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NWAC NEWS

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In this Issue

NWAC NEWS

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Technical Editor: Jimmy Avery
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Trematode Update

David Wise[1], Jimmy Avery[2], Matt Griffin[3], Chuck Mischke[1,] Wes Lowe[4]

Investigations into trematode life stages have uncovered several previously unreported species infecting catfish (see Rosser et al. in this issue). While the effect of most trematode infestations likely has minimal impact, *Bolbophorus damnificus,* and possibly *Drepanocephalus spathans* and *Hysteromopha corti* can have significant effects on production. Fortunately, these species are transmitted by the same snail host(s); therefore, reducing marsh ram's horn and ghost ram's horn snail numbers in catfish ponds should be effective in controlling economically important trematode infestations. Farm closures have been linked to heavy *B. damnificus* infections, and it is important to understand risk factors associated with infestations, such as farm and pond location, pond vegetation, and level of human activity. Ponds with heavy vegetation will support greater snail densities, and farms located near bird migratory flyways and inland loafing sites (cypress breaks, abandoned fishponds, etc.) are at greater risk for widespread infestations.

Recognizing farm risk factors and implementing a monitoring program is critical to control. Close attention to weekly feed records is likely sufficient for farms with low risk factors and historically sporadic trematode prevalence. Whereas farms near bird loafing sites or with remotely located ponds and a history of high trematode prevalence require greater management inputs to minimize the deleterious effects of this disease. High risk operations should have aggressive bird harassment protocols along with routine fish examinations for early detection of infections.

There is no single approach for snail control, and snail treatments strategies depend on several factors including severity of infection, time to fish harvest, location of snails, and pond water temperatures. A risk/benefit treatment assessment should be made for each infested pond to determine the appropriate treatment strategy. Ponds with heavy snail populations along the pond margins can be killed with hydrated lime applied at 0.75-1.0 pound per foot of pond bank as a powder or slurry **(Figure 1)**. This treatment is safe to fish but is only effective against snails in the treatment swath. A more effective treatment is a "whole pond" application of 3 mg/L copper sulfate, but treatments must be used with caution, especially during peak production when pond temperatures are elevated. Elevated copper treatments can be toxic to fish and will likely result in oxygen depletions. Heavy infestations early in production may warrant high dose copper treatments since the impact of the infestation is a greater risk to production compared to the treatment risk. In contrast, mild infestations, or even moderate infestation where feed rates are only slightly suppressed may require a less aggressive treatment approach, especially during extreme pond water temperatures.

There have been testimonials /anecdotal reports of farmers using repeated 1 mg/L copper margin treatments with apparent success which is well below the copper LC50 required to kill snails. Although the efficacy of these treatments has not been validated in field studies, our laboratory data demonstrates repeated low-dose copper sulfate applications are effective in killing adult marsh ram's horn snails. In addition, laboratory trials have shown eggs and early hatched snails are killed at copper levels below what is currently used for off-flavor control (see Mischke et al. this issue). While the effects of multiple low-dose copper treatments have not been evaluated in a field setting, it is likely the off-flavor treatment rate will be effective in minimizing snail reproduction. Research is being conducted to develop more proactive rather than reactive management strategies for controlling snail populations in catfish production ponds.

In collaboration with Mississippi State University Department of Agricultural and Biological

Engineering, a copper application system has been developed to uniformly deliver powered copper sulfate along the pond margins (**Figure 2**). The field-programmable system utilizes the variables of pond depth and perimeter to regulate the powdered copper sulfate application for each pond. The automated system increases copper treatment accuracy and simplifies the application process. In preliminary experimental pond trials, 1 mg/L copper sulfate was shown to kill over 90% of test snails. Work is being conducted to evaluate effects of multiple low dose copper applications (<1 mg/L) on snail survival, pond ecology, and fish production.

Copper toxicity depends on the concentration of free copper in the water. Soon after application, copper can be complexed to dissolved organic matter and inorganic constituents. Temperature is also a major factor in determining toxicity with copper being nearly five times more toxic to snails at 30°C than 15°C. These factors vary greatly among ponds with differing bloom densities and clay particles, all of which will reduce the concentration of free copper and the effective treatment rate. Given the complexity of copper chemistry in pond water, it is difficult to determine a universal treatment rate applicable to all ponds. Variation in pond temperature, chemistry, turbidity, and bloom density can alter copper toxicity to both fish and snails. Research is being conducted to better define treatment recommendations and develop more proactive rather than reactive trematode management strategies.

Figure 1 (top). *Hydrated lime slurry being applied along pond margin.* ***Figure 2.*** *Programable dry copper sulfate applicator.*

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Management of Columnaris Disease

Lester Khoo[1]

Columnaris Disease (Columnaris) is the most frequently diagnosed disease for fish submitted to the Aquatic Research & Diagnostic Laboratory (ARDL) affecting both channel and hybrid catfish equally. Diagnosis is based on gross lesions and the identification of thin, flexing bacilli on microscopic examination of wet mounts of these lesions and/or by bacterial colony morphology of cultures on nutrient poor media. Characteristic necrotic lesions often with a yellow discoloration can be seen on the mouth, fins, body, and gills (**Figure 1**). Typically, there are no obvious gross internal lesions but some fish may still culture positive even when no gross lesions are evident.

Figure 1. *Catfish fingerling with Columnaris Disease.*

Several strains of *Flavobacterium columnare,* the causative agent of Columnaris, are seen in catfish although there is one predominant strain that is commonly implicated. Current work also shows that some of these bacteria are not *F. columnare* but rather are other closely related bacteria. which may partially explain why there are different outcomes when managing this disease. This bacterium is ubiquitous and is part of the microbiota of freshwater fish, eggs, and ponds. Farming practices and pond environments select for virulent strains leading to disease outbreaks. The bacteria can survive for extended periods in hard alkaline waters with high organic loads.

Prevention is always better than cure and there are studies looking at developing vaccines against this disease. Decreasing stress, especially during conducive temperatures (unfortunately, this disease is seen over a wide range of temperatures), is often not possible. Additional complications to management are that asymptomatic fish may act as carriers but even worse, dead infected fish can shed at higher rates than these apparently healthy fish. Thus, like all infectious diseases, removal of dead fish from the culture systems can help reduce the spread of disease by reducing the pathogen load.

Currently, the only approved antibiotic for treating Columnaris in catfish is Aquaflor® medicated feed. There are efforts underway to extend the label claim for Terramycin® 200 which is approved for treatment of this disease in salmonids. Although we have not seen *F. columnare* antibiotic resistance to Aquaflor ® at the ARDL, we have seen resistance to the different antibiotics in a few cases with enteric bacteria such as *Edwardsiella ictaluri* in ponds where fish had been fed medicated feed to treat for Columnaris earlier in the spring. Besides the concern of antibiotic resistance, the other reason medicated feed should be used judiciously is the increased cost of medicated feed which will cut into the profits, especially in non-fingerling sized fish.

The only other Food and Drug Administration approved drugs for treating external Columnaris in catfish are Chloramine T (Halamid® Aqua) and hydrogen peroxide (35% Perox-Aide®). However, they appear to be more suited for treatment in aquaria or troughs. Experimental treatments using other chemicals such as copper sulfate, potassium permanganate, and Diquat® (diquat dibromide) have been explored with variable results. These chemicals are either approved herbicides or water treatment products and the variable results seen may be due to different water quality conditions and/or stage of infection. Salt (sodium chloride) and low pH have also been investigated as possible treatments/prevention of Columnaris. However, lowering pH in ponds and the levels of salt required are not practical. That is not to minimize that increasing salt levels, while not curative, may help the diseased animal deal with stress. Unlike *E. ictaluri, F. columnare* is a non-enteric bacteria and the strategy of leaving fish off feed to reduce oral-fecal route of transmission has not shown to be an effective management tool.

