THAD COCHRAN NATIONAL WARMWATER AQUACULTURE CENTER

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In this Issue

NWAC NEWS

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Mississippi State University and U.S. Department of Agriculture Cooperating

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The Big Fish Problem

Jimmy Avery[1] and Brian Bosworth[2]

The U.S. farm-raised catfish industry has always produced some volume of large fish (typically greater than three pounds). The reasons for this production are varied and have included natural size variation in populations, problems associated with inventory control, harvest delays, fish that are simply missed during harvest, fish grown for specific niche markets, and culling of broodstock. For many years, these large fish were able to be processed and sold through existing markets or would cause only temporary inventory surpluses.

However, during the past couple of years, the volume of big fish has increased and is now a significant problem. Dr. Terry Hanson, Professor at Auburn University, conducts a monthly survey of processors on behalf of The Catfish Institute. Processors are asked to provide an estimate of the average price paid and total pounds processed for three size groups of catfish. These groups are "Very Small" (less than 1 pound), "Premium" (one to four pounds), and "Very Large" (over four pounds). Based on the 2017 reports for January through November, over 27.8 million pounds of "Very Large" catfish were processed. Since processors reported paying an average of $0.39 per pound less for this size fish, producers received almost $11 million less than what they were being paid for "Premium" sized catfish. By November 2017, this price difference between "Premium" and "Very Large" fish had reached $0.61 per pound **(Figure 1)**. This price difference is due to fewer market outlets for whole gutted fish or large fillets.

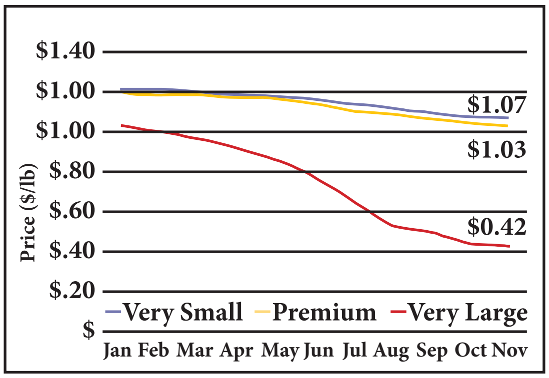

Figure 1. *Prices paid by processors for three size classes of catfish during January to November 2017.*

Some processors have structured their prices into even narrower weight ranges. In December 2017, one processor was reportedly paying $1.05 per pound for one to two pound fish, $0.80 per pound for two to four pound fish, $0.50 per pound for four to eight pound fish, and nothing for fish over eight pounds. If you assume a break-even price of $0.90 per pound, catfish producers were losing $0.10 per pound on two to four pound fish, $0.40 per pound on four to eight pound fish, and $0.90 per pound on catfish over eight pounds.

The primary contributor to the current big fish issue is the industry's transition to the use of hybrid catfish. It has been estimated that hybrid catfish comprise over half of the total U.S. catfish production. The single-batch production strategy commonly used with hybrids typically results in a large variation in size at harvest ranging from 0.75 pounds to more than five pounds. To address this problem, management strategies must be developed that addresses fingerling, stocker, and foodfish production phases.

Grading of hybrid fingerlings could result in more uniform fingerlings and allow similar size fish to be stocked in grow-out ponds. Grading could also support the development of a stocker-production phase. There has been little interest in grading hybrid fingerlings due to increased labor, losses due to stress, and uncertainty of the value of small fingerlings from the same age group. An economic evaluation of the benefits/losses of grading is needed.

MSU and USDA-ARS researchers are currently looking at the impact of culture systems, harvest technology, genetics, stocking density, and feeding rate on size variability at harvest. The USDA Southern Regional Aquaculture Center is also funding research in these areas with Auburn University and the USDA-ARS Warmwater Aquaculture Research Unit. Recent work on the effects of a graded partial harvest on hybrid catfish size variation is summarized by Mischke in this newsletter (page 2).

[1]Mississippi State University – Extension Service
[2]USDA-ARS Warmwater Aquaculture Research Unit

Effects of a Graded Partial-harvest on Hybrid Catfish Size Variation

Charles Mischke[1], Craig Tucker[2], Les Torrans[2], Ambika Tiwari[1], and Thishya Perera[2]

Large fish size variation at harvest is a problem in single-batch production systems. The problem is particularly acute with hybrid catfish because of the fish's faster growth. Two-year-old hybrid catfish commonly range from 0.75 pound to more than five pounds at harvest depending on size and size range of fingerlings used. Most fish processors desire a range of fish sizes to meet demand for various product types; however, the greatest demand (so-called "premium-sized" fish) is generally for fish ranging from one to four pounds, although specifications for desired fish sizes vary among processors and from year to year. Farmers may be penalized for oversized and undersized fish, resulting in loss of income.

Hybrid catfish production practices are relatively new, and limited information is available on production strategies and economics. This study was conducted to determine the effect of mid-summer partial harvest of faster-growing fish on production characteristics in ponds with hybrid catfish in single-batch culture. Twelve, 1.0-acre ponds were stocked with 10,000 hybrid catfish (~ 0.12 lb/fish) in mid-March 2015. In August

Table 1. *Total weight (lbs/ac ± SEM) and weight (lbs/ac ± SEM) of fish in each size class of hybrid catfish produced in partly harvested and control ponds. P-values are the result of an un-paired t-test between total harvest of partly harvested and control ponds.*

Weight range categories							
Treatment	Total wt	0.0-1.0 lbs	1.0-1.5 lbs	1.5-2.0 lbs	2.0-3.0 lbs	3.0-4.0 lbs	4.0-99.0 lbs
Control							
	18,064 (374)	376 (89)	1,768 (212)	3,959 (329)	8,426 (628)	3,151 (329)	380 (100)
Partly harvested							
1st harvest	3,841 (350)	10 (10)	2,012 (405)	1,626 (94)	176 (58)	0 (0)	9 (9)
Last harvest	11,374 (533)	282 (48)	1,547 (136)	3,696 (201)	5,027 (437)	701 (180)	125 (18)
Total	15,216 (307)	292 (53)	3,568 (384)	5,322 (230)	5,203 (444)	701 (180)	134 (14)
P-value	< 0.001	0.437	0.002	0.007	0.002	<0.001	0.035

2015, six random ponds were partially harvested to remove fish larger than ~1.25 pounds using an in-pond, flexible-panel grading sock. In October 2015, all ponds were completely harvested.

Mid-summer, size-selective harvest removed about a quarter of fish originally stocked in partial-harvest ponds and reduced the total number of fish in the two to four pound range. Partial harvest also reduced the total amount of feed fed to fish.

Final harvest in late October yielded 11,374 lb/ac from the partial-harvest ponds **(Table 1)**. When final harvest weight was added to the mid-summer partial harvest, overall production from partial-harvest ponds was 15,216 lb/ac. The single, final harvest from control ponds yielded 18,064 lb/ac, which was significantly greater than from partial-harvest ponds.

Overall, partial harvest of faster-growing fish in mid-summer did reduce the overall biomass of discounted, out-of-size fish, but higher production in control ponds resulted in greater net revenue **(Table 2)**.

