THAD COCHRAN
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# Replacing Soybean Meal and Corn in Catfish Diets

*Menghe Li and Edwin Robinson*

Soybean meal and corn have traditionally been the main protein and energy sources for catfish feeds. This is because soybean meal is high in protein, highly digestible and palatable, and has the best amino acid balance among most, if not all, plant-based feedstuffs. Corn is rich in starch which, until recently, has been a relatively inexpensive energy source for catfish. Also, starch is needed to make a high quality extruded feed pellet that is stable and floats on the water surface. Even though nutrient and feed processing characteristics of soybean meal and corn make them highly desirable in catfish feeds, their use is limited because of their high cost. To make affordable and cost-effective diets, alternative feedstuffs must be used to replace part of the soybean meal and corn without negatively impacting feed pellet quality and fish performance.

Alternative feedstuffs of interest include cottonseed meal, corn gluten feed, corn germ meal, and distillers dried grains with solubles. These feedstuffs are generally less expensive and readily available. However, as a protein source, these ingredients contain less protein and less lysine (first limiting amino acid in plant-based catfish feeds), and their protein and essential amino acids are less digestible/available than soybean meal. They also contain more fiber than soybean meal and corn. Compared with corn grain, corn gluten feed and corn germ meal are low in starch, and distillers grains essentially does not have any starch. In addition, distillers grains contain high levels of oil and yellow pigments which are considered undesirable for catfish feeds. These alternative ingredients also contain less digestible energy than soybean meal, and corn gluten feed and corn germ meal have less digestible energy than corn grain because of  their low starch and high fiber content.

In the past few years we conducted several studies to evaluate the use of these ingredients singly or in combination to replace soybean meal and corn in catfish diets. All studies were conducted in experimental ponds (1/10 acre) using a single-batch system. Fingerling or stocker size of channel catfish or fingerling hybrid catfish were stocked at 6,000 fish per acre depending on specific studies. All

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**Replacing Soybean Meal and Corn in Catfish Diets**
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diets were formulated to contain 28% protein and meet all known nutrient and energy requirements of channel catfish. Fish were fed once daily to apparent satiation for a growing season. Pond management generally follows typical industry practices.

In the first study we looked at the replacement of soybean meal by cottonseed meal and distillers grains. When supplemented with lysine, cottonseed meal could replace about 50% of the soybean meal, and distillers grains could replace about 35% of the soybean meal without affecting channel catfish growth, feed efficiency, or processed yield. Using a combination of cottonseed meal and distillers grains we could replace all soybean meal in the diet without adversely affecting fish performance.

The second study evaluated the use of different levels (0, 10, and 20%) of distillers grain in channel catfish diets. Higher levels of distillers grains were not used, ensuring that the concentration of yellow pigments in the diet did not exceed 7 ppm. There were no significant differences in growth and feed conversion, and no yellow fillet problems, but carcass and fillet yield decreased as the amount of distillers grains increased in the diet.

In the third study we evaluated the use of a combination of cottonseed meal and corn gluten feed to replace soybean meal and corn. Results show that about 50% of the soybean meal and 35% corn in the control diet can be replaced by a combination of cottonseed meal and corn gluten feed (20% of each in the diet) without markedly affecting the physical quality of feed pellets, growth, and processed yield of channel catfish.

Hybrid catfish were used in the fourth study in which we evaluated corn gluten feed singly or in combination with cottonseed meal as replacements for soybean meal and corn. Data from this study show that hybrid catfish can utilize corn gluten feed at levels up to 30% of the diet, and a combination of cottonseed meal and corn gluten feed up to 25% each without significantly affecting growth and feed conversion. However, a combination of corn gluten feed and cottonseed meal at 20% each and above reduced carcass yield.

The fifth study examined the use of corn germ meal in catfish diets. There were no significant differences in weight gain and feed conversion ratio among fish fed diets containing levels of corn germ meal up to 35%. Carcass yield decreased as dietary corn germ meal levels increased.

In summary, based on results from these studies soybean meal can be reduced by 50% in catfish feeds by using a combination of cottonseed meal and either corn gluten feed, or corn germ meal, or distillers grains, and supplemental lysine. The results also show that corn can be reduced to a level of about 15 to 20%. Some corn is needed to provide the starch necessary for manufacturing extruded feeds. The fact that some of the alternative feedstuffs contain moderate to relatively high levels of yellow pigments and/or fiber limits their use. Crude fiber should be maintained at 6 to 7% or less and yellow pigment levels at no more than 7 ppm. Results from these studies also indicate that the use of these alternative feedstuffs especially at high levels may reduce processed yield.

*For detailed information concerning this article please refer to the following publications:*

Robinson, E.H. and M.H. Li. 2008. Replacement of soybean meal in channel catfish diets with cottonseed meal and distillers dried grains with solubles. Journal of the World Aquaculture Society 39:521–527.

Li, M.H., E.H. Robinson, B.G. Bosworth, D.F. Oberle, and P.M. Lucas. 2011. Use of corn gluten feed and cottonseed meal to replace soybean meal in diets for pond-raised channel catfish. North American Journal of Aquaculture 73:153–158.

Li, M.H., E.H. Robinson, D.F. Oberle, P.M. Lucas, and B.G. Bosworth. 2012. Evaluation of corn gluten feed and cottonseed meal as partial replacements for soybean meal and corn in diets for pond-raised hybrid catfish. Journal of the World Aquaculture Society 43:107–113.

Li, M.H., D.F. Oberle, and P.M. Lucas. 2012. Effects of dietary fiber concentrations supplied by corn bran on feed intake, growth, and feed efficiency of channel catfish. North American Journal of Aquaculture 74:148–153.

Li, M.H., D.F. Oberle, and P.M. Lucas. In press. Apparent digestibility of alternative plant-protein feedstuffs for channel catfish. Aquaculture Research doi:10.1111/j.1365-2109.2011.03035.x

# Dr. Craig Tucker Retires from MSU after 32 years

Craig Tucker retired from Mississippi State University on May 18, 2012 after 32 years of service to Mississippi State University. Dr. Tucker had served as the Director of MSU's Thad Cochran National Warmwater Aquaculture Center since 2001 and Director of the USDA NIFA Southern Regional Aquaculture Center since 1997.

Dr. Tucker received a BA in Zoology from California State University (Humboldt) in 1974 and MS in Fisheries (1976) and PhD in Microbiology (1978) from Auburn University. Dr. Tucker did a post-doctoral at Woods Hole Oceanographic Institution (1978 to 1980) before being selected by Mississippi State University as an Assistant Research Professor in 1980. He was the first scientist employed in the Stoneville aquaculture research program. Since then, Dr. Tucker has been a pivotal person in the growth of the state and federal aquaculture research programs at Stoneville to its present level of over 100 employees.

Craig is recognized as a leading contributor to the research fields of water quality, off-flavor, aquaculture effluents, best management practices, stocking/management strategies, and most recently, the split-pond production system.

