased harvestability by seining; and
- increased vulnerability to angling.

The simultaneous improvement of so many traits in a single line of catfish has not been possible through traditional genetic improvement programs, and there are no other examples of a single mating that has produced improvement in so many commercially important traits.

The problem with commercializing CxB hybrids has been the inconsistency of seed production. The gametes (sperm and eggs) are compatible but the two species seldom mate with one another because of behavioral incompatibility, preferences in spawning environments, or some other factor(s). However, recent advances in artificial spawning and fertilization techniques have resulted in improved seed production. Another important development has been the use of different strains of channel catfish and blue catfish to make the hybrid. The crossing of different parental strains has produced genotypically distinct CxB hybrids with even more superior production characteristics. A genotype refers to the actual genes or genetic makeup that produces a trait.

Genotype-environment interactions

The genotype-environment interaction is defined as the way the value of a genotype changes relative to other genotypes when the environment changes. In other words, the best genetic type for one set of environmental conditions may not be the best genetic

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type for another set of environmental conditions, or the advantage of the particular genotype may increase or decrease in a second environment. In general, the genetic advantage of the CxB hybrid relative to channel catfish or blue catfish can increase or decrease depending on the environment in which they are grown.

Appearance of hybrid

The channel catfish has a gentle slope from the tip of the snout to the base of the dorsal fin/spine and is spotted. It has high-set eyes; long, thick lateral barbels (whiskers); and a rounded anal fin with 24 to 26 fin rays. The blue catfish has a steep slope from the tip of the snout to the base of the dorsal fin, giving it the appearance of a "hump." It has no spots (except the Rio Grande strain); the eyes are set lower than the channel; it has short, light colored, thin lateral barbels and a straight or squared anal fin with 30 to 36 fin rays (Fig. 1).

The CxB hybrid looks much more like the male blue catfish parent than the channel catfish. The hybrid has a steep slope from the tip of the snout to the base of the dorsal fin, so it has the "humped" appearance. It has few or no spots (unless the Rio Grande blue is used in the cross); the eyes are set low; the barbels are intermediate and it has a straight anal fin with an intermediate number of fin rays (usually 28).

Production characteristics of CxB hybrids

Growth and feed conversion

Early experiments demonstrated an approximately 20 percent improvement in growth of CxB hybrids over commonly cultured strains of channel catfish. However, recent research using selected parental strains of channel catfish and blue catfish have shown that growth of the CxB hybrid can be twice as fast as commercial strains of channel catfish, depending on environmental conditions. In general, CxB hybrids will demonstrate a 15 to 25 percent improvement in production over improved strains of channel catfish. This increased growth is due to a combination of increased food consumption and improved feed conversion efficiency.

In general, the CxB hybrid grows faster than the channel catfish, at both the fingerling and food-fish phases, when stocking density increases or when there are mixed size populations in the pond, as is the case in the multiple stocking and harvesting systems (multiple-batch system) currently used in most commercial catfish operations. Apparently the CxB hybrid is less affected by high density pond culture conditions than channel catfish. It is important to note the key words **pond culture**, as research has **not** shown that hybrids have any growth advantage under high density cage, tank, or raceway culture conditions. Actually, the growth of CxB hybrids is generally slower under cage, tank, or raceway culture conditions, which appears to be caused by a behavioral problem produced by the extremely high densities or confinement of these systems.

CxB hybrids have even more superiority over channel catfish under pond culture conditions at higher stocking densities. Fingerling CxB hybrids out-perform channel catfish fingerlings at all densities when grown to food-size fish. If fry are stocked at low densities (less than 60,000 per acre), the CxB hybrid grows at the same rate as channel catfish fingerlings until they reach a length of approximately 6 inches; after that the CxB hybrid grows faster. Generally, the CxB hybrid displays its superior growth in the second year and this growth is even more pronounced at densities of 7,000 to 22,000 per acre. Experiments comparing channel catfish to CxB hybrids suggests that the hybrids grow faster because they start feeding earlier