Although there may be marketing advantages to producing more fish in the one to two pound size range that is highly preferred by most fish processors, there was no direct economic benefit to mid-summer removal of faster-growing hybrid catfish in single-batch culture. However, if fingerlings larger than 0.12 lb/fish are used to initiate culture, or if harvest is delayed into the next few months of the next growing season because of market constraints (such as unmarketable, off-flavored fish), the proportion of discounted, oversized fish would be larger and would have a greater effect on net revenues. Future research should focus on using larger, graded and un-graded hybrid catfish fingerlings to stock ponds for foodfish production under the same conditions presented in this study.

Table 2. *Partial budget of changing from harvesting hybrid catfish foodfish at the end of the season to partly harvesting foodfish once during the production season with a second harvest at the end.*

Category	Value or cost/ac
Benefits	
Additional revenue	
Fish sales[a]	$0.00
Reduced costs	
Feed (2.12 ton per pond, $368/ton)	$780.16
Electricity for aeration (694 hp-h per pond, $0.10 per hp-h)	$69.40
Total benefits	$849.56
Costs	
Additional costs	
Labor ($200 per pond)	$200.00
Depreciation ($367.38/yr for 6 ponds)	$61.23
Reduced revenue	
Fish sales[a]	$3,133.87
Total additional costs	$3,395.10
Net benefit	-$2,545.54
[a]Based on prices paid per size group.	

[1]Mississippi State University – MAFES
[2]USDA-ARS Warmwater Aquaculture Research Unit

The mechanical evolution of the oral ESC vaccination platforms with the current version on the right.

Development of an Oral ESC Vaccination Platform

David Wise[1], Ganesh Kumar[1], Terry Greenway[1], and Todd Byars[1]

In 2008, Mississippi Agriculture and Forestry Experimental Station (MAFES) researchers at the NWAC began work developing an oral vaccination platform to immunize fish against enteric septicemia of catfish (ESC), a bacterial disease causing significant financial losses in the U.S. catfish industry. The initial step in this project was the attenuation of the virulent bacterial pathogen. The attenuated isolate was tested in the laboratory and small experimental ponds with promising results. Tests showed the approach was effective in providing a high level of protection against ESC, but the vaccine/feed mixture had to be prepared by hand in small increments and had no prac-

Production Parameters	Units	Channels		Hybrids	
		Vaccinated	Non-vaccinated	Vaccinated	Non-vaccinated
Number of ponds	(nos.)	50	79	43	67
Stocking density	(nos./ac)	123,231	121,752	107,424	102,730
Survival	(%)	80.4*	58.4	78.5*	69.5
Feeding rate	(tons/ac)	5.011*	4.336	7.621*	5.854
Gross yield	(lbs/ac)	6,334*	4,644	8,204*	6,258
FCR	(ratio)	1.65*	1.94	1.84	1.95
Harvest weight	(lbs/1000)	67.8	70.8	99.2	90.4
* Denotes the significance difference @ 5% level of significance of vaccinated treatment from the respective non-vaccinated counterparts.					

Table 1. *Production parameters of commercial vaccination trials, 2013-2015.*

tical application. To address this issue, MAFES scientists collaborated with engineers in the MSU Department of Agriculture & Biological Engineering to develop a mechanized system for preparing the vaccine feed mixture at the point of delivery. This technology was essential to further develop the vaccination platform. The first prototype was validated in 2009 in one-acre experimental ponds using vaccine produced in small volume batch cultures.

The second hurdle was to scale up vaccine production to produce sufficient quantities of vaccine to conduct commercial field trials. A cooperative research agreement was established with the USDA-ARS National Biological Control Laboratory (NBCL), located on the MSU Delta Research & Extension Center Campus, Stoneville, MS, to begin work developing fermentation and processing procedures for commercial scale vaccine production. In 2012, the first vaccine serials were produced from 50-liter batches and validated in laboratory and experimental ponds. After processing, the vaccine was shown stable for a minimum of two years in cold storage (-70°C) without loss of viability or potency. The following year commercial field trials were conducted in collaboration with College of Veterinary Medicine, Aquatic Research and Diagnostic Laboratory (ARDL) using the vaccine delivery system and vaccine serials fermented by NBCL. Other institutions involved in the development of the project included the USDA-ARS Warmwater Aquaculture Research Unit (Stoneville, MS), and USDA-ARS Poultry Research Unit (Starkville, MS)

Further delivery system refinements have been made to increase payload and delivery rates. In 2016 and 2017, the finalized system has been used to vaccinate approximately 400 million stocked catfish fingerings. Economic analysis of commercial trials conducted between 2013-2015 **(Table 1)** demonstrated a net economic benefit to both channel and hybrid catfish ranging between $2,000 to $3,000/ac. Improvements in survival, feed consumption, and feed conversion resulting from vaccination are also anticipated to produce additional economic benefits on farm as a result of diffusion of benefit from fingerling production phase to the stocker and foodfish production phases. Food fish production could benefit either through production intensification or by allocating more of the freed up fingerling ponds to profit maximizing foodfish production strategies. There is also evidence that the ESC vaccine cross protects against *E. piscicida,* an emerging pathogen in larger hybrid catfish (see Griffin article this issue Emergence of *Edwardsiella piscicida* in Channel and Hybrid Catfish, page 6).

These collaborative efforts between MAFES, MSU Department of Agriculture & Biological Engineering, NBCL, and catfish producers have led to the development of an oral vaccination platform that allows for the successful immunization of catfish against ESC. This is the first delivered vaccine to show benefit in commercial catfish culture and is a milestone in aquaculture vaccinology. It is anticipated the oral vaccination platform will be commercially available by the 2018 catfish production season.

[1]Mississippi State University - MAFES

Emergence of *Edwardsiella piscicida* in Channel and Hybrid Catfish

Matt Griffin[1], Suja Aarattuthodiyil[2], Cynthia Ware[1], James Steadman[1], Marsha Lewis[1], Patricia Gaunt[1], Lester Khoo[1], and David Wise[2]

Disease case submissions to the Aquatic Research and Diagnostic Laboratory (ARDL) at the Thad Cochran National Warmwater Aquaculture Center in Stoneville, and anecdotal reports from the catfish industry point to an increased incidence of *Edwardsiella piscicida*-septicemia particularly in hybrid catfish over the past decade **(Figure 1)**. From 2013-2017, a total of 3,242 disease cases were submitted to the ARDL. While hybrids only account for about 40% of the cases, they account for nearly 90% of the *E. piscicida* (previously referred to as *E. tarda*). Of the *E. piscicida* cases, one was from largemouth bass, 19 were from channel catfish and 120 were from hybrid catfish. Previously, a molecular survey of archived isolates recovered from farm-raised catfish in Mississippi from 2007-2012 revealed that all suspected *E. tarda* isolates were in fact *E. piscicida*. This is consistent with recent work, which confirmed 99.2% of suspected *E. piscicida* recovered from 2013-2017 as *E. piscicida* by multiplex real-time PCR. Lesions associated with *E. piscicida* septicemia are similar to lesions associated with Enteric Septicemia of Catfish caused by *E. ictaluri* **(Figure 2)**.