To date, Craig has edited or authored eight books and authored or co-authored 87 referred journal articles, 24 book chapters, 41 other peer-reviewed publications, 50 popular articles, and 39 special reports. He has been asked to represent MSU and the catfish industry on committees for United Nations FAO, USDA ARS, USDA NIFA, USDA APHIS, U.S. Environmental Protection Agency, American Water Works Association, National Invasive Species Task Force, Federal Joint Sub-committee on Aquaculture, and The Catfish Institute. His research and service have been recognized with awards from USDA, World Aquaculture Society, US Aquaculture Society, Delta Council, MSU, MAFES, Catfish Farmers of America, and Catfish Farmers of Mississippi.

Fortunately for the Stoneville research effort and the catfish industry, Craig did not remain retired for very long. Effective May 21, 2012 Dr. Craig Tucker was appointed by USDA ARS as the Research Leader of the Catfish Genetics Research Unit, Stoneville, Mississippi. He plans to continue his water quality and catfish production systems research in addition to leading the federal unit.

# Avery, Wise Assume New Leadership Roles at NWAC

Two Mississippi State University scientists are taking on new leadership roles at the National Warmwater Aquaculture Center in Stoneville.

Jimmy Avery, who has served as the MSU Extension Service aquaculture specialist since 1999, has been named director of the Southern Regional Aquaculture Center. The mission of the center is to support aquaculture research and extension in the Southeast. Its goal is to enhance aquaculture production to benefit consumers, producers, service industries, and the American economy. Dr. Avery will continue to serve as the Extension aquaculture specialist, in addition to fulfilling his administrative responsibilities at the aquaculture center.

David Wise, a research professor with the Mississippi Agricultural and Forestry Experiment Station, has been named coordinator of the Thad Cochran National Warmwater Aquaculture Center. Wise has been employed by the center since 1993. In that time, he has conducted aquaculture research with an emphasis on fish health. Wise will continue to conduct research that targets specific diseases and parasites that threaten the health of fish and the economic well-being of producers

Avery completed a bachelor's degree at the University of Mississippi and a master's degree at Delta State University. He earned his doctorate at Louisiana State University. Wise earned his bachelor's degree at Texas State University and master's and doctorate degrees at Clemson University.

The duties assumed by Avery and Wise were previously held by research professor Craig Tucker, who retired from MSU following more than 32 years of service.

# What is the Best Nitrogen Fertilizer for Catfish Fry Ponds?

*Chuck Mischke*

When high-nitrogen fertilizers are applied to Mississippi Delta catfish nursery ponds rather than the conventional high phosphorus fertilizers, the phytoplankton population is shifted to desirable algal groups, thus providing a quick algal bloom and adequate forage for zooplankton without the use of organic fertilizers.

Primary nitrogen sources in pond fertilizers can be from urea, or salts with ammonia, nitrite, or nitrate. Various sources of nitrogen fertilizer in nursery ponds may affect water quality and plankton differently. Water quality and plankton population responses were evaluated when using different nitrogen sources for nursery pond fertilization.

In a 4-week study, mesocosms were fertilized on an equal nitrogen basis, with the first application providing the equivalent of 18 pounds of nitrogen per acre and 5 additional applications (2 applications per week) of 9 pounds of nitrogen per acre. The treatments were: calcium nitrate (12% N), sodium nitrite (20% N), ammonium chloride (26% N), ammonium nitrate (34% N), and urea (45% N) (Table 1).

Dissolved oxygen, pH, soluble reactive phosphorus, and ammonia nitrogen were not affected by nitrogen source. Sodium nitrate-fertilized mesocosms had higher concentrations of both nitrate and nitrite relative to the other treatments during the first week of sampling, but returned to similar levels for the remainder of the study.

There were no significant differences in phytoplankton among the various nitrogen treatments used. Individual zooplankton groups were not significantly different among treatments; however, desirable zooplankton for catfish fry culture (i.e., the sum of adult copepods, cladocerans, and ostracods) did show a significant interaction. Mesocosms treated with calcium nitrate had a rapid increase in the desirable zooplankton concentrations at the beginning of sampling, and urea-fertilized mesocosms showed an increase in desirable zooplankton concentrations at the end of sampling.

The choice of nitrogen type to use as pond fertilizer would depend on the effectiveness of the fertilizer to increase desirable zooplankton and phytoplankton concentrations in the pond, minimize deleterious effects on water quality (e.g., changes in ammonia and nitrite concentrations), cost per unit nitrogen of each fertilizer, and local availability.

At the nitrogen fertilization rate and the time-frame used in this study, it appears that different nitrogen sources – if applied at an equal nitrogen basis – will influence the phytoplankton population similarly. However, urea-fertilized microcosms showed increased desirable zooplankton concentrations at the end of the study. Generally, catfish nursery ponds are filled and fertilized for about 3 weeks before fry are stocked. Therefore, urea may have an advantage over the other nitrogen fertilizers, providing higher desirable zooplankton concentrations at the time of stocking.

Although water quality was similar by the end of the study, using nitrite fertilizer did cause nitrite levels to increase slightly during the first week. Therefore, nitrite fertilizers may be less desirable for use in nursery ponds relative to the other nitrogen sources.

Based on the results of this study, any form of nitrogen used for pond fertilization should perform similarly without causing substantial water quality deterioration. Ammonium nitrate and urea contain a higher percentage of nitrogen

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**Table 1. Various nitrogen fertilizer types, % nitrogen, and required application rates for channel catfish fry ponds.**

| Fertilizer | % Nitrogen | Initial Rate | Subsequent Rate |
|---|---|---|---|
| Urea | 45 | 40 lb/ac | 20 lb/ac |
| Ammonium Nitrate | 34 | 53 lb/ac | 26 lb/ac |
| N-Sol | 32 | 5 gal/ac | 2.5 gal/ac |
| Ammonium Chloride | 26 | 69 lb/ac | 34 lb/ac |
| Sodium Nitrite | 20 | 90 lb/ac | 45 lb/ac |
| Calcium Nitrate | 12 | 150 lb/ac | 75 lb/ac |

than other nitrogen fertilizers, so a smaller weight of fertilizer would be required. Urea is usually readily available, and may increase the desirable zooplankton concentrations for catfish culture. If both urea and ammonium nitrate are available, use the one with the least cost per unit of nitrogen. If both types of fertilizer have an equal cost per unit of nitrogen, use urea due to the potential advantage of increasing desirable zooplankton concentrations.

This year, there was a shortage of urea in some locations. Most producers found that N-Sol was available. N-Sol is a liquid nitrogen fertilizer that is 32% nitrogen. It is a urea ammonium nitrate solution, so there should be no problems substituting N-Sol for urea. In fact, N-Sol may be less expensive per pound of nitrogen than urea. The application rate of N-Sol would be 5 gallons per acre followed by subsequent twice per week applications of 2.5 gallons per acre.