Thus, the management of Columnaris is multifactorial. While antibiotics have often been effective, other management strategies such as vaccination, removal of dead or severely diseased fish, and palliative treatments such as using salt should lessen the effects of Columnaris infections in ponds. If in other rearing systems, there may be other possibilities as listed above.

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Economics of Cormorant Predation on Catfish Farms

Carole Engle[1], Ganesh Kumar[2], Terrel Christie[3], Brian Dorr[4], Brian Davis[3], Luke Roy[5], and Anita Kelly[5]

The Double-crested Cormorant is the primary avian predator on catfish farms causing significant economic losses primarily due to 1) on-farm expenditures related to bird-management activities and 2) value of the catfish lost to cormorants. This comprehensive economic study quantified these two economic effects by surveying catfish farms in the delta regions of Mississippi and Arkansas. On-farm expenditures for bird scaring were used to quantify bird-management costs. Economic losses from fish consumed by cormorants were quantified by evaluating data from field studies of the abundance, distribution, and diet of cormorants in the Mississippi delta.

This study found that catfish farmers spent an average of $285 per acre on farms to scare birds, making bird-scaring costs one of the top five expenditures of raising catfish. Expenses for manpower (labor/manager) were the greatest cost, followed by vehicle expenses (fuel/depreciation/repairs/maintenance) used to run birds, and cost of levee upkeep to chase birds **(Figure 1)**. Many of these costs were fixed in that effort was needed regardless of the volume of catfish produced. Increased fixed costs disproportionally harm small catfish farms because of their limited scale of production.

Estimation of the average annual value of catfish losses industrywide to cormorant predation amounted to $47 million **(Table 1)**, most of which occurred on foodfish farms. Hybrid catfish fingerling losses were seven times higher than channel catfish fingerlings primarily because of the increased value of hybrid fingerlings and greater consumption by cormorants. Historical estimates of the economic effect from cormorant predation were also found to increase substantially over time **(Figure 2)**. Total direct economic effects (bird-scaring costs and the value of fish lost to cormorants despite bird-scaring activities) averaged $65 million **(Table 1)**. This study also found the economic effect of bird predation to influence the profitability of catfish farms. Removing the economic effects surrounding predation losses due to cormorants would improve the profitability of catfish production operations by 4-23% across various farm size and production strategies **(Figure 3)**.

Although recognized as an agriculture sector under the National Aquaculture Act 1980, aquaculture does not receive the same attention as several of the larger livestock industries. Catfish losses to avian predators are not compensated under the federal Livestock Indemnity Protection (LIP), nor under the Emergency Assistance for Livestock, Honeybees, and Farm-raised Fish Program (ELAP). Federal efforts to protect natural resources, such as cormorants, have increased cormorant populations with the subsequent effect of increased losses on aquaculture farms without compensatory relief programs.

Editor's Note. This article is a summary of results of a recently published scientific article Engle et al. (2020): Engle, C.R., T. Christie, B. Dorr, G. Kumar, B. Davis, L. Roy, and A. Kelly. 2020. Principal economic effects of cormorant predation on catfish farms. Journal of the World Aquaculture Society. https://doi.org/10.1111/jwas.12728

***Table 1.** Industrywide total direct economic effects of bird predation on catfish farms. Source: Engle et al. 2020.*

Life stages	Bird-scaring costs	Value of fish losses	Total direct economic effects
Fingerlings	$2,393,742	$641,629	$3,035,371
Channels	$797,914	$81,189	$879,103
Hybrids	$1,595,828	$560,440	$2,156,268
Foodsize	$15,080,297	$46,582,632	$61,662,929
Total	$17,474,039	$47,224,261	$64,698,300

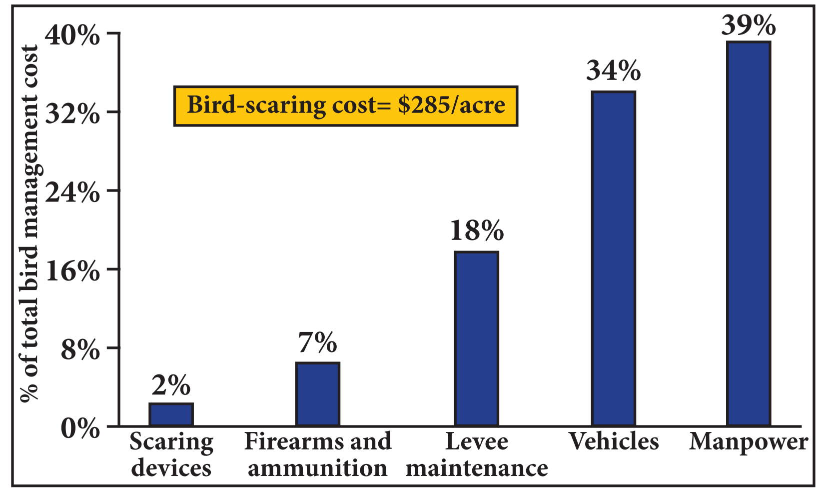

***Figure 1.** Components of bird management cost on MS delta catfish farms, 2018. SOURCE: Engle et al. 2020.*

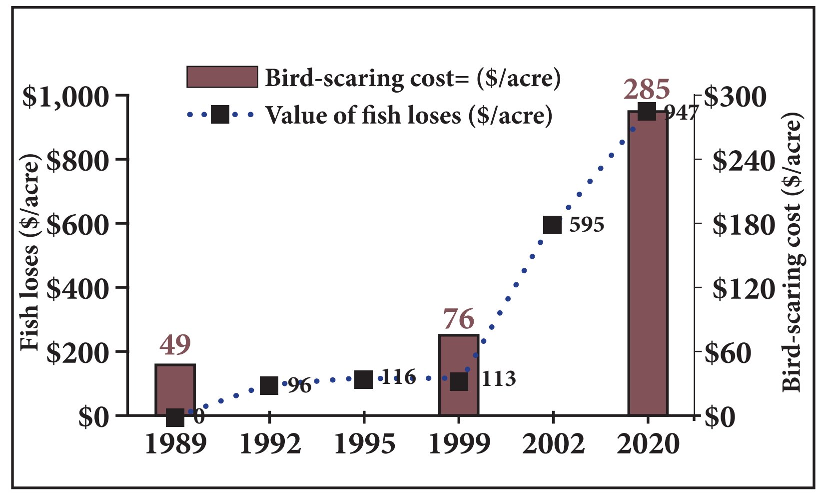

***Figure 2.** Historical estimates of negative economic effects from fish-eating birds on catfish farms. SOURCE: Engle et al. 2020.*

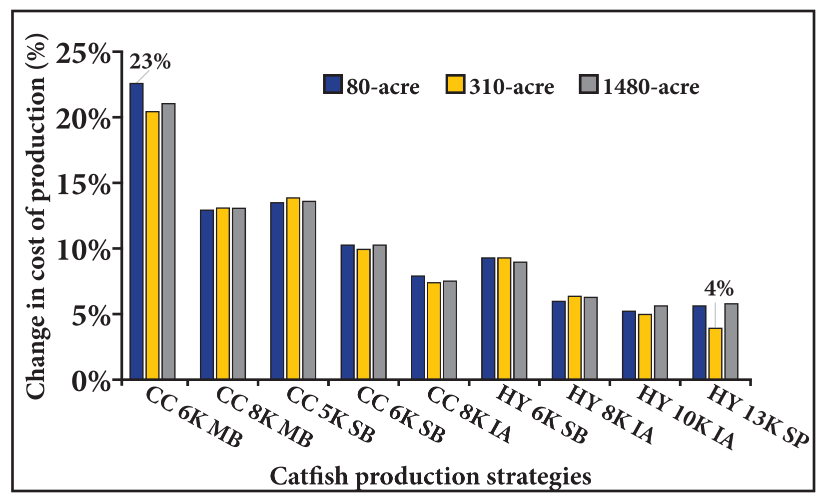

***Figure 3.** Percentage change in cost of production without the economic effect associated with birds. (CC=channel catfish; HY=hybrid catfish; MB=multiple-batch system; SB=single-batch system; IA=intensively aerated ponds; SP=split-pond system; Numbers represent fingerling stocking densities in thousands/acre). SOURCE: Engle et al. 2020.*