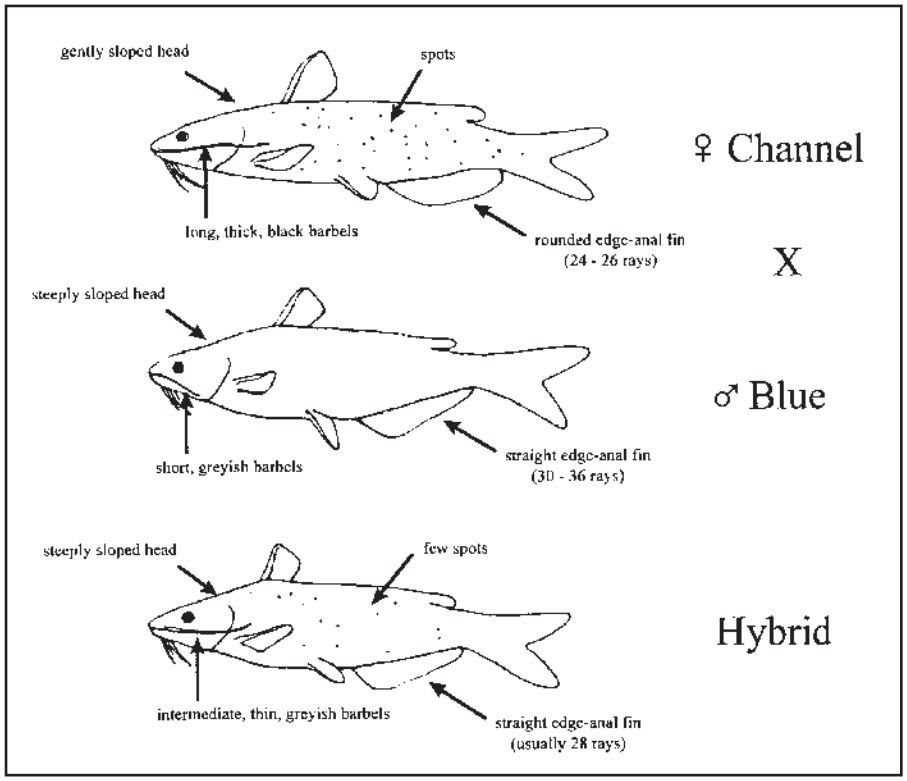

Figure 1. External characteristics of channel catfish, blue catfish and hybrid catfish.

in the spring. Growth rates in the summer and winter are approximately the same as in channel catfish.

Research has shown that feed conversion in CxB hybrids averages 10 to 15 percent better than channel catfish.

Effects of parental strain

The parent strain or line of channel catfish and blue catfish affects the performance of the CxB hybrid. Growth of the CxB hybrid is affected by the genotype of the parents. In some experiments the CxB hybrid did not grow as fast as selected strains of channel catfish or blue catfish. However, in these cases the channel catfish or blue catfish was not the same strain used to make the hybrid. When CxB hybrids are produced by crossing superior strains of channel and blue catfish, these hybrids out-perform the parental strains for growth in open ponds. The strain of the parents also affects characteristics such as dressout percentage, body composition, seinability, angling vulnerability, and tolerance to low oxygen.

Uniformity

The uniformity of growth and body shape of hybrids is superior to channel catfish, but not always superior to blue catfish. Dressout percentage and fillet percentage are generally higher for the CxB hybrid compared to channel catfish. However, some selected strains of channel catfish can have higher carcass yields than the hybrid.

CxB hybrid fingerlings produced at high densities (200,000 per acre) are not particularly uniform, but fingerlings produced at the lower densities have very uniform growth.

Research has shown that the body weight and length of the CxB hybrid are more uniform than that of channel catfish. Body shape is also more uniform in CxB hybrids than in channel catfish. This should increase dressout percentage for processing plants using automatic processing equipment, because it allows the equipment to make more precise cuts and achieve maximum carcass yield. However, this uniformity can be a problem, as fish that are too uniform will not utilize all the processing lines simultaneously, possibly reducing processing plant efficiency. There has been some concern that automated processing machines would have to be reset to accommodate the hybrid's body shape. However, recent observations have shown that the hybrid can be processed by the same equipment used for channel catfish without any adjustments.

Survival and disease resistance

Many disease problems in the channel catfish industry could be reduced or alleviated by the culture of CxB hybrids. Survival of the CxB hybrid has proven superior to channel catfish in all growth phases. In 20 years of research at Auburn University, fingerling production survival has averaged 85 percent and food-fish production survival has averaged 90 percent.

Although the CxB hybrid is not totally resistant to disease, it is more resistant than channel catfish to columnaris (*Flexibacter columnaris*), enteric septicemia of catfish (*Edwardsiella ictaluri*), aeromonas (*Aeromonas hydrophila*), Ich (*Ichthyophthirius multifilis*), and channel catfish virus.

Other commercially important traits

One of the most important traits of the CxB hybrid is its seinability. The hybrid is generally two to three times easier to catch by seining than channel catfish. This makes the hybrid better suited for all open-pond culture systems, particularly where seining of large channel catfish is problematic and ponds are seldom completely drained for harvest. Hybrids in hill ponds are also easier to trap than channel catfish, and more susceptible to angling. In fact, the CxB hybrid is about twice as easy to catch by hook-and-line as channel catfish, a trait that has important implications for fee-fishing and recreational fisheries.