# Effects of Fry Age-at-stocking on Growth and Survival of Channel Catfish

*Chuck Mischke, Terry Greenway, Matt Griffin, and David Wise*

Channel catfish fry readily consume zooplankton and select the largest zooplankton available. These large zooplankton are excellent nutritional sources for fry. Although the common hatchery practice is to hold fry in the hatchery and feed commercial starter diets for 7 to 10 days after the swim-up stage, fry may be missing out on the benefits of zooplankton during this time.

Better use of natural forage organisms and reducing the residence time of fry in the hatchery may be ways to improve fry production efficiency. When catfish fry diets are supplemented with zooplankton in the lab, fry weight is increased 40 to 50% in just 19 days compared to fry fed only commercial diets. A study was conducted to compare the growth and survival of fingerlings harvested from nursery ponds that had been stocked as either sac fry, swim-up fry, or hatchery-fed fry.

In the study, survival increased with increasing time in the hatchery, with fingerlings stocked as hatchery-fed fry achieving significantly higher survival than fingerlings stocked as sac fry or swim-up fry (Table 1). Total weight of fish harvested was lowest for fingerlings stocked as sac fry; average fish weight decreased with increasing survival. Total feed fed also increased with increased survival.

It was expected – based on the results of previous age-at-stocking studies – that survival would be similar among treatments or even superior in the early stocked fry. Because new fertilization recommendations increase the density of desirable zooplankton for channel catfish fry and provide important nutritional value to the fry, it was expected the early stocked fry would perform better as seen in the hatchery trials with zooplankton.

Using the same methods to stock different ages of fry into nursery ponds increased mortality of younger stocked fry. The results of this study indicate that with these methods, stocking younger fry would be too risky for commercial producers. Zooplankton inclusion in catfish fry diets can provide benefits; however, if early stocked fry survival is low, most benefits gained from natural foraging on zooplankton would be negated. A researcher in the 1960's used boxes covered with plastic window screening to protect fry with some success; other ideas such as shore-line raceways or tanks and in-pond net pens may be useful in transitioning fry to ponds and reducing hatchery residence time while providing access to zooplankton.

**Table 1. Production variables (mean +/- SE) from ponds stocked with 81,000 fry per acre as either sac fry, swim-up fry, or hatchery-fed fry. Within a row, values with different letters are significantly different (P<0.05).**

| Variable | Sac fry | Swim-up fry | Fed fry |
|---|---|---|---|
| Survival (%) | 4.5 (2.6)a | 7.1 (2.1)a | 41.6 (3.4)b |
| Total Weight Harvested (kg) | 155 (76)a | 372 (45)b | 399 (25)b |
| Average weight/fish(g) | 128 (38.6)a | 78 (10.0)ab | 12 (0.9)b |
| Total Feed Fed (kg) | 298 (104)a | 472 (99)ab | 619 (24)b |

# 2011 Aquatic Diagnostic Laboratory Summary Report

*Lester Khoo and Pat Gaunt*

The Aquatic Diagnostic Laboratory is dedicated to the success of Mississippi's commercial catfish industry through service, research, and teaching. Our staff and fish health professionals strive to support the industry's efforts to produce a high quality, economical, and profitable product. Our goals are derived from the needs of the industry and aimed at developing management strategies for controlling the impact of diseases that affect profitability. These goals can only be accomplished through mutual respect, cooperation, and maintenance of a close supportive relationship with our clients.

**Diagnostics**

In 2011, the Aquatic Research & Diagnostic Laboratory (ARDL) at Stoneville received a total of 599 producer submitted fish diagnostic cases (Table 1). These cases were received from 54 different farms. This is a 14.1% increase in the number of submissions over the 525 cases in 2010. There were an additional 253 cases submitted by researchers for a total of 852 cases. There were 1060 water quality samples that were analyzed representing a 21% decrease from the 1341 samples received in 2010.

Individual case submissions represent a composite sample of fish collected from a single pond on a given day. The numbers reported are derived solely from submissions processed by the ARDL and do not necessarily reflect actual disease incidence in the field. Routine diagnostic procedures include evaluation of gill clips and skin scrapes for parasites, external and internal examination for signs of disease, bacterial and viral cultures, histopathology, and water quality evaluation. The ARDL works closely with Mississippi Agriculture Forestry and Experiment Station (MAFES) fish health professionals to offer treatment recommendations, monitor disease trends, provide surveillance for new and emerging diseases, provide field service investigation, and maintain a database of epidemiologic information on diseases of catfish. The ARDL supports the research efforts of other National Warmwater Aquaculture Center (NWAC) units, including MAFES, MSU Extension Service, College of Veterinary Medicine, and USDA ARS Catfish Genetics Research Unit. Furthermore, the laboratory provides an outlet for the dissemination of information gained from research efforts back to producers.

Bacterial diseases dominated the number of cases submitted as in previous years. However, there were more *E. ictaluri* cases this year (195 cases or 22.9%) than Columnaris (167 cases or 19.6%). As single entities there were 91 cases of *E. ictaluri* and 25 cases of *F. columnare*. There were no incidences of antibiotic resistance for the two major bacterial diseases in catfish with only intermediate sensitivity to Romet in one *E. ictaluri* case and 2 *Aeromonas* sp. cases. There were also 3 cases of the virulent strain of *Aeromonas hydrophila* from area farms.

Proliferative gill disease (PGD) remained the most commonly diagnosed parasitic disease and was seen in 122 submissions. Interestingly, there were no submissions with *Ichthyophthirius multifiliis* (Ich) while *Bolbophorus* sp. trematode cases comprised 1.1% of cases submitted, just slightly lower than the previous year. Farmers are encouraged to continue surveillance efforts and to control rams horn snails (intermediate host of the parasite) with lime or copper sulfate treatments, particularly if pelicans have been observed visiting their ponds. *Bolbophorus* sp. trematodes are capable of killing fingerlings and increasing susceptibility to ESC, as well as decreasing feed consumption in larger fish. This can result in significant economic losses even with mild infestations.

**Table 1. 2011 annual case summary for the Aquatic Research & Diagnostic Laboratory - Stoneville, MS.**

| Disease | Number of Cases | % of Total Cases |
|---|---|---|
| Columnaris | 167 | 19.6% |
| ESC | 195 | 22.9% |
| PGD | 122 | 14.3% |
| Saprolegnia | 34 | 4.0% |
| CCV | 29 | 3.4% |
| Anemia | 49 | 5.8% |
| Brown Blood | 4 | 0.5% |
| Ich | 0 | 0.0% |
| VTC | 13 | 1.5% |
| Health Check | 47 | 5.5% |
| Bolbophorus | 9 | 1.1% |

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Saprolegnia was seen in 4% of the cases submitted, close to the previous year (4.4%). There were exactly the same number of channel catfish virus (CCV) disease cases (29) as the previous year. There were 49 (5.8%) cases of anemia last year which was close to the previous year of 5% of the cases. Visceral toxicosis of catfish (VTC) made up 1.5% of cases submitted. These last two diseases are still diseases of research interest because of the economic impact. Producers are highly encouraged to submit cases of these diseases.