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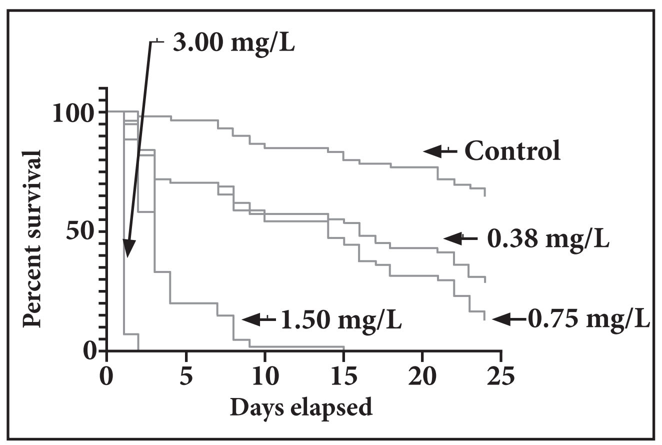
Copper Sulfate Treatments in Multiple, Low Doses May be Effective in Controlling Ram's Horn Snails in Catfish Ponds

Charles Mischke[1], David Wise[1], Matt Griffin[2], Graham Rosser[2], and Ambika Tiwari[1]

Trematodes have caused significant problems in commercial catfish aquaculture since the mid-1990s. To combat trematode infestations, research has focused on breaking the parasite life cycle by eliminating snails from production ponds. Whole pond treatments with 2.5-5.0 mg/L copper sulfate applied as a single dose are effective in killing snails in catfish ponds. However, in hot weather application of moderate to high levels of copper sulfate can be toxic to fish and will likely result in an oxygen depletion. To increase treatment safety, we are evaluating toxicity of repetitive low dose copper treatments to developing snail life stages.

Adult Snails. Adult ram's horn snails collected from a commercial catfish pond were treated with four weekly doses ranging from 0.38-3.0 mg/L copper sulfate in 2-fold increments **(Figure 1)**. Mortality increased with increasing copper concentrations. All copper doses increased mortality compared to non-treated snails. A single dose of 3.0 mg/L and three weekly doses of 1.5 mg/L killed 100% of snails. Partial mortality was observed in snails treated with 0.75 and 0.38. However, because of relatively high mortality in non-treated snails (68%) the test was repeated with laboratory reared snails. No mortality was observed in non-treated snails or snails treated with copper sulfate concentrations < 0.38 mg/L. Three 1.5 mg/L doses killed all snails, and four 0.75 mg/L doses killed 53% of the snails. Toxicity differences between the two trials is unknown but likely related to the condition of snails at the time of testing. Poor snail condition could be related to snail age, exposure to suboptimal environmental conditions present in commercial catfish ponds or snail parasitism. Snails for the first trial were collected from a commercial catfish production pond diagnosed with a *B. damnificus* infestation. We have preliminary data suggesting parasitism reduces snail fitness, indicating parasitized snails may be more susceptible to chemical treatments than non-parasitized snails. This would indicate complete eradication may not be necessary to control trematode infestations in commercial catfish ponds, as the treatments would preferentially target parasitized snails that are the source of infection. Additional snail toxicity trials are being conducted to confirm these initial findings. This work will also focus on determining longevity and reproductive potential of infected snails and if infected snails can over winter and serve as a source of infection over several growing seasons.

Eggs and Juveniles. Another study evaluated repeated copper sulfate treatments (0.05-0.75 mg/L) on eggs and juvenile snail survival. Two weekly 0.75 mg/L copper sulfate exposures were sufficient to kill snail eggs. Doses as low as 0.18 mg/L arrested embryo development and significantly reduced hatching rates to negligible levels. Two doses of 0.09 mg/L resulted in only 50% of eggs hatching **(Figure 2, 3)**. Over time, repeated doses as low as 0.05 mg/L copper sulfate partially reduced juvenile snail survival (data not shown).



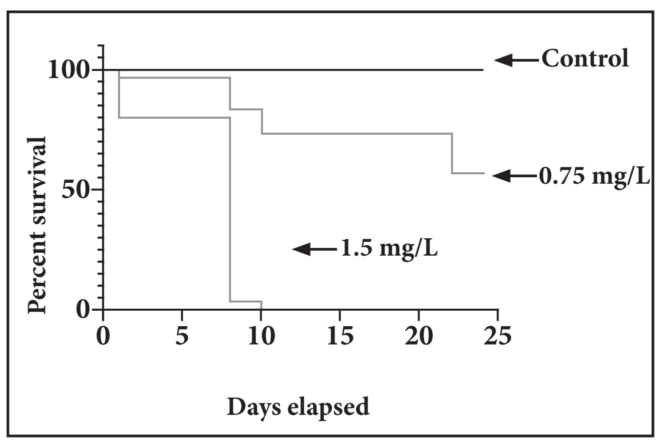


Figure 1. Survival curve showing triplicate tanks of ram's horn snails assigned to treatments of copper sulfate and untreated controls. Treatments were applied at day 0, 7, 14, and 21. The left graph represents snails collected from a commercial operation, and the test was conducted at 82°F. The right graph represents laboratory reared snails, and the test was conducted at 73°F; no mortality was observed in treatments <0.75 mg/L copper sulfate in the laboratory reared snails.

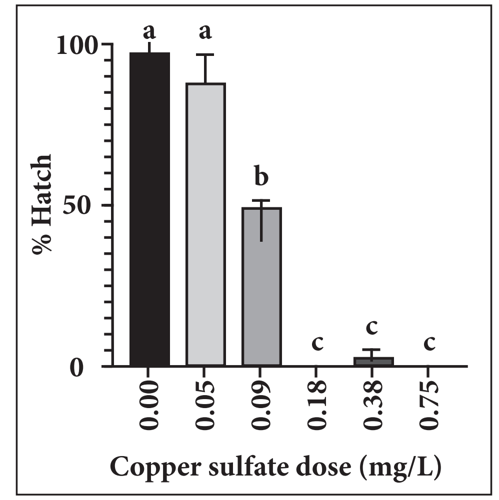


Figure 2. *Hatch percentage of snail egg masses at 10 days post-spawning after two copper sulfate treatments administered on day 0 and day 7. Bars sharing the same letter are not significantly different (P<0.05).*

Toxicity of copper to aquatic animals has been studied in detail, but it is difficult to offer simple practical guidelines for safe and effective copper delivery rates as several environmental variables (pH, total alkalinity, hardness, salinity, and dissolved organic matter) affect copper toxicity. Perhaps the most influential variables to copper toxicity are temperature and total suspended solids. We previously showed a significant linear relationship between copper toxicity to snails and temperature, revealing copper to be nearly five times more toxic to snails at 86°F than 59°F. As such, a higher dose of copper may be required at lower temperatures. Also, the higher the concentration of total suspended solids in the water, the more quickly copper is bound to particulates and loses efficacy.