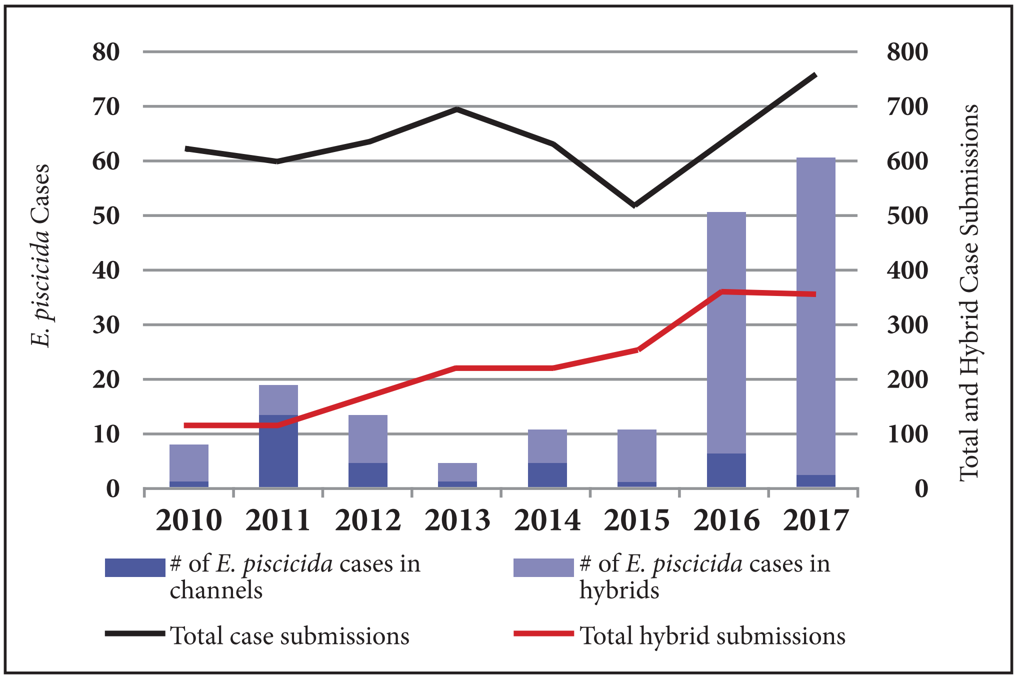

***Figure 1.** ARDL statistics through October 2017. The left axis represents presumptive <u>E. piscicida</u> cases in hybrid and channel catfish. The right axis represents disease case submissions.*

This emergence of *E. piscicida* infection is of high priority, as it is the first pathogen confirmed to have increased virulence in hybrid catfish. In addition, the bacteria show a wide host range, causing disease in >20 species of fish including several sport and ornamental fish. Since its recognition in 2013, *E. piscicida* has been attributed to bacterial septicemia in largemouth bass, farmed whitefish, blotched fantail stingray, and barramundi. Recent studies at the NWAC indicated *E. piscicida* to be 10 times more lethal in hybrids than in channel catfish.

Hybrid catfish continue to gain popularity amongst catfish producers in Mississippi and the surrounding states, increasing from an estimated 20-25% of total production in 2012 to nearly 30-40% of US catfish production in 2014 due to of their favorable production characteristics. It is

***Figure 2.** Gross lesions of E. piscicida in hybrid catfish.*

possible that with expanding hybrid production, disease entities could emerge that were of minimal concern or non-existent when U.S. catfish aquaculture was comprised primarily of channel catfish. As hybrid production expands, more research is needed to develop effective treatment and prevention strategies to mitigate losses associated with *E. piscicida* infection.

Most importantly, the overwhelming majority (97%) of *E. piscicida* recovered from farm raised catfish in this survey (2013-2017) were from stocker or market-sized hybrids. *E. piscicida* tends to occur during grow-out season, and impacts primarily food-sized, marketable fish where significant producer costs have already been invested. Therefore, the resultant economic losses are particularly damaging on farm profits. As summer months are critical for foodfish growers, occurrence of *E. piscicida* in late summer and early fall magnifies its impact on feed intake and lost production time.

A single dose of an orally delivered, *E. ictaluri* vaccine (ESC vaccine) developed by MAFES researchers at the National Warmwater Aquaculture Center in Stoneville has been successful in protecting catfish against *E. ictaluri* infection, improving survival, yield, feed efficiency, and feed conversion. At present it is unknown if vaccinating populations of catfish against *E. ictaluri* will also confer protection against *E. piscicida*, although this avenue of research appears promising. Establishing the efficacy of the ESC vaccine against *E. piscicida* will negate the need for development of an attenuated *E. piscicida* vaccine and will afford catfish producers a tool to combat an emerging disease.