With the interest in hybrid catfish, we have listed the numbers of hybrid as well as blue catfish cases submitted in Table 2.

**Table 2. Number of blue catfish and hybrid catfish cases submitted in 2011.**

**BLUE CATFISH**

| **Disease** | **Number of Cases** |
|---|---|
| Columnaris | 1 |
| Brown Blood | 1 |
| **Total** | **2** |

**HYBRID CATFISH**

| **Disease** | **Number of Cases** |
|---|---|
| Ammonia toxicity | 1 |
| Anemia | 9 |
| *Bolbophorus* | 1 |
| *Clinostomum* sp. | 1 |
| Columnaris disease | 4 |
| Columnaris, external | 3 |
| *E. tarda* | 2 |
| *E. tarda*, Columnaris disease | 1 |
| *E. tarda*, PGD | 2 |
| ESC | 27 |
| ESC, Anemia | 1 |
| ESC, Columnaris disease | 5 |
| ESC, external Columnaris | 3 |
| ESC/*Bolbophorus* | 1 |
| Health check | 1 |
| Brown Blood, Saprolegnia | 1 |
| No infectious disease identified | 19 |
| PGD | 6 |
| Toxin (rotonone presumptive) | 1 |
| VHS testing | 14 |
| **Total** | **103** |

**Highlights**

Research continues on florfenicol (Aquaflor®). Intervet/Schering–Plough Animal Health has funded pharmacokinetic studies to help determine the drug's duration in catfish and its ability to control ESC and Columnaris.

Results from the "Efficacy of florfenicol for the control of mortality caused by *F. columnare* infection in channel catfish" study conducted by MSU CVM were accepted by FDA in late 2010. This study and one conducted by the USFWS cleared the way for an all freshwater-reared warmwater fish columnaris claim effective May 1, 2012.

MAFES researchers and ARDL faculty are currently investigating the life stages and biology of *Henneguya ictaluri*, the causative agent of PGD. Researchers are also investigating novel management strategies to reduce the impact of PGD on catfish production.

Faculty of the ARDL have continued to cooperate with researchers from Alabama, Arkansas, and Louisiana to develop rapid diagnostic methodologies for an unusually virulent strain of *Aeromonas hydrophila*. This continues to be a problem in Alabama and east Mississippi and there have been a few cases in the Delta.

Research is also being conducted on another digenetic trematode, *Drepanocephalus spathans*, a parasite of the double-crested cormorant, that has demonstrated the ability to infect juvenile channel catfish. The impact of this trematode and another digenetic trematode that also uses the rams horn snail as an intermediate host are being investigated.

Work also continues on the development of molecular based assays to detect and quantify *E. ictaluri*, *E. tarda*, and *F. columnare* in the pond environment. This will provide methods to better evaluate management schemes aimed at controlling diseases caused by these bacteria.

VTC continues to be an area of active research. We would like to ask farmers to bring suspect VTC fish to the ARDL. Ongoing VTC research requires blood from affected fish and case submissions will help us understand how widespread the disease is and what pond factors may be triggering outbreaks.

We also solicit producers' help with anemia in our efforts to understand the etiology of the profound anemia that is seen typically in foodfish. Producers are also highly encouraged to submit those fish and keep accurate pond records.

# Optimizing Egg Quality and Calcium Hardness Improve Hatching Success of Hybrid Catfish Eggs

*Nagaraj Chatakondi*

Hybrid catfish, produced by fertilizing stripped channel catfish eggs with blue catfish sperm, are increasingly sought by catfish producers. Hybrid catfish contributed to 25% of the total catfish processed in 2011 (USDA NASS 2010). Estimated hybrid fry production in commercial hatcheries has almost doubled from 60 million (2009) to 111 million (2011). This was largely due to a decade of continued effort by researchers and producers mostly funded by USDA ARS, SRAC and SBIR research projects to improve the efficiency of hybrid catfish fry production. However, variable and inconsistent hybrid fry production is still a major problem in hatcheries. This study evaluated optimizing egg quality and calcium hardness.

The term 'egg quality' describes the proportion of eggs in an egg batch which successfully complete development to a distinct ontogenetic stage. Variable egg quality is one of the most important constraints in hatchery production of hybrids. Poor egg quality can stem from parental genetics, diet, stress, poor water quality or variable egg maturation and increased handling and manual stripping. A reduced egg quality may also contribute to lower survival during the early life history stages. Unfortunately, there are not many ways to determine egg quality, and in practical hatchery operations, egg quality is revealed only at hatching. If eggs of poor quality are incubated, hatcheries suffer losses from fungal diseases and from the cost of labor and facilities used to incubate them.

Studies were conducted to determine the effect of ovarian fluid pH of 71 stripped unfertilized channel catfish eggs on fertilization and hatch rate of channel x blue hybrid eggs. A significant correlation was established between ovarian fluid pH and hybrid embryo hatch rate, suggesting ovarian fluid pH of stripped eggs prior to fertilization can be predictive of hatching success. The pH of stripped eggs were categorized as low (pH < 7.0), medium (pH 7.0 to 7.4) and high (pH >7.4). The range in percent hatch for these pH categories were < 15%, 15 to 30%, and > 30% respectively (Figure 1).

Hormonal induction often results in reduced egg quality compared to naturally spawned eggs. This may be a consequence of a particular hormone, the dosage or administration protocol, varying stages of maturation (both under-ripe and over-ripe), mechanical damage from the stripping process, or being a few hours younger than pond-spawned eggs when first handled. The predictive model presented here describes a quick method for evaluating stripped catfish eggs for hybrid fry production in catfish hatcheries.

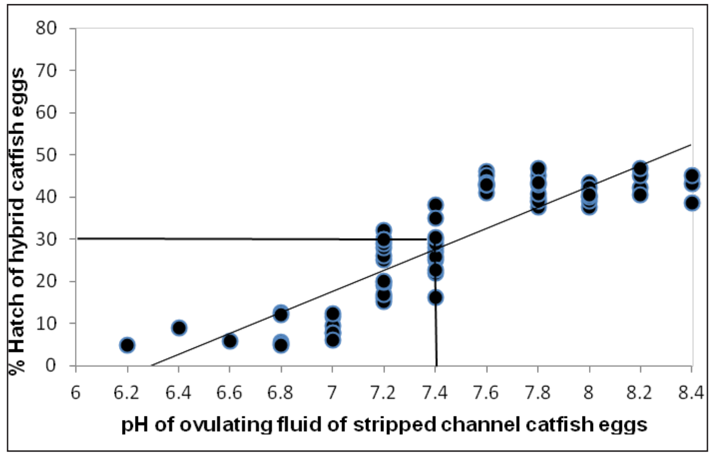


Figure 1. Effect of ovarian fluid pH on subsequent hatching success of hybrid catfish eggs.