If immediate control is warranted, a single dose of 2.5 mg/L may be required to kill adult snails, considering fish and algal toxicity. A safer treatment would be to use multiple lower doses which should reduce adult snail populations and prevent juvenile snail development.

We will be evaluating the efficacy of lower copper sulfate applications, used to control algal blooms, to control snails in commercial catfish ponds. Future studies will determine the economic benefits of repeated weekly low-dose copper sulfate applications to reduce snail populations and mitigate off-flavor through blue-green algae control.

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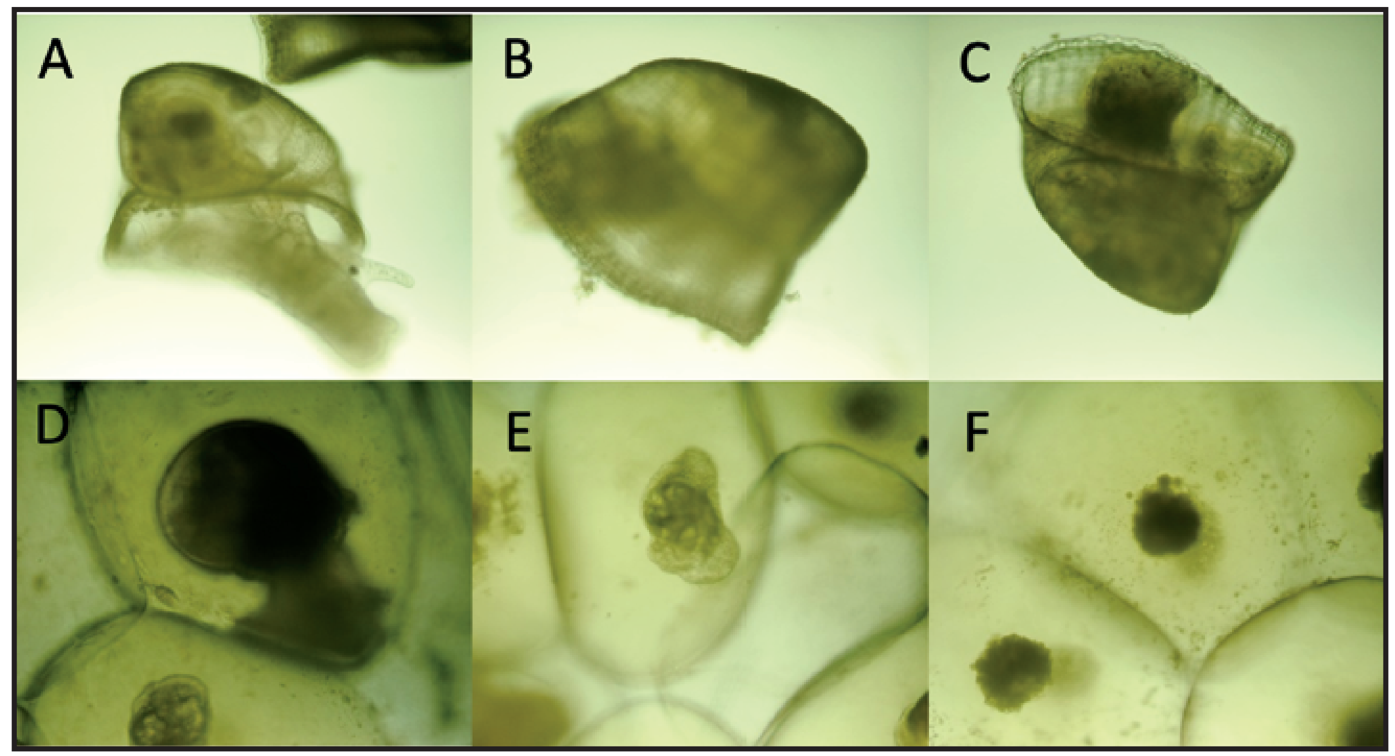

Figure 3. *Snail development at 10 days post-spawning. Snail egg masses were treated with copper sulfate on day 0 and day 7. Snails from representative copper sulfate treatments are as follows: A=control, B=0.05 mg/L, C=0.09 mg/L, D=0.18 mg/L, E=0.38 mg/L, and F=0.75 mg/L.*

Effect of Fingerling Understocking Densities on Intensively Aerated Multiple-batch Systems

Ganesh Kumar[1], David Wise[1], Menghe Li[2], Suja Aarattuthodiyil[1], Shraddha Hegde[1], Billy Rutland[1], Sean Pruett[1], Matt Griffin[3], and Lester Khoo[3]

Producers are continuously adopting intensified production practices such as increased stocking densities and aeration rates in multiple-batch systems as means to improve cost efficiencies. Proven stocking recommendations are vital for efficient implementation of these developments in multiple-batch production. The first step towards this goal is to establish economically optimal understocking densities for channel catfish fingerlings. In 2018, a production study was conducted understocking fingerlings with densities at 7,000, 8,200, and 10,500 fingerlings per acre (mean length = 6.5 inches) over equal weights of carryover fish (1.01 pounds per fish at 4,038 pounds per acre) in 1-acre ponds (4 ponds per treatment). Fish were fed 28% protein feed once daily to satiation and provided with 10-horsepower per acre aeration.

Most production variables such as gross, net, daily-net yields, marketable yields (≥1.25 pounds), growth (grams per day), and survival were similar among the three understocking density treatments **(Table 1, Figure 1)**. Sub-marketable yield (<1.25 pounds) and feeding rate increased significantly with increased understocking density **(Figure 2)**. Economic analysis found the cost of production to increase and net returns to decrease with increased stocking density when sub-marketable fish were not considered as revenue. However, when sub-marketable fish were included as revenue, the differences in production costs and net returns among the three treatments were minimal **(Table 2)**. Annual net cash flow in all three treatments was positive. This study confirms channel catfish understocking densities of 7,000-10,500 fish per acre can improve cost efficiency in intensively aerated, multiple-batch production systems.

Previous studies evaluating on-farm catfish production strategies under current market conditions found traditional multiple-batch production systems using channel catfish fingerlings to be non-profitable at lower stocking densities (4,000-6,000 fish per acre). Results of this study suggest higher aeration and stocking densities can enhance production in multiple-batch systems with annual fish production exceeding 9,000 pounds per acre, leading to improved profitability and cash flow. Understocking densities utilized in this study had no measurable effect on marketable fish yield. However, increases in understocking densities yielded corresponding increases in sub-marketable yield. Increased yield of sub-market sized fish, without compromising the growth of understocked and carryover fish is vital for generating continual profits and positive cash flows in multiple-batch systems. The value of sub-marketable yield and available operating capital in the subsequent year of production are two important on-farm factors determining stocking densities in multiple-batch systems.