[1]Mississippi State University - CVM
[2]Mississippi State University – MAFES

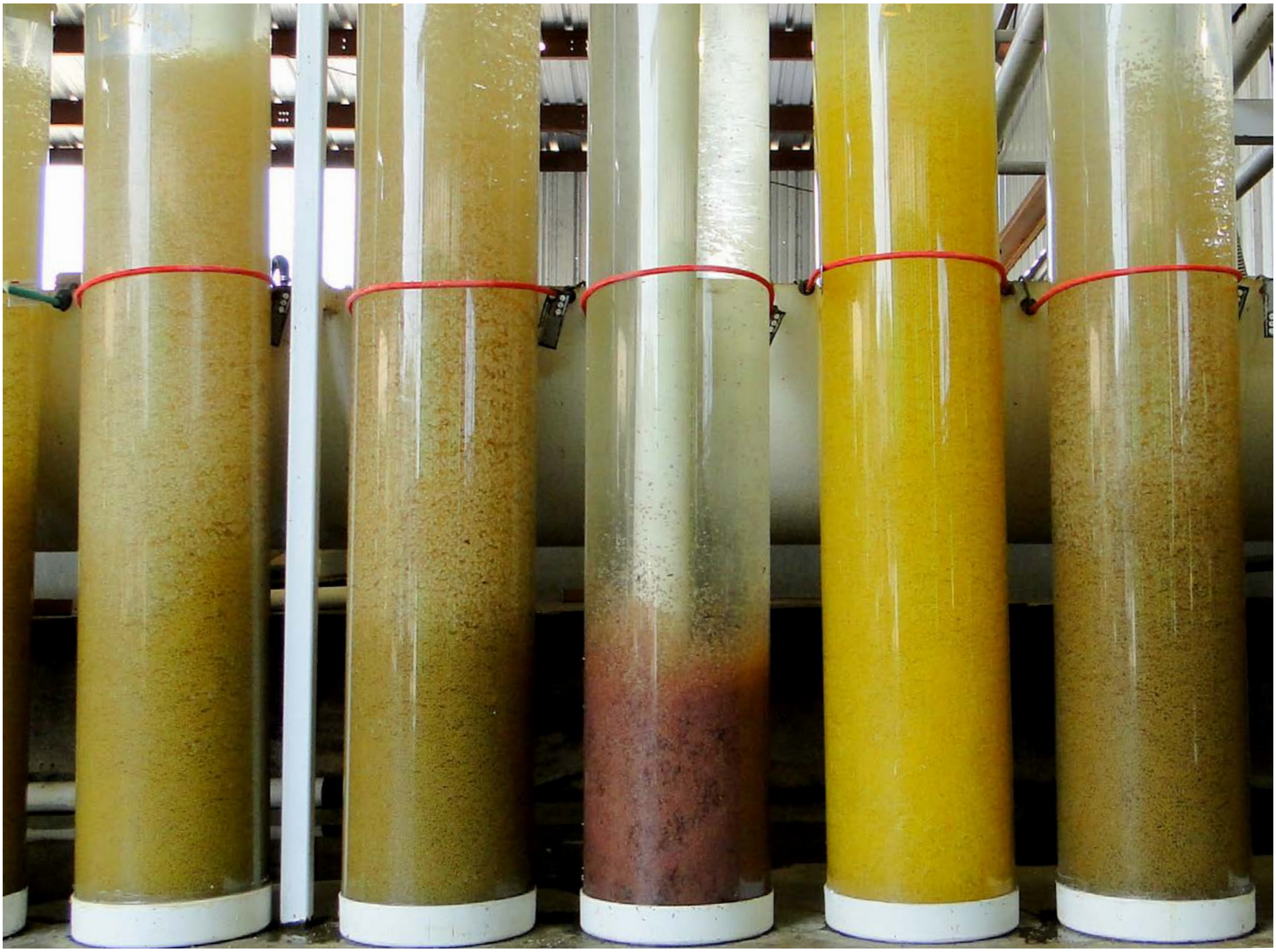

Figure 1. Several large tube incubators (approx. 4' tall X 10" diameter) containing eggs at several developmental stages. The second tube from the right contains the youngest eggs; the third tube contains the oldest eggs.

Oxygen Requirement of Separated Hybrid Catfish Eggs

Les Torrans[1] and Brian Ott[1]

Channel catfish egg masses require hatchery water with over 7.8 ppm dissolved oxygen (DO) at 80° F (95% air saturation) to maintain maximum oxygen consumption as they near hatching. This DO concentration is called the critical oxygen requirement by scientists but for the purpose of this article we will call it the oxygen requirement. With a lower DO concentration, the developing embryos consume less oxygen, hatch prematurely, and have a poorer survival. Premature hatching has also been linked to the so-called "triple-tail" deformity.

Hybrid catfish eggs (female channel catfish X male blue catfish) are rarely produced by natural pond spawning but usually by "hand-stripping" in the hatchery after the female receives a series of hormone injections. Hybrid eggs are often kept separated after fertilization by adding fuller's earth and are incubated in large tube incubators **(Figure 1)**. It is assumed but not known that the oxygen requirement for these separated hybrid catfish eggs/embryos is lower than channel catfish embryos because they are not clumped together in an egg mass. This study was conducted to determine the oxygen requirement for incubation of developing hybrid catfish embryos.

Forty-three measurements were made on 16 different spawns at three to five days post-fertilization and a total of nine measurements were made on sac fry from five different spawns ranging in age from zero to two days post-hatch **(Figure 2)**. The water temperature averaged 77° F.

The DO required by hybrid catfish eggs peaked at 6.5 ppm (79% air saturation) during the last two days of incubation. This is considerably lower than the oxygen required by catfish eggs in an intact egg mass. While sac fry have a higher metabolic rate (greater oxygen consumption per body weight) than hybrid embryos just before hatching, the loss of the egg shell makes oxygen transfer easier and sac fry only require about 4.5 ppm DO (55% saturation) for the first two days post-hatch.

Hatchery managers should maintain DO at or above 6.5 ppm for hybrid catfish eggs in tube incubators during the last two days before the eggs hatch.

[1]USDA-ARS Warmwater Aquaculture Research Unit

Figure 2. *Required oxygen concentration of separated hybrid catfish eggs. The eggs require approximately 6.5 ppm during the last two days of incubation; sac fry only require 4.5 ppm the first two days after they hatch.*

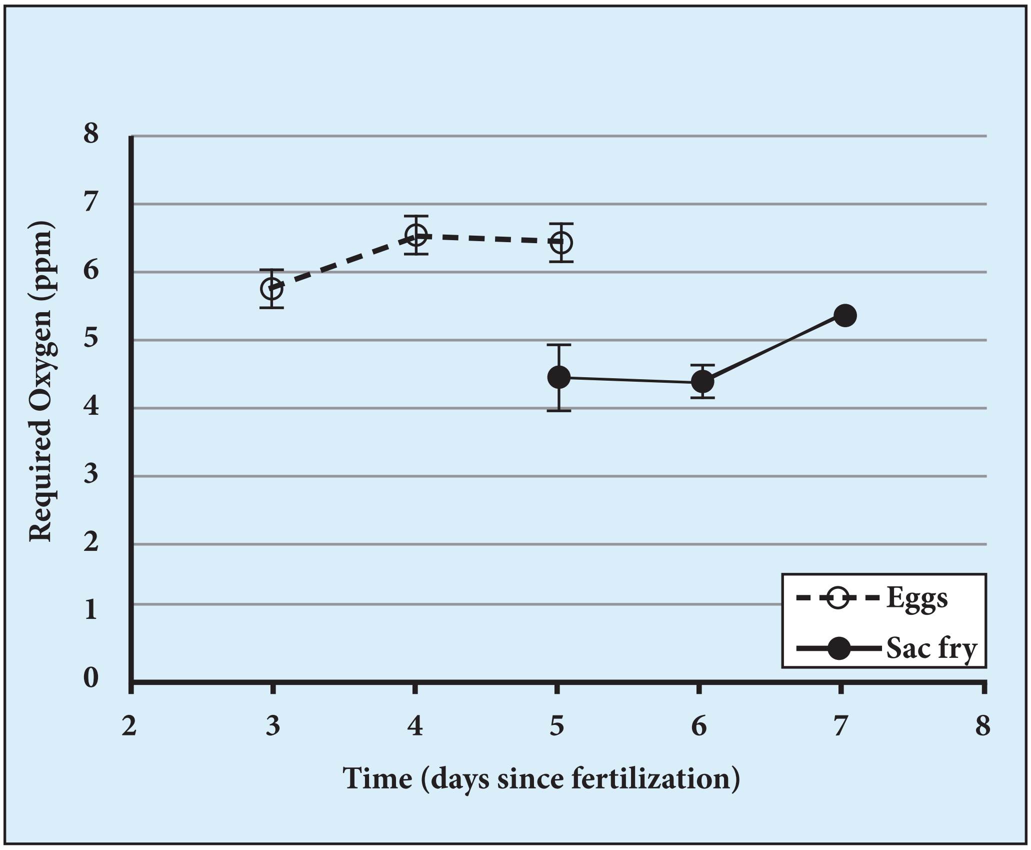

Figure 1. Research design developed at the Thad Cochran National Warmwater Aquaculture Center, Stoneville, MS.