Calcium is essential to adequate growth and development of fish. Differences in the availability of calcium place constraints on the speed and extent of embryo development. Water hardness is the measure of all divalent cations and is expressed in mg/L as calcium carbonate. In freshwater, calcium and magnesium are the major constituents of water hardness. Water hardness has a major effect on egg development, and egg and larval survival. It has been shown to have a direct effect on the swelling of newly fertilized eggs, which is an important process during the early development of the egg. Water hardness can be increased by the addition of salts such as calcium chloride or decreased by precipitating carbonates out of a solution or adding water of low or no hardness. Therefore, hatchery systems can be adjusted to provide optimal water hardness levels for the incubation and hatching of fish.

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Previous NWAC research identified the optimal calcium hardness concentrations to hatch channel catfish eggs to be at least 10 ppm in hatchery waters. However, the optimal calcium hardness concentration to hatch hybrid catfish eggs has not been determined. In this study, hybrid catfish eggs from ten individual females were incubated in 25, 50, 75, and 100 ppm of calcium hardness prepared waters in replicated baskets. The mean hatching success of hybrid catfish eggs incubated at 75 ppm was significantly higher than the mean hatch of hybrid eggs incubated at 25, 50, or 100 ppm of calcium hardness waters (Figure 2). The results of the study suggest that a calcium concentration to incubate hybrid catfish eggs should be at least three times the concentrations to hatch naturally pond spawned channel catfish eggs.

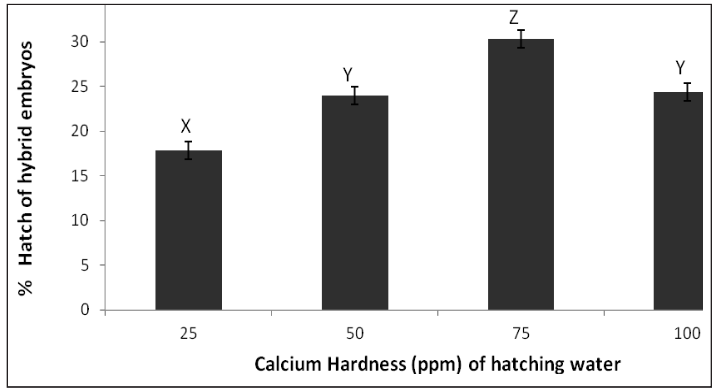


Figure 2. Percent hatch of hybrid catfish eggs incubated at 25, 50, 75, and 100 ppm of calcium hardness prepared waters. Values with different letters are significantly different (P<0.05).

# Using Threadfin Shad to Manage Blue-Green Off-Flavors

*Craig Tucker and Chuck Mischke*

Off-flavors caused by blue-green algae are the most common flavor problems found in catfish during warmer months. Under the right conditions, blue-green off-flavors can be managed by using diuron or copper-based algicides to kill algae that produce odorous compounds. After the odor-producing algae are killed, off-flavors are quickly purged from fish in warm water. Although they can be reasonably effective, algicides can be risky to use in hot weather. Sudden death and decomposition of large amounts of algae can cause severe oxygen depletions and copper-based algicides have relatively little margin of safety between concentrations that kill algae and concentrations that kill fish.

Biological control of odorous algae is an attractive alternative to using algicides for off-flavor management. Most studies of biological control in fish ponds have focused on using plankton-grazing fish. Most plankton-grazing fish eat larger plankton species, which include the filamentous and colonial blue-green algae that cause off-flavors.

Several fish species have been studied for algae biological control in catfish ponds. Silver carp and tilapia are not native to the United States and have undesirable traits when cultured with catfish. Threadfin shad are small, native fish and past studies of using shad for off-flavor management have been promising, but inconclusive. Therefore, a large-scale, year-long study was conducted on the effects of threadfin shad on catfish off-flavors.

In early spring, adult shad were stocked into ponds at about 10 pounds per acre and relied on natural reproduction to produce large numbers of fish. Through the summer, grazing by shad dramatically reduced abundance of odor-producing blue-green algae, which caused a corresponding reduction in off-flavor prevalence and intensity in catfish.

Although threadfin shad reduced catfish off-flavor incidence during the warm season, catfish in many ponds with shad developed "fishy" off-flavors in the winter. This undesirable flavor was caused by catfish foraging on dead shad. Threadfin shad are cold-intolerant and many fish died when water temperatures were low.

Using threadfin shad for off-flavor management therefore presents a dilemma. Shad reduce catfish off-flavors in warm months but cause off-flavors in the colder months. Catfish farmers must consider these benefits and risks when deciding to use threadfin shad as a management tool.

# Genetic Effects of Male Blue Catfish and Female Channel Catfish on Offspring Performance

*Brian Bosworth and Geoff Waldbieser*

Catfish production has decreased over 50% since 2003 primarily due to increased feed costs and competition from imported *Pangasius* and channel catfish from Southeast Asia. While commercial catfish farming is still the largest segment of U.S. aquaculture, farmers must reduce production costs in order to remain competitive in a global seafood market. Hybrids produced by crossing female channel catfish with male blue catfish generally have better growth, survival, meat yield and ease of harvest than purebred channel catfish. Improvements in techniques and increased experience with hybrid production techniques have resulted in substantial increases in hybrid fry and foodfish production over the last 5 years.

Although hybrids exhibit good performance for important production traits, there is potential for further improvement through genetic selection in the parent species. However, little is known about the genetic basis underlying differences in performance among hybrids. Understanding the genetic basis affecting performance is required to develop efficient breeding programs designed to improve important traits of hybrid catfish.

One of the most critical components to designing a breeding program is to know how much of the difference in offspring performance is due to differences in the genes inherited from the parents and how much is due to differences in the environment the animal experiences (feed, water quality, etc.). If nearly all the differences observed in a population are due to environmental effects, there is little ability to improve performance through a breeding program and efforts should be focused on optimizing the production environment. If, on the other hand, a substantial portion of the differences in performance is related to genetic differences among individuals, then improvements can be made by selecting the genetically 'best' animals as parents of the next generation.

Selecting the genetically best animals as parents is not always straightforward, because how accurately the performance of the parent predicts performance of the offspring depends on the type of gene action that influences the trait. Geneticists refer to two types of gene action: 'additive' or 'dominance'. Although the concepts of additive and dominance gene action can be confusing, it basically boils down to how well a parent's own performance predicts its offspring's performance.

Much of the genetic improvement in livestock has been achieved through selection for "additive genetic effects". Selection is based on keeping the best performing animals as parents because their performance reflects their genetic value and they pass their superior genes to their offspring who inherit their parent's superior performance. The gene action involved is called additive because the effect of the each parent on the offspring performance is independent of the other parent's contribution. Performance of the offspring can be predicted from the 'additive effect' or sum effect of each parent independently. For example if the best animal is mated to the worst animal the offspring will be average because the offspring's performance is based on the contribution of each parent independently (one good and one bad added together to give an average animal). In practice, breeders select the best performing parents and mate them together to produce superior performing offspring.