Editor's Note. This article is a summary of results of a recently published scientific article Kumar et al. (2020): Kumar, G, Wise, D, Li, M, Aarattuthodi, S., Hegde, S., Rutland, B., Pruett, S., Griffin, M., and Khoo L. 2020. Effect of understocking density of channel catfish fingerlings in intensively aerated multiple-batch production. Journal of the World Aquaculture Society. https://doi.org/10.1111/jwas.12733

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Table 1. *Production performance of channel catfish fingerlings under three different understocking densities. Within rows, values with different superscripts are significantly different (p ≤ 0.05). SOURCE: Kumar et al. 2020.*

Production parameters	Units	7,000 fingerlings/acre	8,200 fingerlings/acre	10,500 fingerlings/acre
Yield				
Partial harvest	lb/acre	5,525	4,985	4,858
Second harvest	lb/acre	6,929	8,324	9,037
Marketable yield	lb/acre	9,343	9,710	9,383
Sub-marketable yield	lb/acre	3,112[a]	3,599[ab]	4,511[b]
Net yield	lb/acre	7,795	8,574	8,922
Net daily gain	lb/acre	53	58	61
Total yield	lb/acre	12,455	13,309	13,893
Average size				
Fingerlings	lbs	0.82	0.75	0.77
Carryovers	lbs	3.40	3.37	3.37
Survival				
Fingerlings	%	81	78	74
Carryovers	%	98	95	94
Overall	%	87	83	80
Feed fed	tons/acre	9.28[a]	10.52[ab]	10.66[b]
FCR	ratio	2.45	2.49	2.42

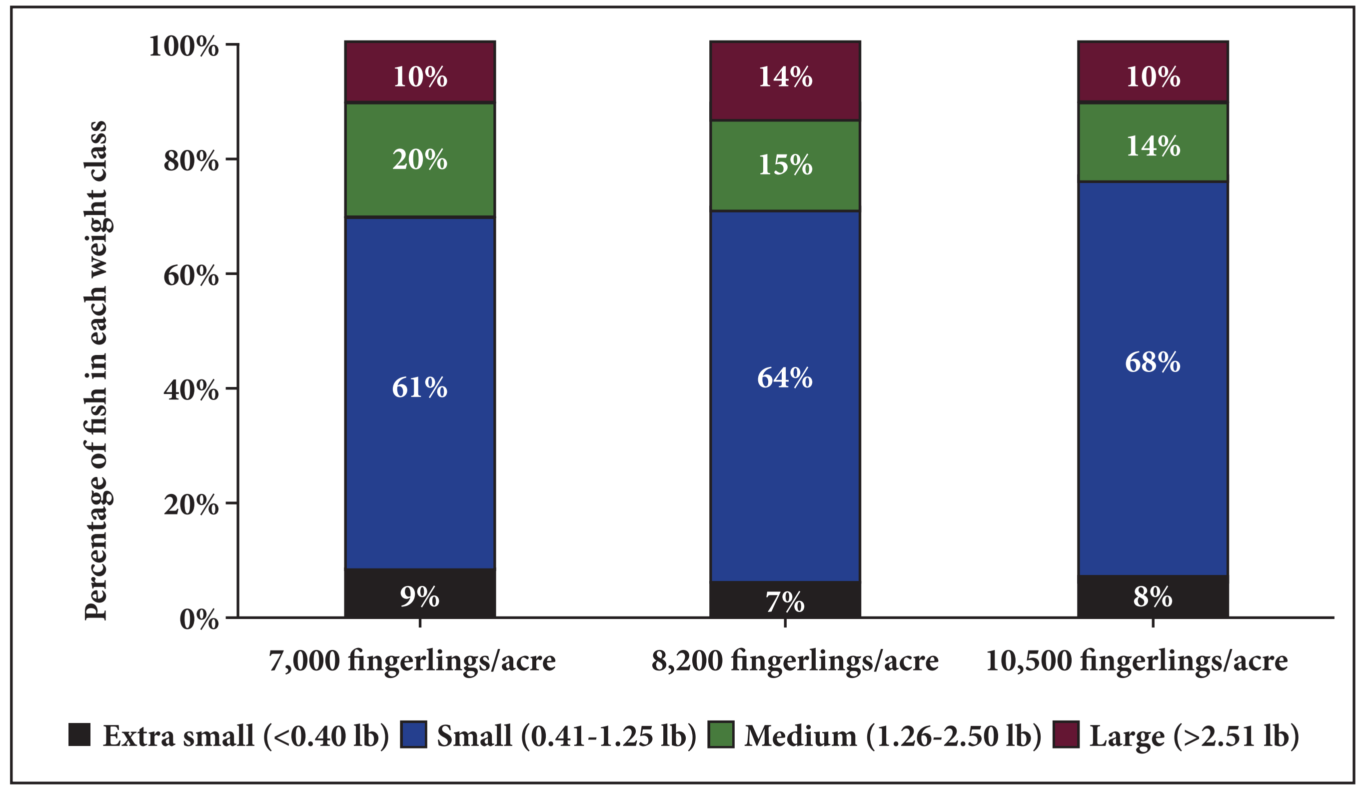


Figure 1. *Percentage of fish (at harvest) in different weight classes among the three different fingerling understocking densities. SOURCE: Kumar et al. 2020.*

Table 2. Economic performance of channel catfish fingerlings under three different understocking densities. SOURCE: Kumar et al. 2020.

Economic performance	Units	7,000 fingerlings/acre	8,200 fingerlings/acre	10,500 fingerlings/acre
Fingerling cost	$/acre	$734	$866	$1,097
Feed cost	$/acre	$3,702	$3,797	$3,961
Total variable cost	$/acre	$7,077	$7,318	$7,740
Total cost	$/acre	$8,963	$9,204	$9,626
Without sub-marketable yield				
BEP/VC	$/lb	0.75	0.77	0.82
BEP/TC	$/lb	0.95	0.97	1.02
Net returns above variable costs	$/acre	$2,599	$2,358	$1,936
Net returns above total costs	$/acre	$713	$472	$50
Total annual cash inflow	$/acre	$9,676	$9,676	$9,676
Total annual cash outflow	$/acre	$8,697	$8,939	$9,361
Total annual net cash flow	$/acre	$979	$737	$315
With sub-marketable yield				
BEP/VC	$/lb	0.55	0.55	0.57
BEP/TC	$/lb	0.70	0.70	0.71
Net returns above variable costs	$/acre	$6,328	$6,572	$6,977
Net returns above total costs	$/acre	$4,441	$4,686	$5,091