Potential commercial problems

Seines and grading socks in current use do not work well with CxB hybrids. The hybrid has a small head and sharp spines inherited from the paternal blue catfish. This trait means that when hybrids are selectively graded by traditional equipment, they tend to gill themselves in the netting. Obviously, this creates a handling and stress problem. Alternative grading systems or seining procedures need to be developed for the hybrid. In the case of a single-crop system, this problem is solved by using a smaller mesh seine than normally used for channel catfish.

Production expectations

Research and commercial trials have shown that CxB hybrids stocked in May or early June at 100,000 fry per acre (in Alabama, Mississippi) can yield 7,000 to 10,000 pounds of fingerlings per acre by late October. If these fingerlings (7+ inches) are stocked in a single-crop system at 3,000 fish per acre in the spring, then 5,500 pounds of marketable fish should be ready for harvest in the fall. If stocked at 5,000 fingerlings per acre, then 9,000 pounds of marketable fish should be ready for harvest in the fall. This production level requires near satiation feeding and adequate aeration to sustain the fish.

Spawning methods

Open-pond spawning

Open-pond spawning is not a consistent way to produce CxB hybrids. Usually, no spawns occur, but there have been rare instances where up to 33 percent of the female channels have spawned. In many cases where spawns have been reported in

open ponds, it appears that the adults were not sexed properly (i.e., only female channels and male blues were stocked) and either channels spawned with channels or blues spawned with blues. No hybrids were actually produced. Therefore, the open-pond spawning of channel catfish with blue catfish to produce CxB hybrids cannot be recommended.

Pen spawning

Pen spawning is a more consistent way of producing CxB hybrids. Pens should be similar to those used in traditional channel catfish spawning. Spawning pens are constructed next to the bank of the pond, using treated lumber driven into the pond bottom and plastic mesh or plastic coated wire mesh for sides. The mesh should allow for adequate water circulation (1/2- to 2-inch). Most spawning pens have dimensions of 4 x 6 or 4 x 8 feet. Spawning containers must be large enough to accommodate the size of the male blue catfish.

Male blue catfish and female channel catfish are individually paired in pens when the water temperature at the depth of the spawning container is between 75 and 82º F at sunrise. Male blue catfish should be placed in the pens a day or two before the female channel catfish. Female channel catfish chosen should show the classic signs of readiness for spawning, including a soft, distended belly and, preferably, a genital opening that is red and swollen. Female channel catfish are injected with human chorionic gonadotropin (HCG) at 1,100 to 1,800 IU/kg, lutenizing hormone (LHRH) at 100 mg/kg, or carp pituitary extract (CPE) at 2 mg/kg. **At the time this publication was written, not all of these hormones were approved by FDA for spawning fish. Please check with your Extension fisheries/ aquaculture specialist for current registrations before using these hormones.**

If matings occur, spawns will usually be found 72 hours after the female is introduced into the pen. In rare cases, spawning has occurred up to a week after the female is introduced into the pen. Pen spawning success has been as high as 100 percent, but usually results in 0 to 20 percent success. Average spawning success over 14 years of continuous research at Auburn University is approximately 15 percent. Therefore, pen spawning is not considered a dependable method of producing CxB hybrid fry.

Artificial spawning

Artificial spawning and fertilization can virtually guarantee production of CxB hybrid fry every year if properly conducted. The success of artificial spawning of female channel catfish should be 67 to 100 percent. The economics of this approach are still being examined. The following protocol has been the most successful in producing CxB hybrids.

Female channel catfish broodstock should be stocked at no more than 1,500 pounds/acre and fed a commercially manufactured 32 percent protein diet at 3 percent of body weight 3 days a week during summer and fall. Starting in January and continuing through spawning, the female broodstock should be fed a 48 percent protein brood fish feed that contains 60 percent fish meal twice a week, and liver (chicken, beef or pork) once a week. Females are spawned most successfully when water temperature is between 75 and 82º F at a depth of 2 to 3 feet at sunrise. Females selected for injection should have soft, distended bellies and, preferably, red, swollen genital openings. Selected females are placed in holding vats. Water flow and aeration in the vats should maintain total ammonia near 0 mg/l and dissolved oxygen above 6 mg/l. If possible, water temperature should be slowly increased to 80 to 82º F in the vats after the first injection.