The other type of gene action that can influence offspring performance is called dominance gene action. For traits affected by dominance, the offspring performance depends on the interaction of genes from both parents. Since dominance effects depend on the interaction or combinations of genes from both parents, it is not possible to predict offspring performance from the parent's performance. Most people have heard of hybrid vigor, when the hybrid (or crossbred) offspring performs better than either parent. This is an example of dominance gene action since the offspring actually performs considerably better than either parent. Perhaps the most commonly known example of exploitation of dominance genetics or "hybrid vigor" is in commercial corn breeding. Nearly all corn grown by farmers is a hybrid of 2 inbred lines. It is generally not possible to predict which corn lines will produce a superior hybrid because the parent's effects on offspring performance are not independent, they are based on how

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the genes from the two parents interact in the offspring. Corn breeders spend a great deal of effort screening different hybrids among lines to identify which ones will produce a superior hybrid offspring. It is possible that two poor performing parents can produce the best performing offspring because the genes the parents contribute 'interact' in a favorable way.

The objectives of this study were to determine how much of the variability in hybrid catfish offspring growth and carcass yield was due to genetic differences and then to determine if the genetic differences were primarily due to additive or dominance genetic effects. This information will be critical in developing efficient breeding programs to improve these traits in hybrid catfish.

Male blue catfish were mated to female channel catfish using a factorial mating design (every male mated to every female). This mating design is useful because it allows estimation of both the magnitude and type of genetic influences on traits. Two factorials were used, in one group 10 males were mated to 7 females (70 total families) and in the second group 12 males were mated to 5 females (60 total families). Fry were stocked communally (mixed together) in ponds to eliminate environmental effect of different ponds on offspring performance. Fish were fed a commercial catfish feed and after about 18 months were harvested, weighed, and fish larger than 0.9 pounds were processed and measured for carcass yield (headed-gutted yield). We used DNA markers, similar to techniques used for human paternity testing, to identify the mother and father of each hybrid offspring. A total of 1289 offspring were measured for growth and 1101 were measured for carcass yield. Data was analyzed to estimate how much of the differences in offspring performance were due to independent effects of the channel catfish female and blue catfish male parents (additive effects) and how much were due to interaction between specific female x male combinations (dominance effects).

Results indicated that independent, female channel catfish parent effects (additive effects) were substantial, explaining 25% of the offspring differences in carcass yield and 32% of the differences in harvest weight. Male blue parents had a smaller, but significant effect on offspring performance, explaining 8% of differences in carcass yield and 4% of differences in harvest weight. Specific female x male combinations (dominance effects) were small, and explained only 2% of the differences in carcass yield and 1% of the differences in harvest weight. Therefore, the data indicate that there were substantial genetic differences for growth and carcass yield in hybrid offspring and that these genetic differences were primarily additive. In simple terms, there is substantial potential to improve hybrid performance through genetic selection and that a genetically 'good' female or male will produce good offspring consistently across all matings. This will simplify selecting the best channel and blue parents because there is no need to spend effort looking for specific male x female combinations that produce superior offspring, selection of 'good' males and 'good' females will produce good performing offspring.

In conclusion, the results of this study indicate that channel female and blue male parent effects on hybrid offspring performance will be consistent across matings. Improvements in hybrid performance should be possible by identifying the best male and female parents without the additional effort needed to search for specific, superior male x female combinations. Studies are currently underway to determine if the channel catfish females that produce the best hybrid offspring also produce the best purebred channel offspring. If that is the case, then it will be possible to select for improved performance for purebred and hybrid performance simultaneously.

# Improving Channel Catfish Growth and FCR through Oxygen Management

*Les Torrans*

Since feed represents the single greatest cost in U.S. channel catfish production, the feed conversion ratio (FCR) is the most common indicator of catfish production efficiency. Realized or practical feed conversion (weight of feed fed divided by net fish production) is affected by many variables in addition to feed quality, including disease losses, bird depredations, feeding practices, cropping system, and so on. Many farmers and scientists also believe that feed conversion is affected by the dissolved oxygen (DO) concentration, but convincing data has been lacking to date. This article may help to answer that question by summarizing research conducted at our facility on the impacts of DO on catfish feed consumption, growth and FCR. More recent research on blue and hybrid catfish will be reported at a later time.

Two facilities were used to conduct these studies – six 0.25-acre ponds at the Thad Cochran National Warmwater Aquaculture Center (NWAC) as well as fifteen 1-acre ponds at the Delta Western Research Center (DWRC) in Indianola, MS. Fish in all studies were fed to apparent satiation every 2 to 3 days in the spring when water temperatures were low, and once daily after the pond temperatures reached 77° F. Ponds were clean-harvested in the fall. High aeration capacities (5 to 6 hp per acre) were used so desired minimum DO concentrations could be maintained through the growing season. The lowest DO concentrations studied were higher than those at which catfish show a visible stress response.

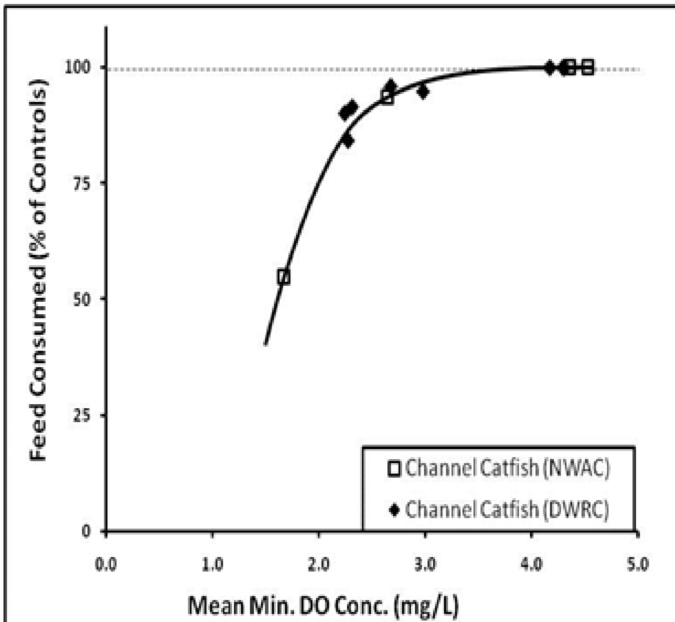


Figure 1. Effect of minimum DO concentration on feed consumption of channel catfish. Low oxygen ponds were compared to the high oxygen (control) ponds in each study. X-axis values are mean minimum (low) DO concentrations from June through September.