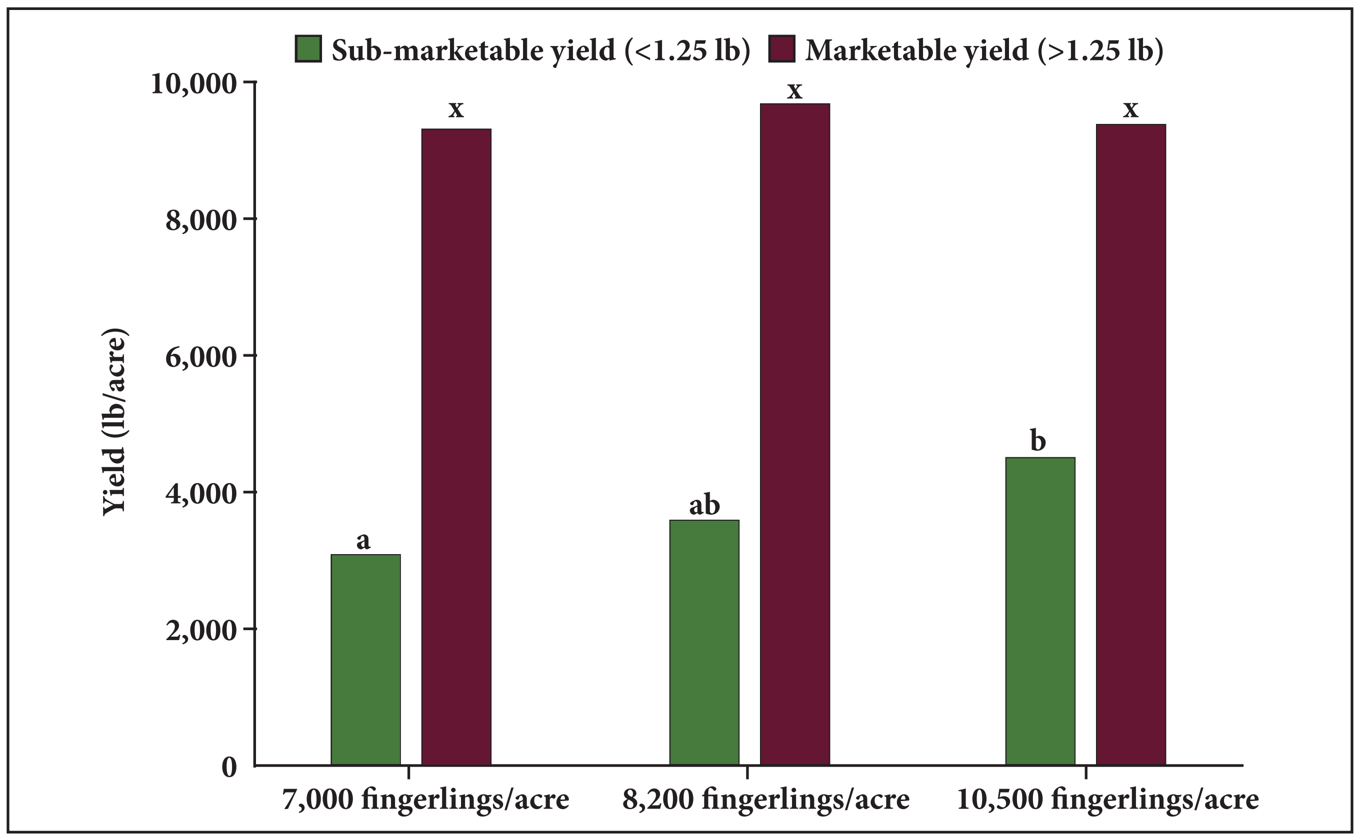


Figure 2. *Marketable and sub-marketable yield of channel catfish from three different fingerling understocking density treatments. Values with different letters indicate statistically significant differences ($p \leq 0.05$). SOURCE: Kumar et al. 2020.*

Menghe Li Retires after 28 Years of Service to MSU

Dr. Menghe Li, Research Professor, retired on June 30, 2020 after nearly 28 years with Mississippi State University and a total of 35 years of working. Menghe received a Bachelor of Science in 1982 in Freshwater Aquaculture from Dalian Fisheries College (now Dalian Ocean University), Dalian, Liaoning, China. He received a Master of Science in Fisheries and Allied Aquacultures (1989) and a Doctor of Philosophy in Fisheries and Allied Aquacultures (1991) from Auburn University. Before joining the MSU faculty ranks in 1997, he served the MSU National Warmwater Aquaculture Center as a Postdoc Research Assistant from 1991-1997.

Dr. Menghe Li

During his career, he was recognized for his academic excellence with induction into Phi Kappa Phi (1991), Delta Council Outstanding Contributions to Aquaculture Award (2020), StatePride Faculty Awards (2010 and 2011), MAFES Award of Excellence for Outstanding Work (2007), MSU CFR Research Award (2005), and MAFES Publication Award – Most Relevant to Mississippi, Coauthor (2005). He has assisted graduate students from MSU, TAMU Corpus Christi, and Southern Illinois on diet preparation and sample analysis.

Dr. Li has a distinguished research record. His 332 publications include 128 refereed journal articles, 15 book chapters, 122 other publications (popular articles, bulletins, reports, newsletter, etc.), and 67 conference proceedings/abstracts. During his career, he made 97 presentations at national scientific meetings, commodity association meetings, as well as producer meetings. Menghe was always eager to present his new research findings at the Annual NWAC Seminar Series in Stoneville and East Mississippi. He is considered one of the preeminent catfish nutritionists in the United States.

The main goal of the catfish nutrition and feeding program at the NWAC/DREC is to develop cost-effective feeds and optimum feeding strategies that can be used by catfish industry for efficient production. Based on results from his research, dietary protein levels and the amount of animal protein have been reduced in commercial catfish feeds. Practical vitamin requirement studies have shown that certain vitamins can be reduced or eliminated in the diets for pond-raised catfish. His team has also demonstrated that phosphorus supplementation can be reduced in catfish diets and microbial phytase enzymes can be used to replace inorganic phosphorus supplements. Recent research on evaluation of alternative feedstuffs has shown that traditional feedstuffs such as soybean meal and corn can be partially replaced with combinations of lower-cost alternative feedstuffs such as cottonseed meal, corn gluten feed, corn germ meal, and distillers grains without significantly affecting fish performance. These research efforts have resulted in considerable savings on feed cost for the U.S. catfish industry.

Menghe has served as an Associate Editor of the North American Journal of Aquaculture from 2006 - 2020. He served on the Institutional Animal Care and Use Committee (IACUC) from 2006–2009. He was a member of the World Aquaculture Society, the US Aquaculture Society, and Catfish Farmers of America.

Dr. Menghe Li was unanimously selected to receive the honor of Emeritus Professor in the MSU Department of Wildlife, Fisheries, and Aquaculture!

2019 MSU CVM Aquatic Research and Diagnostic Laboratory Report Summary

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

The Aquatic Research and Diagnostic Laboratory in Stoneville, MS received a total of 721 case submissions in 2019. Of these, 665 were submitted by producers and 56 were submitted by USDA and Mississippi State researchers. There were also 556 water samples submitted for analysis.

Of the catfish cases, 367 were hybrid catfish, 328 were channel catfish, and 4 were blue catfish. Bacterial disease predominated the case submissions with columnaris disease being the most diagnosed disease with 346 cases (**Figure 1**). There were 247 cases of Enteric Septicemia of Catfish (ESC) caused by *Edwardsiella ictaluri,* and 80 cases of *Edwardsiella piscicida* (formerly *E. tarda*) **(Table 1)**.

This year, we have also provided the case breakdown for channel, hybrid, and blue catfish, in addition to the other species to provide additional information and illuminate potential disease trends **(Table 2)**. Data indicates *E. piscicida* is predominantly an issue in hybrid catfish, which account for 75 of the 80 (93.8%) cases. There were 12 cases of *Aeromonas hydrophila,* 7 of which had lesions and biochemical codes consistent with the atypical *A. hydrophila* associated with catastrophic outbreaks. Three cases of the suspect atypical *A. hydrophila* were fingerling/fry cases from an outbreak in a research setting. The remaining 5 *A. hydrophila* cases did not have lesions or biochemical codes consistent with atypical *A. hydrophila.*

Of the 247 cases of ESC, 75 (30.3%) *Edwardsiella ictaluri* isolates were deemed resistant to one or more antibiotics. Of these, 26 were multiple submissions from the same pond(s) but on different days. In addition, 29 of the 80 (36.3%) *Edwardsiella piscicida* (formerly *E. tarda*) isolates demonstrated resistance to one or two antibiotics. The numbers are a continual reminder of the need for antibiotic stewardship in treating bacterial infections.