Economic and Risk Considerations of Intensive Catfish Production Technologies

Ganesh Kumar[1], Carole Engle[2], and Craig Tucker[3]

Rising costs of inputs and increased competition from imports have resulted in considerable contraction of the U.S. catfish industry from 2003 through 2013. The future success of catfish farming therefore depends on improvements in production practices that bring cost efficiencies. Such improvements can be achieved either by modifying existing traditional catfish production technologies or by technological innovation that results in greater productivity. Research conducted at Mississippi State University stimulated adoption of yield-increasing technologies such as intensively aerated ponds and split-pond systems. These intensive systems combine biological, chemical, and physical intensification elements into a single, integrated system providing better production control than traditional open-ponds.

Successful industry-wide adoption of these intensive systems will depend upon their productivity and cost efficiencies. With this objective in mind, economic analyzes were conducted to determine costs, investment feasibility, and

Figure 2 (left). *Waterwheel design tested on commercial catfish ponds.* ***Figure 3*** *(right). Screw-pump design tested on commercial catfish ponds.*

economic risks associated with these two intensive systems. Performance of the following three split-pond design scenarios were monitored in Arkansas and Mississippi: (1) a research design developed at the Thad Cochran National Warmwater Aquaculture Center, Stoneville, MS **(Figure 1)**; (2) a waterwheel design tested on commercial catfish ponds **(Figure 2)**; and (3) a screw-pump design tested on commercial catfish ponds **(Figure 3)**. An economic-engineering approach using standard enterprise budget analysis was used to develop estimates of break-even prices (BEPs; $/lb) for producing food-size hybrid catfish (female channel catfish x male blue catfish) for each scenario.

Estimates of BEPs of hybrid catfish raised in split ponds ranged from $0.78 to $0.91/lb. The cost of catfish production in split ponds was sensitive to yield, fish prices, and feed prices. Annual net cash flows from both commercial split-pond systems were high and sufficient to make the investment profitable in the long run **(Table 1)**. The most important contributors to risk when using split ponds were yield, feed conversion ratio, and feed price.

Similarly, economic monitoring was performed on commercial catfish farms that employ high levels of aeration (> 5 hp/ac) in Alabama, Arkansas, and Mississippi. A multivariate-cluster analysis was used to identify four different management clusters of intensively aerated commercial catfish farms based on stocking density, size of fingerlings at stocking, and feed conversion ratios (FCR). Aeration rates did not differ among the four management clusters (average = 7.7 hp/ac).

Break-even prices of hybrids raised in intensively aerated pond systems were estimated to range from $0.85/lb to $0.99/lb, with the lowest costs associated with the second greatest level of production intensity. The two intermediate intensity clusters generated sufficiently high revenues for long-term profitability **(Table 2)**. However, the least-intensive and the most-intensive clusters were economically feasible only when catfish and feed prices were closer to less probable market prices. Feed price, FCR, and yield contributed the most to downside risk. Intensive aeration in catfish ponds, up to the levels analyzed in this study, appears to be economically feasible under the medium-intensity management strategies identified in this analysis.

Owing to the high upfront investment costs and high operating costs, these intensive systems should be adopted only after careful examination of equity and cash flow situations on individual farms. Feeding efficiency has always been a key to economic success in catfish farming, but is even more when raising fish in intensive production systems. The improved productivity that has been demonstrated in split-ponds and intensively aerated ponds under commercial conditions has potential to reduce costs, increase production, and enhance the competitiveness of the U.S. catfish industry.

[1]Mississippi State University – MAFES
[2]Engle-Stone Aquatic$, LLC
[3]USDA-ARS Warmwater Aquaculture Research Unit

Table 1. *Production and economic performance of different split-pond designs.*

Parameters	Units	Research design	Waterwheel design	Screw-pump design
Additional investment required for conversion	($/ac)	$7,750	$5,400	$4,400
Stocking density	(fish/ac)	12,800	12,000	14,000
Gross yield	(lbs/ac)	18,100	15,500	18,700
FCR	(ratio)	1.80	2.30	2.60
Break-even price above total costs	($/lb)	$0.78	$0.93	$0.91
Break-even yield above total costs *	(lbs/ac)	14,207	14,143	16,834
Payback Period*	(yrs)	2.5	4.7	3.4
Net present value*	($/ac)	$16,274	$2,755	$6,135
Modified internal rate of returns*	(%)	21%	14%	17%
Probability of success (long-run economic conditions*)	(%)	100%	81%	88%
*@ fish price of $1.00/lb and feed price of $410/ton.				

Table 2. *Production and economic performance of different intensively aerated commercial pond management strategies.*

Parameters	Units	Low intensive	Medium intensive	High intensive	Very-high intensive
Additional investment for intensification	($/ac)	$2,994	$2,994	$2,994	$2,994
Stocking density	(fish/ac)	6,900	8,500	10,000	13,300
Gross yield	(lbs/ac)	11,500	13,000	14,600	15,500
FCR	(ratio)	2.50	2.24	2.06	2.61
Break-even price above total costs	($/lb)	$0.99	$0.91	$0.85	$0.98
Break-even yield above total costs *	(lbs/ac)	11,362	11,862	12,416	15,155
Payback Period*	(yrs)	11.2	5.2	3.5	9.7
Net present value*	($/ac)	-$2,116	$863	$2,973	-$1,706
Modified internal rate of returns*	(%)	4%	12%	16%	5%
Probability of success (long-run economic conditions*)	(%)	91%	98%	100%	91%
*@ fish price of $1.00/lb and feed price of $410/ton.					

2016 Aquatic Research and Diagnostic Laboratory Summary Report

Lester Khoo[1], *Patricia Gaunt*[1], *and Matt Griffin*[1]

For 2016, the Aquatic Research and Diagnostic Laboratory (ARDL) in Stoneville, MS received a total of 744 case submissions. Of these, 631 were submitted by producers and 113 were submitted by USDA and MSU researchers. There were also 770 water samples submitted for analysis. The number of cases of common diseases are provided in the table together with their monthly occurrence. Bacterial diseases were the predominant diagnosis for the submissions. Columnaris disease (both external Columnaris [where the agent was not isolated but seen on wet mounts] and when the etiological agent *Flavobacterium columnare* was isolated) was diagnosed in 303 submissions representing 40.7% of total case submissions. None of these bacterial isolates were resistant to the three antibiotics tested (i.e. Terramycin®, Romet® and Aquaflor®). *Edwardsiella ictaluri,* the causative agent of Enteric Septicemia of Catfish (ESC) was isolated from 292 submissions which was 39.2% of all submissions. Antimicrobial resistance seen in 25 isolates from 22 different ponds with four repeat submissions. Twenty-four were resistant to Terramycin® with intermediate resistance to Aquaflor® and one was resistant to Terramycin®. *Edwardsiella tarda (E. piscicida)* was added to the list of major diseases as it appears to be coming more prevalent. There were 51 *Edwardsiella tarda (E. piscicida)* and these were confirmed by molecular testing to be *E. piscicida.* Interestingly of all these cases, 47 were from hybrid catfish. All but one (resistant to Terramycin®) of these isolates was susceptible to the 3 antibiotics tested. There were 24 atypical *Aeromonas hydrophila,* one of which was resistant to Terramycin®. *Yersinia ruckeri,* a bacterial pathogen usually associated with salmonids, was diagnosed in four cases. All these four cases were from hybrid catfish.