Effect of DO on feed consumption and growth. Figure 1 illustrates the impact of the morning DO concentration on feed intake of channel catfish. These studies consistently demonstrate that until the morning DO concentration falls below 3.0 mg/L, feed consumption of channel catfish is not affected. Feed consumption begins to decrease as the DO concentration drops to 2.5 mg/L, and decreases rapidly as the concentration falls below that. With an average morning DO concentration of 1.6 mg/L (the lowest concentration we studied), feed consumption of channel catfish was reduced by 45%. Hypoxia has been shown to limit feed consumption in rainbow trout at least partially by increasing production of corticotrophin-releasing factor and urotensin I which contribute to stress response and regulate appetite. A similar mechanism has not yet been demonstrated in channel catfish but is presumed to exist.

Restricted feeding, whether imposed by management (putting a limit on per-acre feeding rate as many farmers do) or as a voluntary response of the fish to low morning DO concentrations, reduces growth rate and may add months or even years to the production cycle, depending on the degree of restriction. For example, in one study channel catfish fingerlings averaging 82 pounds per 1000 grew to 1.7 pounds in one season when managed with a high morning DO concentration, while channel catfish maintained at 1.6 mg/L ate 45% less and grew to only 1.2 pounds. The smaller fish would require an additional winter and at least part of another growing season to reach market size. Fish also feed more aggressively with higher morning DO concentrations.

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Slower growth means that more time is needed to produce a food fish, and more time in the pond will result in additional mortality. Overall mortality from all causes in commercial ponds has been estimated at 1 to 2% per month, thus every additional year in the production cycle (two years for a stocked fingerling to reach market size instead of one year, for example) could mean an additional 12 to 24% mortality. These fish losses, especially losses of larger fish which have eaten more feed, can have a major impact on the farm-level FCR. Mortality resulting from extended production cycles is likely one of the major causes of high FCRs seen on some farms.

Direct Effect of DO on FCR. Aside from the effect of low DO concentration on feed intake, which affects growth, time to harvest, total mortality, and ultimately FCR, can the DO concentration have a direct impact on FCR? The answer from our research is no – and yes.

Channel catfish FCRs from individual ponds in multiple studies at DWRC and NWAC maintained at different morning DO concentrations are shown in Figure 2a and 2b. While the FCRs differ slightly between the two facilities, the data at both facilities indicate that within the DO range examined, FCR is not directly affected by morning DO concentration; that is, catfish convert feed to flesh at roughly the same efficiency at DO concentrations ranging from 1.6 to nearly 5 mg/L.

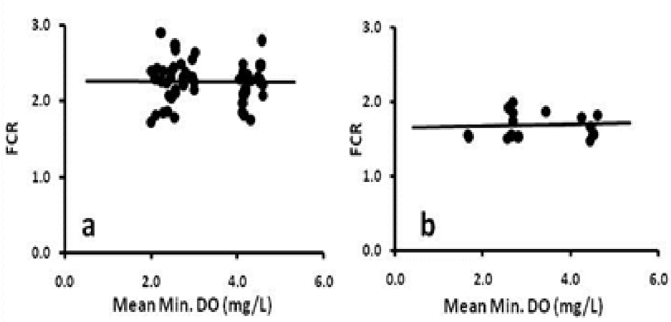


Figure 2. Feed conversion ratios of channel catfish in a) 1-acre ponds at DWRC; b) ¼-acre ponds at NWAC. X-axis values are mean minimum (low) DO concentrations from June through September.

However, evidence indicates that morning DO concentrations lower than occurred in our studies could have a direct negative impact on FCR. It is not unusual to see commercial ponds with DO concentrations dropping down to 1.0 mg/L or even lower. At these extremely low DO concentrations, fish are typically seen near the water surface in the aerator outflow, and even bunched up around the ends and inflow side of the aerators. Feed intake is likely reduced by over 70% under these conditions. Nutritional studies have shown that when feed intake is restricted to approximately 1% body weight daily for fingerlings and slightly lower for larger fish, FCR's do get worse. This is not due to poor digestion or assimilation of feed, but simply because a larger proportion of feed intake is used for maintenance, and less is available for growth when feed intake is very low. It appears that extremely low DO concentrations which limit voluntary feed intake to near-maintenance levels will directly result in both poor growth and higher FCRs.

In summary, FCRs can be improved through oxygen management in two different ways. Poor FCRs may be due directly to extremely low DO concentrations, which may limit feed intake to near-maintenance levels. In those cases FCRs can be immediately improved by raising the minimum DO concentration. Once morning DO concentrations are between 1-2 mg/L, FCRs will not be directly improved by further increases in morning DO, but catfish will consume more feed and grow faster up to a morning DO concentration of approximately 3.0 mg/L. This faster growth will result in a shorter (two-year total) production cycle for channel catfish, less overall mortality, and an improved FCR. This may be the best practical method we have of improving catfish FCRs.

# SRAC Funds Three New Catfish Projects in 2012

*Jimmy Avery, Sarah Harris, and Kristen Walters*
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SRAC provided funding to several regional universities for three new catfish research and extension projects in 2012.

Improving Catfish Broodstock Management. The goal of this research is to provide data related to alterations in current broodfish management that could improve economic efficiency of catfish fry production. There are two objectives to this project. The first objective is to identify diet formulations to improve reproductive performance (egg biochemical composition, fecundity, egg and fry quality) of catfish and determine associated effects on production costs. The second objective is to determine effects of sex ratios, stocking densities, and post spawning brood fish consolidation on catfish reproductive success and determine associated costs.

University of Arkansas at Pine Bluff (UAPB), Texas A&M University, and USDA ARS Catfish Genetics Research Unit (CGRU) will collaborate on the project. SRAC is providing $388,385 in funding over three years. The official start date for the project was January 1, 2012.

Performance Evaluation of Intensive, Pond-Based Culture Systems. One approach farmers are using to intensify production is to stock catfish at high densities in smaller commercial ponds (4 to 8 acres) and installing more aeration per acre. Another approach is to modify a catfish pond to confine fish in a small portion of the total pond area and intensively aerate/manage that area. Either production system may allow farmers to manage their fish production more efficiently as compared to larger commercial ponds. Some of these systems have recently been constructed on commercial operations and many believe they are more controllable and efficient at producing catfish than traditional large pond systems. Little data is available on the economics of intensified pond-based catfish production systems on commercial farms.

Intensified production systems will likely continue to draw the interest of catfish farmers in the future. However, without proper understanding of production efficiencies and thorough economic analysis there will be no definitive recommendations. As a first step, this study will evaluate the production efficiencies of these new production systems on commercial catfish farms. Based on these findings, a complete economic analysis will be performed and will provide the necessary guidance to make recommendations to farmers. In addition, detailed physical descriptions of each culture system will be thoroughly investigated and the most efficient and practical designs will be recommended to farmers.

USDA ARS CGRU, Auburn University, Mississippi State University, and UAPB will collaborate on the project. SRAC is providing $300,000 in funding over 3 years. The official start date for the project was October 1, 2012.