Proliferative Gill Disease (PGD), caused by the myxozoan parasite *H. ictaluri,* is still the most prevalent parasitic disease, although with only 48 cases in 2019 there appears to be a downward trend

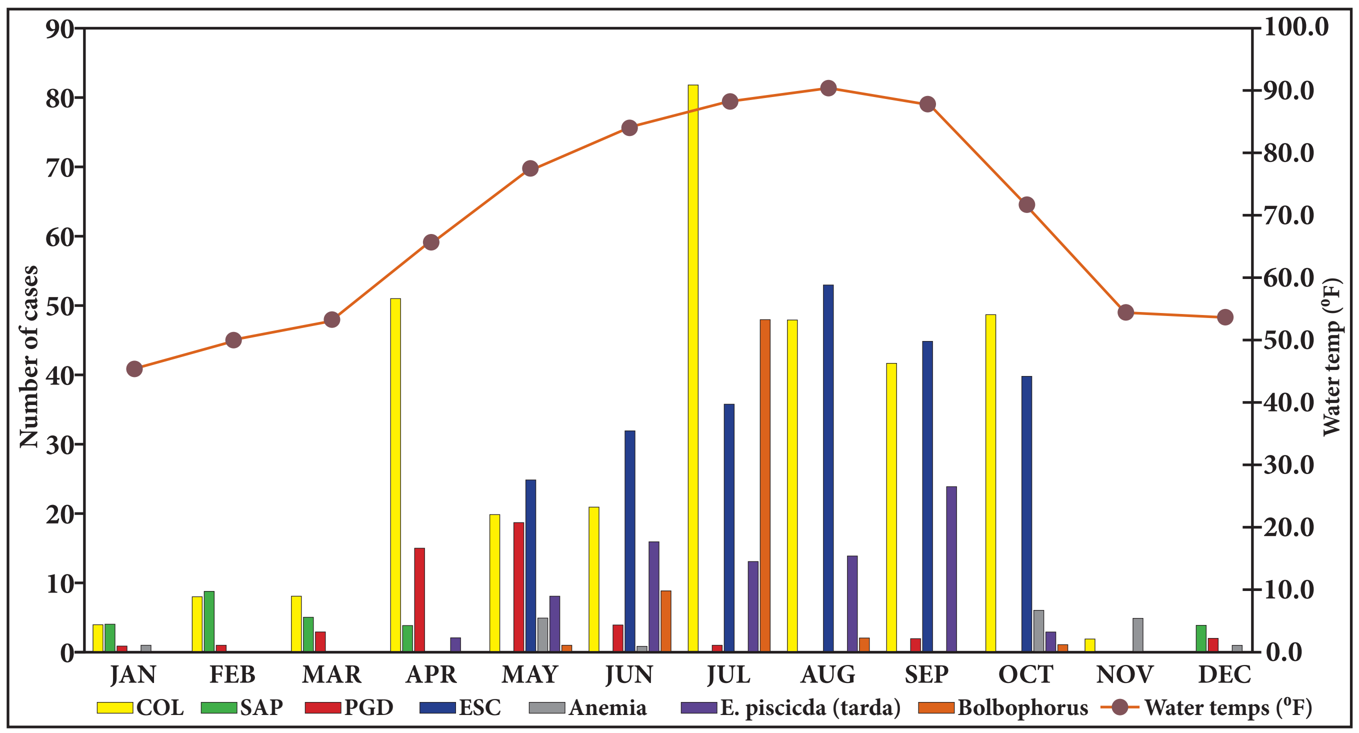


Figure 1. *2019 case submissions to the MSU CVM Aquatic Research and Diagnostic Laboratory.*

Table 1. *Ten-year trend of case submissions to the MSU CVM Aquatic Research and Diagnostic Laboratory.*

Disease	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Average
Columnaris	24.6	26.8	19.6	24.0	34.7	49.9	54.3	40.7	45.5	49.1	48	41.7%
ESC	15	18.1	22.9	21.4	30.9	45.6	27	39.2	41.5	28.8	34.3	32.5%
E. Tarda (E. piscicidia)	1.9	1.3	2.2	1.7	1.0	1.6	2.0	6.9	8.4	7.1	11.1	4.5%
PGD	21.4	15.9	14.3	14.1	11.6	15.8	9.2	11	10.3	9.5	6.7	14.0%
Saprolegnia	9.4	4.5	4	5.4	1.2	3.4	3.7	1.9	3.5	6.4	3.6	4.7%
CCV	7.2	4.7	3.4	0.9	1	0.6	1.7	1.5	0	0.2	0.4	2.2%
Anemia	2.8	5	5.8	3.2	4.4	1.9	2.7	3.1	3	2	2.6	3.7%
Ich	3.1	0.5	0	0	0.1	0	0.3	.03	0.5	0.3	.04	0.6%
Bolbophorus	1.8	1.8	1.1	2.3	9.2	4.7	2.3	6.2	3.9	5	8.5	4.7%
VTC	3.4	1.9	1.5	6.1	0	0.6	.02	0	0.2	.05	0.3	1.5%
No pathogens identified	16.1	15.1	10.4	17.9	20.4	11.6	13.9	7.8	13.5	13.2	7.9	14.8%
Number of cases	678	623	852	772	867	701	599	744	861	660	721	807.80

in incidence and severity **(Table 1)**. Further, PGD appears to be more common in channel catfish than hybrids, which is consistent with infectivity studies performed at NWAC indicating arrested development of *H. ictaluri* in hybrid catfish. Comparatively, there were 61 cases of *Bolbophorus damnificus* trematode, which represents 8.5% of case submissions. There were just 3 cases of *Ichthyophthirius multifiliis* (Ich) which is roughly consistent with the last 5 years. There were 26 cases of Saprolegnia (Winter fungus) and 2 suspect cases of Visceral Toxicosis of Catfish (VTC), although these VTC cases were not confirmed by bioassay. There were three cases of channel catfish virus disease (CCV) diagnosed in 2019.

We appreciate producers utilizing the diagnostic services at NWAC which affords us the opportunity to track disease trends within the industry.

[1]Mississippi State University – CVM

Table 2. *Major disease diagnoses as a percentage of diagnostic case submissions[1]*

Disease	Total # Disease Cases	% Total Disease Cases	Channel	Hybrid	Blue	Other
Columnaris	346	48.0%	185	157	3	1
ESC	247	34.3%	159	87		
PGD	48	6.7%	33	15		
Edwardsiella piscicida[2]	80	11.1%	3	75	1	1
Bolbophorus	61	8.5%	36	26		
Anemia	19	2.6%	6	11	2	
Saprolegnia	26	3.6%	17	9		
CCV	3	0.4%	3			
Brown blood	7	1.0%	3	4		
Ich	3	0.4%	1	2		
VTC[3]	2	0.3%	1	1		

[1]A case may be represented by more than one disease.
[2]Biochemically *E. tarda* cases confirmed molecularly as *E. piscicida*
[3]Including suspect cases (unconfirmed by bioassay)

Blue Catfish Alloherpesvirus - A threat to Hybrid Catfish Production?

Vandana Dharan[1], Suja Aarattuthodi[2], Ganesh Kumar[2], and Lester Khoo[3]

Infectious viral disease outbreaks can cause substantial fish mortalities and associated production and economic losses. Catfish herpesviruses (channel catfish virus (CCV) and blue catfish alloherpesvirus (BCAHV)) are the most significant viruses affecting the catfish industry. The BCAHV (family Alloherpesviridae), is a novel strain of Ictalurid herpesvirus 1 and was first reported from blue catfish fingerlings. This virus genome is closely related (94%) to CCV. Also, clinical signs of disease **(Figure 1)** and cytopathic effects (CPE) in cell lines **(Figure 2)** are similar to that of CCV.