Of the parasitic diseases, there were 82 cases of Proliferative Gill Disease (PGD), 46 cases of *Bolbophorus* trematode, and 2 cases of *Ichthyophthirius multifiliis* (white spot). The number of *Bolbophorus* trematode cases were much higher than last year, where *Bolbophorus* was reported from only 14 submissions.

There were 11 cases of channel catfish virus disease, 14 cases of saprolegniasis, and 23 anemia cases.

The case submissions appear to reflect the trend of increasing use of hybrid catfish. Out of the 738 catfish cases, 368 were channel catfish, 362 were hybrid catfish, and eight were blue catfish.

The table of the 10-year trends of the major diseases seen by the ARDL is also provided. This shows the percentage that each disease represents of the total number of cases for each year as well as the 10-year average. While the data provides an indication of the prevalence of the each of the diseases, there are also inherent biases since the data is dependent on case submissions.

[1]Mississippi State University - CVM

Disease	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
Columnaris	37.5	36.7	24.6	26.8	19.6	24.0	34.7	49.9	54.3	40.7	34.9%
ESC	32.8	18.6	15	18.1	22.9	21.4	30.9	45.6	27	39.2	27.2%
PGD	18.4	33.7	21.4	15.9	14.3	14.1	11.6	15.8	9.2	11	16.5%
Saprolegnia	8	9.2	9.4	4.5	4	5.4	1.2	3.4	3.7	1.9	5.1%
CCV	2	0	7.2	4.7	3.4	0.9	1	0.6	1.7	1.5	2.3%
Anemia	10.7	2.7	2.8	5	5.8	3.2	4.4	1.9	2.7	3.1	4.2%
Ich	0.6	0.8	3.1	0.5	0	0	0.1	0	0.3	0.3	0.6%
Bolbophorus	1.5	0.3	1.8	1.8	1.1	2.3	9.2	4.7	2.3	6.2	3.1%
VTC	1.3	5.4	3.4	1.9	1.5	6.1	0	0.6	0.2	0	2.0%
E. tarda (E. piscicida)	2.2	5.9	1.9	1.3	2.2	1.7	1	1.6	2	6.9	2.7%
No pathogens identified	17.1	17.5	16.1	15.1	10.4	17.9	20.4	11.6	13.9	7.8	14.8%
Number of cases	1,144	630	678	623	852	772	867	701	599	744	761

Prophylactic Treatment of Catfish Fry Ponds with Copper Sulfate

Charles C. Mischke[1], David Wise[1], Matt Griffin[2], and Ambika Tiwari[1]

Trematodes are a serious problem in farm-raised channel catfish. They have caused millions of dollars in economic losses and are especially impactful to fingerling catfish. The trematode life cycle involves the marsh ram's-horn snail and the American white pelican. Management techniques for controlling infestations are primarily aimed at disrupting the trematode life cycle by reducing snail populations.

Copper sulfate is an effective treatment to control snails but has not been evaluated for fry ponds. Fry ponds are managed as an all-in and all-out production system, where ponds are drained each year after harvest and refilled 21–28 days before stocking the next production season. This provides a logical opportunity to eradicate snail populations with high copper concentrations 14–21 days before stocking. This control strategy, at a producer's request, was evaluated on a commercial operation. In response to this initial trial, an experimental pond study was conducted to evaluate the safety of copper sulfate used as a prophylactic snail control treatment in fry ponds.

The on-farm trial was conducted at a commercial catfish farm. Fourteen ponds were treated with four mg/L fine copper sulfate crystals, and ten ponds served as controls. Treated ponds were stocked about 21 days after treatment. Ponds ranged from four to 10 acres and were stocked with catfish fry at about 150,000/acre.

The experimental study was conducted in 15 earthen ponds (0.1 acre). The ponds were randomly assigned to the following treatment groups: copper sulfate application 21 days before stocking, copper sulfate application 14 days before stocking, copper sulfate application seven days before stocking, copper sulfate application one day before stocking, and no copper sulfate application. On the designated dates, fine copper sulfate crystals were applied to treatment ponds by dissolving the crystals in water and applying behind a running aerator.

In the on-farm trial, copper sulfate-treated ponds had a significant reduction in catfish fingerling survival, weight harvested, and revenue **(Table 1)**. Survival in copper-treated ponds was only 17.7% compared to 63% in control ponds. Of the 14 treated ponds, six had 0% survival. In comparison, survival of non-treated ponds ranged from 43–90%. Low survival resulted in lower total pounds/acre harvested, less feed fed, and significantly reduced revenue. The cause of poor survival is unknown. Based on previous literature, free copper should dissipate within 24–48 hours. Because fry were stocked well after copper treatment, and zooplankton populations, although affected by copper treatment, should have been adequate for fry production, the cause of low fry survival could not be determined. As a result, experimental pond trials were conducted to substantiate these observations.

In the experimental trial, at two hours post-treatment, free copper concentrations ranged from 0.64–1.04 mg/L and from 0.52–0.78 mg/L after 24 hours **(Table 2)**. In all treatments it took about 20 days for free copper to return to pre-treatment concentrations– in contrast to reports copper should dissipate within 24-48 hours.

Similar to the on-farm study, but not as dramatic, catfish fry survival was lower in all treatment groups compared to controls and was lower the closer treatment was to fry stocking **(Table 3)**. Mean fish size was inversely proportional to survival leading to similar total pounds harvested and total feed fed among treatment groups.

Although copper did not dissipate as quickly as previously reported, direct copper toxicity should not be the issue, but changes in environmental quality, indirectly related to the copper treatment, could have been associated with lower fry survival, but a specific variable could not be identified. Similar chlorophyll *a* concentrations among treatments indicate similar bloom density and no suboptimal environmental quality variables, including dissolved oxygen concentrations, were observed in the experimental pond trial. Copper purportedly mineralizes and precipitates; therefore, it is possible free copper is higher at the water-sediment interface compared to the water column. The precipitate is initially weekly mineralized, and free copper may be released if pH at the water-sediment interface is acidic due to respiratory activity. Since fry typically go to the bottom of the pond when first stocked, they could be exposed to higher copper concentrations than are present in the water column. Until further work is done evaluating the relationships, copper sulfate should not be used to prophylactically treat catfish fry ponds.