Using National Retail Databases to Determine Market Trends. A previous SRAC project provided guidance to major southern aquaculture commodities on current retail market trends. The 2-year project was based on the acquisition of scanner data from 52 cities across the U.S. for a 5-year period ending June 30, 2010. The project used the store scanner data to analyze market trends and retail pricing issues for catfish, crawfish, clam, and shrimp, and used household-based scanner data to analyze consumer behavior.

Processors asked project participants what effect the 2010 price increases will have on competitiveness of U.S. farm-raised catfish in the marketplace. Unfortunately, the data purchased through this project did not include this period of recent price increases. Moreover, Wal-Mart did not contribute scanner data to the national retail database until 2010. Acquiring two more years of data will allow the project to examine how supermarket trends vary with and without Wal-Mart sales in the dataset. This will allow tracking of how recent increases in prices affect sales in each of the 52 cities, how other competing products and companies adjust to these price changes.

The existing team of collaborators includes UAPB, Texas Tech University, Auburn University, and University of Florida. SRAC is providing $150,000 in funding over 2 years. The official start date for the project was March 1, 2012 to analyze an additional 2 years of market data.

# Aquaflor® Receives Full Approval for Columnaris Disease and Streptococcal Septicemia in Freshwater-reared Fishes

*Patricia Gaunt*

On April 9, 2012, the FDA gave final approval to Aquaflor® for control of mortality associated with columnaris disease in freshwater-reared fishes and streptococcal septicemia associated with *Streptococcus iniae*. The product became available in feed mills on May 9, 2012. The medicated feed was conditionally approved as Aquaflor-CA1® since 2007 for treatment of columnaris disease associated with *Flavobacterium columnare* at a dose rate of 10 mg/kg for 10 consecutive days. The conditional approval, granted under the Mums Health Act of 2004, allowed the drug's sponsor, Merck Animal Health, five years to demonstrate efficacy through laboratory and field trials. During the five year period, farmers could use Aquaflor-CA1 for control of mortality associated with columnaris disease under a veterinary client patient relationship (VCPR).

Aquaflor was fully approved for control of mortality associated with enteric septicemia of catfish (ESC) in 2005. Although Aquaflor and Aquaflor-CA1 were chemically identical products, they were not interchangeable. Aquaflor could not be used to treat columnaris disease and Aquaflor-CA1 could not be used to treat ESC. Veterinarians had to use separate forms for prescribing the medicated feeds. Feed mills had to blend Aquaflor and Aquaflor-CA1 separately and dedicate separate chutes for each. "If we were running low on one product, we couldn't substitute one for the other," states Bob Harris of Fishbelt Feeds in Moorhead, MS. As part of the VCPR agreement, farmers had to use each product according to the label directions. That included storing Aquaflor and Aquaflor CA-1 in two separate bins if there were separate outbreaks of ESC and columnaris disease in ponds.

With the advent of one product, Aquaflor medicated feed, the duplicity of forms, blending processes, and bins goes away. The product will still remain a Veterinary Feed Directive (VFD) drug which requires diagnosis by a licensed veterinarian. There will only be one form which can be used for both ESC and columnaris disease in catfish. Feed mills will only have one medicated article to manufacture - Aquaflor medicated feed. If there are separate outbreaks of ESC and columnaris disease on a farm, the same product can be used to treat both diseases, and farmers can store Aquaflor medicated feed in one bin for both diseases.

Producers should also be aware of the product's new expanded dose rate and withdrawal time. For ESC and columnaris disease treatments, Aquaflor can now be dosed at a rate ranging from 10 to 15 mg active ingredient/kg of fish for 10 consecutive days. This rate change reflects Aquaflor's approval for columnaris disease in freshwater-reared, warmwater fishes besides catfish, and its approval for streptococcus septicemia in freshwater-reared fishes susceptible to the disease. "However, the 10 mg/kg dose rate will still be used to manufacture medicated catfish feed at Fishbelt Feeds," states Harris. A survey of feed mills producing catfish feed in the southeast U.S. indicated that they will follow suit with the 10 mg/kg bw dose rate. Producers of other warmwater fishes besides catfish should check with their veterinarians or feed mills on locally blended dose rates.

All farmers of freshwater-reared fishes including catfish will be affected by the new Aquaflor withdrawal time that the US Food and Drug Administration extended from 12 to 15 days. The purpose of the extension was to facilitate compliance across all freshwater fish species and dose rates.

The species affected by the new Aquaflor label claim include catfish, trout, striped bass, and all other freshwater-reared finfish. Farmers needing further information on the new Aquaflor label claims, dose rates, or withdrawal time are encouraged to contact either Drs. Lester Khoo or Pat Gaunt at the MSU College of Veterinary Medicine Aquatic Diagnostic Laboratory in Stoneville, MS at (662)686-3302.

# Time Still Remains for TAA Training and Funds

*Jimmy Avery*

The Trade Adjustment Assistance for Farmers (TAA) program of 2010 offered educational benefits and payments to help catfish farmers adjust to increased competition from foreign imports. Participants are eligible for cash payments of $4,000 for completing 12 hours of intensive educational sessions and development of an approved initial business plan, and an additional $8,000 for completing an approved long-term business plan. All phases must be completed before May 24, 2013.

Those of you who have not completed all four phases of the program have received letters from FSA and the Southern Risk Management Education Center. If you need to check your status, go to the TAA for Farmers website at www.TAAforFarmers.org. Feel free to contact me if you can't access your status. The following is a list of possible categories other than "Complete".

FSA Application Status - Disapproved. There are two ways you could have received this status. You were either determined not to be eligible or you did not complete the Initial Orientation by the deadline. If this is your status, I am afraid there is nothing that can be done.

Intensive Training Status – Not Started/In Process. Participants must complete a minimum of 12 hours intensive training before they can submit their Initial Business Plan. You can go online at the TAA for Farmers website (www.TAAforFarmers.org) and take online training classes. There are still plenty of on-line courses available.

Initial Business Plan – Not Submitted. After completing the 12 hour requirement, you are eligible to complete the Initial Business Plan and upon successful completion will qualify for the $4,000 payment. The Initial Business Plan consists of six simple questions. To get the Plan approved, you must make a serious attempt to have the answers make rational sense. You should describe your business and plans as best you can. The form is available online at the TAA website, or contact the Southern Risk Management Education Center to have a copy sent to you. You can also contact my office for a copy. The last question on the Plan is whether you intend to complete a long-term business plan.

Long Term Business Plan – Not Submitted. Once your Initial Business Plan was approved, you were assigned a Business Planning Consultant to help guide you in preparation of the plan. The plan can be completed using online programs or software provided by the consultant. Once the plan is approved, the participant is eligible for $8,000 to implement the plan.

If you have any questions or need assistance to complete the TAA requirements, please contact the Regional Office listed below.

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