First injections (called the "priming dose") should be made in the evening of the same day the female brood fish are seined from the broodstock ponds. The longer fish are held in vats, the lower the number that will spawn, the poorer the egg quality, and the lower the number of fry that will hatch. It is essential to get an accurate weight of each female in kilograms so that precise doses of hormone can be calculated. Carp pituitary extract (CPE) has been the most consistently successful hormone for spawning channel catfish. The first injection of CPE at 2 mg/kg of female body weight should be administered intraperitoneally (into the body cavity under the base of one of the pelvic fins) between 6 and 8 pm. After the injection, the female should be placed in a separate vat for injected females. This process is repeated 12 hours after the first injection, with a second dose of 8 mg/kg of body weight (called the "resolving dose"). If water temperature in the brood fish pond has reached 82º F at sunrise prior to seining the fish, then the resolving dose should be reduced to 4 mg/kg of body weight.

Thirty-six hours after the first injection, the female channel catfish should be ready to ovulate and hand stripped if they have been held at 80 to 82º F. Just before stripping the females, the male blue catfish must be sacrificed and their testes removed. Males are usually euthanasized by bludgeoning them across the head. The male blues must be surgically opened with an incision from the anal opening to about three-fourths of the way to the head along the belly. The testes are removed by gently cutting them from the mesentery connective tissue. Try to minimize bleeding, as this will obscure the view of the testes and make removal difficult (Fig. 2). Remove only the white portion of the testes. Gently dry the testes until all blood and moisture have been removed. This prevents activation of the sperm as the testes are macerated for

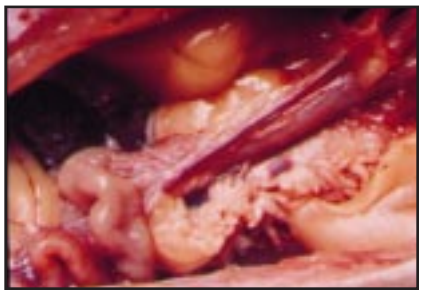

Figure 2. Testes of male blue catfish.

release of the sperm. Finally, weigh the testes with an accurate electronic gram scale. Approximately 0.5 g of testes is needed for each 100 ml of eggs.

Females are removed from the tanks and placed in an anesthetizing solution of MS-222 at a concentration of 250 mg/l. When the fish are immobilized but the gills are still slowly moving, remove the female from the anesthetic solution and quickly rinse her with clean water to remove any remaining anesthetic. Carefully towel dry the female and wrap the towel around her head and upper body. Again, this is to remove moisture that might cause premature activation of the eggs and sperm. The female is held head up and tail down with the genital opening over a bowl lightly coated with vegetable shortening during the stripping process. Feel the belly region to locate the roll (mass) of eggs in each ovary. Gently but firmly press the belly with strokes beginning at the top of one ovary (one side at a time) and ending at the genital opening (Fig. 3). When it becomes difficult to get eggs to flow out of one ovary, begin stripping the other ovary and alternately strip each ovary as needed. The eggs are stripped into the dry, lubricated bowl. When no more eggs can be stripped or blood begins to come out of the genital opening, then stripping is completed and the female should be returned to a vat for recovery.

After the eggs have been stripped the male testes should be macerated and the sperm squeezed out of the testes and over the eggs at the rate of 0.5 g of testes per 100 ml of eggs. As a general rule, it takes one male to fertilize three to five females, depending on the size and quality of the male. Well oxygenated water is added to the egg and sperm mixture and the eggs are allowed to "harden" for 45 minutes with gentle agitation. Gentle agitation allows maximum contact between eggs and sperm. Water on the eggs should be exchanged every 15 minutes. Then the eggs are placed in a traditional catfish egg hatching trough. After this point the egg and fry are handled like channel catfish eggs.

Figure 3. Hand stripping of eggs from female channel catfish.

Hybrid fertility

Most first generation (F1) CxB hybrids can spawn and produce a second generation (F2) of hybrids, or they can be crossed with a pure strain of channels or blues to produce "backcross" hybrids. However, the performance of these F2 and backcross hybrids is inferior to the F1 hybrids. Therefore, production of fry from CxB hybrid parents is not recommended.

Conclusion

Obviously, there is more expense involved in producing CxB hybrid catfish than channel catfish (produced by traditional pond spawning methods). The best estimate for this increased cost is approximately 1/2 cent per inch. In other words, where channel catfish purchased in commercial quantities presently cost about 1 1/2 cents per inch, the CxB hybrids will cost 2 cents per inch. This additional cost should be recovered through the improved feed conversion efficiency, higher survival, and higher capture rates (seinability).

Use of the CxB hybrid in the catfish industry could improve farm productivity and profitability by reducing the incidence of disease, increasing total production (pounds/acre), improving seinability, and increasing dressout yield. In limited field studies, the CxB hybrid, even with the increased hatchery costs, could increase farm profitability by as much as 10 percent. The major impediments to the rapid expansion of hybrid production are the current lack of blue catfish brood stock, since virtually all of the catfish industry is based on channel catfish, and the need for improved spawning techniques.

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