[1]Mississippi State University – MAFES
[2]Mississippi State University - CVM

Table 1. *Commercial farm comparison of harvest variables from copper sulfate-treated fry ponds and control ponds. Values in a row sharing the same letter are not significantly (P>0.1) different.*

	Treatment	
Variable	**Copper**	**Control**
Survival	17.7 (5.3)a	63.0 (5.6)b
Harvest weight (lb/ac)	26,263 (6,504)a	58,765 (4,007)b
Feed fed (lb)	4,793 (1,201)a	11,428 (410)b
Feed conversion	1.83 (0.12)a	1.71(0.06)a
Revenue ($/ac)	$4,150 (1,035)a	$11,120 (594)b

Table 2*. Free copper concentration (mg/L Cu, SEM) 2 h post-treatment, 24 h post-treatment, at stocking, and number of days required for free copper concentration to return to pre-treatment concentrations in ponds treated with 1.27 mg/L Cu at different times before stocking.*

Treatment	**Free copper concentration 2 h post-treatment**	**Free copper concentration 24 h post-treatment**	**Free copper concentration at stocking**	**Days to return to pre-treatment concentration**
1 d	1.01 (0.16)a	0.52 (0.04)bc	0.52 (0.04)a	20
7 d	0.64 (0.07)b	0.52 (0.06)bc	0.10 (0.01)b	27
14 d	0.79 (0.09)abc	0.65 (0.04)b	0.04 (0.01)c	20
21 d	1.04 (0.07)ca	0.78 (0.05)a	0.02 (0.01) c	20

Table 3. *Experimental study harvest results comparing ponds receiving copper sulfate treatment 1 d, 7 d, 14 d, 21 d before stocking fry and control ponds. Results within a column sharing a common letter are not significantly different (P>0.1).*

Treatment	**Mean size (g)**	**Total lb harvested**	**% Survival**	**Lbs feed fed**	**Feed conversion ratio**
1 d	8.0 (1.0)b	75.6 (4.6)	43.0 (3.6)c	85.0 (2.4)	1.11 (0.05)abc
7 d	6.3 (0.3)bc	84.4 (4.8)	60.8 (5.3)bc	87.3 (3.1)	1.01 (0.03)a
14 d	5.3 (0.6)ac	73.2 (3.7)	63.1 (5.7)b	90.8 (2.4)	1.24 (0.08)b
21 d	6.3 (0.9)bc	84.2 (6.2)	63.4 (1.2)b	89.1 (2.4)	1.07 (0.10)abc
Control	4.3 (0.3)ac	82.9 (2.0)	86.1 (4.8)a	87.1 (3.5)	1.02 (0.04)ac

Using Phytase in Catfish Feeds

Menghe Li[1], David Wise[1], Chuck Mischke[1], Suja Aarattuthodiyil[1], Craig Tucker[2], Les Torrans[2], Ambika Tiwari[1], Thishya Perera[2], and Penny Lucas[1]

Phytase is an enzyme that can break down phytic acid or its salt, phytate, inherent in plant-based feed ingredients, and release inorganic phosphorus which can be readily absorbed by animals. Phytase has been used in animal feeds for more than 25 years and is one of the most commonly used animal feed additives in the United States. Researchers at the NWAC started looking at using phytase in catfish feeds in the mid-1990's. Several studies were conducted, and results showed 250–500 phytase units (FTU) per kilogram diet improved growth, bone phosphorus, and hematocrits in channel catfish over plant-based control diets without phosphorus supplements. These studies also indicated phytase could completely replace dietary inorganic phosphorus supplements. Based on these results, some catfish feed mills began using phytase in commercial feeds in the early 2000's.

Recently, there is renewed interest in using phytase in catfish feeds. But rather than using low phytase levels to make phosphorus more available from plant feed ingredients, the new interest involves "super-dosing" of phytase. Reports from the swine and poultry industries showed super-dosing of phytase (2,500 FTU per kilogram and higher) further improved feed consumption, growth, feed conversion, and absorption of phosphorus and other minerals over a normal dose (500 FTU per/kg). Preliminary results from Auburn University demonstrated pond-raised hybrid catfish fed a phytase super-dose diet had superior growth and feed conversion, and higher hematocrits than fish fed a control diet.

The first commercialized phytase was made from a fungus, and since then new phytase products made from bacteria or other fungi have been developed, which have shown to be more effective than the older version of phytase. Since dietary iron plays an important role in red blood cell production, and phytase may liberate more iron from the diet which may potentially improve iron absorption by fish, we were particularly interested in using super-dosing of the new phytase products to reduce the occurrence of catfish anemia.

In 2016 and 2017, we conducted two pond trials with hybrid catfish to look at the effects of super-dosing of commercial catfish feeds with phytase on feed consumption, growth, feed conversion, survival, and hematocrits. In 2016, we stocked hybrid fingerlings in 18 ponds at 7,000 fish per acre, and fed 28% protein diets with or without phytase (2,500 FTU per/kg) for 198 days. In 2017, we tested 32% protein diets with or without phytase (5,000 FTU per/kg) for hybrid fingerlings stocked in 10 ponds at 10,000 fish per acre and fed for 128 days.

In 2016, about two months after stocking, fish developed anemia, and there were mortalities in most ponds. At the end of the study, statistical analysis was performed on data including all ponds and data including ponds with > 50% survival only; the latter are reported in **Table 1**. Both datasets showed no significant differences in total feed fed, gross yield, final weight per fish, survival, or hematocrits between fish fed diets with and without phytase. Also, there were no statistical differences in total phosphorus, soluble reactive phosphorus, or chlorophyll *a* concentrations **(Table 2)**. We saw similar responses in 2017, except ponds receiving the phytase diet had significantly higher soluble reactive phosphorus concentrations in the water. One pond had high mortality due to bird predation in the spring, but the remaining ponds had much better survival than the 2016 study **(Table 1)**.

The lack of positive responses of catfish to phytase super-dosing is likely because the control diets used had enough available phosphorus. The control diets had 0.93–0.94% total phosphorus and are estimated to have 0.34–0.38% available phosphorus, which is above the catfish's phosphorus requirement (0.3% of diet). Any extra phosphorus liberated by phytase above the requirement is not used by the fish, and therefore released into the pond water, leading to higher soluble reactive phosphorus levels as shown in 2017. Phytase may free more nutrients such as amino acids and other minerals like iron from phytate binding, but amounts released probably do not make much difference considering anemia occurred in fish fed both control and phytase diets and similar mortalities were observed in 2016.

Results from this study and previous work at the NWAC show phytase at 500 FTU per kilogram is enough to replace inorganic phosphorus supplements in catfish feeds. Phytase is not necessary if inorganic phosphorus is used and diets have 0.3% or more available phosphorus. Phytase super-dosing does not appear to have additional benefits beyond the normal dose at least on promoting growth and preventing anemia in catfish. A phytase level of 500 FTU per kilogram is recommended to replace inorganic phosphorus supplements in catfish feeds.

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Table 1. *Production data of hybrid catfish fed diets with or without phytase. There were no statistical differences between dietary treatments at the 5% probability.*

Phytase (FTU/kg)	No. of ponds	Total feed fed (lb/ac)	Gross yield (lb/ac)	Final weight[1] (lb/fish)	Feed conversion (feed/gain)	Estimated survival[1] (%)	Hematocrit (%)
2016							
0	3	14,296	8,600	1.79	1.87	68.6	32.7
2,500	3	15,450	8,768	1.66	1.96	79.6	31.3
2017							
0	4	17,575	10,664	1.15	1.84	91.0	39.5
5,000	5	15,961	9,861	1.07	1.82	90.8	40.7

[1]Estimated based on sample weight of 500 fish per pond.

Table 2. *Water quality data in ponds receiving diets with or without phytase. In each year, means within each column followed by different letters were different at the 5% probability.*

Phytase (FTUs/kg)	Total phosphorus (ppm)	Soluble reactive phosphorus (ppm)	Chlorophyll *a* (ppb)
2016			
0	0.58	0.16	260
2,500	0.56	0.15	253
2017			
0	0.56	0.08 b	260
5,000	0.54	0.13 a	288

U.S. catfish processors are inspected daily by the USDA Food Safety and Inspection Service. So, when you choose U.S. farm-raised catfish, not only are you selecting the best tasting, most consistent fish available, but you can also rest assured it has met the world's highest standards.

Avoiding Residues in U.S. Farm-raised Catfish

Jimmy Avery[1] and Lester Khoo[2]

The USDA Food Safety and Inspection Service (FSIS) began inspecting domestic catfish processing facilities in March 2016 with full inspection starting in September 2017. A critical component of the inspection process is sampling for residues of chemical compounds in the edible portion of catfish. Fillet samples are taken directly from the processing line on a schedule determined by FSIS and tested for pesticides, veterinary drugs, and environmental contaminants. In total, U.S. farm-raised catfish are tested for over 200 compounds. A violation occurs when an FSIS laboratory detects a chemical compound level in excess of an established tolerance or action level or the residue detected has no approved tolerance.

How do catfish get exposed to chemicals? They can ingest chemicals through contaminated feed or forage fish. A second route of exposure is through absorption from water used in production or transport. This occurs primarily through the gills but can also be absorbed through the skin.

The US Environmental Protection Agency (EPA) sets tolerance for pesticides. Currently there are only 11 herbicides and four algicides approved for use in catfish ponds. To limit the exposure of catfish to pesticides, producers should follow these guidelines:

1. Accurately identify target weed species and select suitable herbicides for use.
2. Only apply pesticides that are EPA registered and are labeled for aquatic use.
3. Read and follow all label instructions.
4. Carefully calculate the volume of water to be treated and the amount of chemical to apply.
5. Do not exceed label rates of approved products.
6. Keep records of pesticides purchased, amount applied, when they were applied and where they were used.
7. Use all precautions to prevent pesticide contamination through drift or runoff.

The US Food and Drug Administration (FDA) sets tolerances for veterinary drugs. Currently there are four approved drugs and one drug of low regulatory priority for use in hatcheries. Chorionic gonadotropin is used as an aid in improving spawning function and requires a prescription from a licensed veterinarian. Formalin, povidone iodine, and hydrogen peroxide are used and as egg disinfectants. Tricane methansulfonate is used for the temporary immobilization of fish and requires a 21-day withdrawal time before fish can be processed. Copper sulfate is a regulatory deferred action drug that is effective at killing fungus on eggs.

There are four products used in ponds that are classified as low regulatory priority drugs, regulatory action deferred, or EPA pesticides. Salt is registered as an osmoregulatory enhancer and is effective in preventing brown-blood disease. Potassium permanganate, copper sulfate, and hydrated lime are used to control parasites and address water quality issues. None of these products have withdrawal times

There are four FDA approved drugs products registered for use in ponds, three of which are FDA approved antibiotics. Each of the three registered antibiotics requires a prescription from a licensed veterinarian. Aquaflor® is used to control ESC and columnaris disease and requires a 15-day withdrawal time before fish can be sold. Romet®-30 is used to control ESC and requires a 3-day withdrawal period. Terramycin® 200 is used to control *Aeromonas* and requires a 21-day withdrawal time. Producers should identify populations treated with antibiotics and insure that these fish are not sold before withdrawal times are met. Formalin is also registered for use in ponds and is typically used only for controlling the *Ich* parasite.

There are four FDA low regulatory priority drugs used as hauling aids for foodfish. These are ice and three sources of chlorides. Producers and haulers should ensure that no other hauling aids are used on catfish or forage fish that are fed to foodfish. There is a possibility that forage fish treated with known, unapproved products could lead to bioaccumulation in foodfish.

It is vital that all segments of the industry strive to prevent residues in our product. Extension Specialists at Mississippi State University, University of Arkansas Pine Bluff, and Auburn University have been offering educational sessions on this subject beginning in November 2017 with more sessions scheduled through the end of January 2018. Contact your State Extension Specialist in any of the three states if you would like more information.

[1]Mississippi State University – Extension Service
[2]Mississippi State University - CVM

Cormorant Roost Dispersal Program

Dust'n Lunsford[1]

USDA Wildlife Services (WS) is in the middle of this year's Cormorant Roost Dispersal Program. The Roost Dispersal Program is centered on major pushes, which are two-day events requiring all participants to monitor and disperse birds simultaneously each evening **(Table 1)**. Major pushes should be conducted in addition to normal dispersal activities. If birds are not present during the first evening of a major push, it is essential to continue monitoring the roost on the second day. The birds will be moving from roost to roost each evening as dispersal efforts continue so monitoring all roost sites both days of the push is necessary. As a direct response to dispersal pressure, these birds will begin to look for new places to roost and to prevent damage to aquaculture, it is essential that they be prevented from roosting near aquaculture facilities. It is important to move cormorants as soon as a roosting population is established. The longer dispersal is postponed, the more difficult it will be to move the cormorants.

WS realizes many producers have neighbors unwilling to participate, so if we can be of assistance in covering additional roosts please contact our office. You can contact Dust'n Lunsford, Aquaculture Program Coordinator at the USDA Wildlife Services office in Stoneville by cell phone (228-990-1852) or e-mail (Dust'n.d.lunsford@aphis.usda.gov). WS will be conducting limited lethal control during the dispersal program due to the revocation of the USFWS Depredation Orders (50 CFR 21.47).

Just as a reminder, it is the responsibility of each participant to obtain written permission from the property owner(s) where a cormorant roost is located before proceeding with dispersal efforts. Many of these roost areas are leased or used solely for the purpose of waterfowl hunting. Cooperating with these hunting groups as much as possible can help smooth the way for all parties to accomplish their goals.

Anyone aware of heavy roosting sites is encouraged to contact the Stoneville Office or a member of the WS aquaculture program. We suggest that those groups volunteering for a particular area meet and coordinate dispersal for assigned roosts in that area. Site specific maps of individual cormorant night roosts can be provided upon each participant's request. Recruitment of additional volunteers is still needed. Anyone recruited to assist with roost dispersal should contact our office so we can provide them with up-to-date information on cormorant numbers, roost dispersal information, and technical assistance on dispersal methods. Coordination and team work is the key to a success for our cormorant roost dispersal program.

[1]USDA-APHIS Wildlife Services

Table 1. *USDA Wildlife Service's Cormorant Dispersal Program schedule for 2018.*

Date	Activity
January 16th-19th	Aerial Survey
January 23rd	Major Push
January 24th	Major Push
January 30th	Major Push
January 31st	Major Push
February 6th*	Mid-Winter Census*
February 7th*	Mid-Winter Census*
February 13th	Major Push
February 14th	Major Push
February 20th-23rd	Aerial Survey
February 27th	Major Push
February 28th	Major Push
March 5th-8th	Aerial Survey
March 13th	Major Push
March 14th	Major Push
March 19th-22nd	Aerial Survey
March 27th	Major Push
March 28th	Major Push
April 2nd-5th	Aerial Survey
April 10th	Major Push
April 11th	Major Push
April 16th-19th	Aerial Survey
April 24th	Major Push
April 25th	Major Push

* WS and other personnel will conduct a complete count of cormorants at night roosts.

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