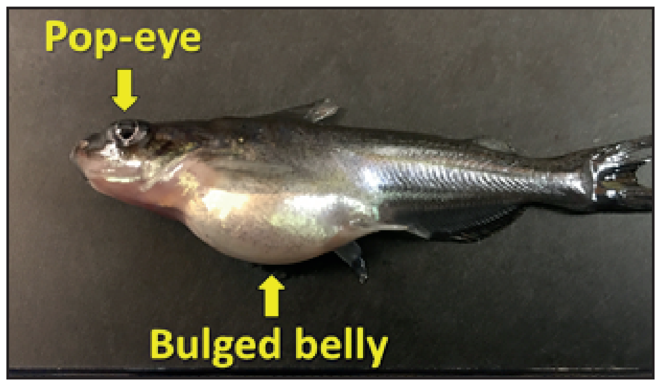


Figure 1. *Catfish fingerling infected with blue catfish herpesvirus. Characteristic catfish herpesvirus clinical signs of disease such as pop-eyes and bulged belly are visible. The infected fish also exhibited lack of appetite and circular swimming patterns. (BCAHV isolate (S98-675) was provided by Dr. Larry Hanson, CVM, Starkville, MS).*

As catfish aquaculture shifts towards enhanced use of hybrid catfish in intensive production units, emerging pathogens among parental population could pose a major threat. Exacerbating the situation is the lack of effective therapeutic options and practical vaccines against these viruses. By causing severe hemorrhagic disease and significant mortality in catfish fry and fingerlings, this herpesvirus has the potential to drastically reduce hybrid fingerling production and could affect the ability of farms to procure enough fish for grow out. As an emerging pathogen in hybrid catfish culture, information on BCAHV is limited, which is critical to establish comprehensive management strategies including vaccination.

In order to determine the potential host range and host-specificity of BCAHV, the virus was inoculated onto various fish cell lines of families Ictaluridae, Cyprinidae, Centrarchidae, and Clariidae. Results showed the virus replication and exhibition of CPE restricted to cell lines from only family Ictaluridae indicating the host preference of BCAHV. The CPEs primarily involved rounding of cells, syncytia (cell clumping) formation, and dissociation from culture surface **(Figure 2)**.

Subsequently, to compare the pathogenicity of BCAHV towards different catfish strains, a viral challenge was conducted involving channel, blue, and hybrid catfish fingerlings. Fish acclimated in flow through systems for two weeks were exposed to a virus dose of $10^{3.5}$ TCID$_{50}$ for three hours at ~25°C. Water flow remained static throughout the virus exposure and was resumed afterwards. Fish mortalities in treatment and control groups were recorded for two weeks. Percentage mortality was found to be significantly higher in blue catfish when compared to hybrid and channel catfish **(Figure 3)**. Histopathology analysis of the spleen tissue sections from the virus-infected fish showed inflammation of the spleen and destruction of red blood cells **(Figure 4)**.

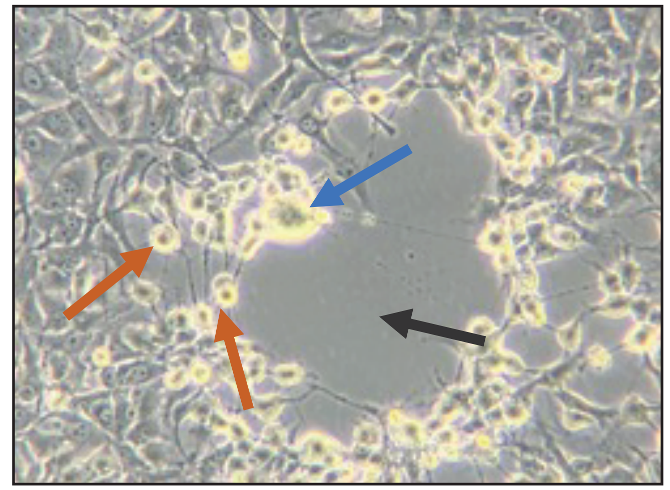


Figure 2. *Brown bullhead (BB) catfish cells infected with blue catfish herpesvirus. The cytopathic effects such as rounding of cells (brown arrows), plaques (black arrow), clumping of cells (blue arrows), and cell de-tachment from the culture surface are visible.*

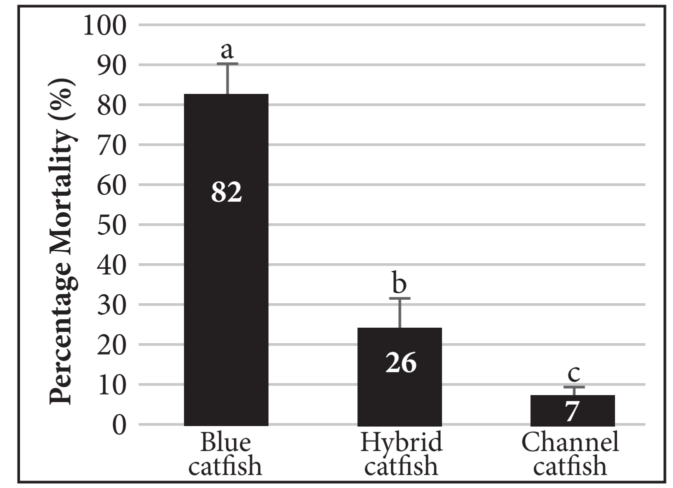


Figure 3. *Percentage mortality of channel, blue, and hybrid catfish fingerlings exposed to blue catfish herpesvirus. Fish mortalities were recorded for 14 days following virus exposure and cumulative mortalities (%) were plotted.*

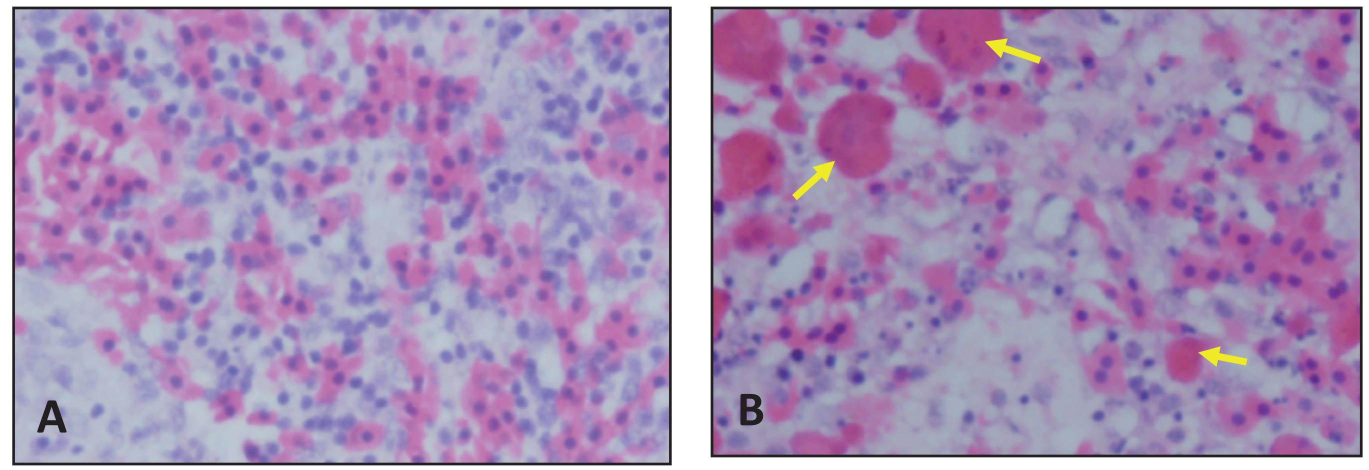


Figure 4. *Histopathology of spleen tissue sections from a non-infected catfish (A) and a BCAHV infected catfish (B). Inflammation of the spleen is visible with the arrows indicat-ing erythrophagia.*

Since, BCAHV is a herpesvirus similar to CCV which exhibits latency, environmental factors could trigger the latent virus resulting in viral disease outbreaks. In another challenge study with different fish stocking densities (reflecting crowding), the percent mortality was found to be significantly higher in high density tanks, indicating that crowding affects BCAHV-associated mortality in catfish fingerlings. The pathogenicity of BCAHV towards blue catfish as observed in this study reveals the potential of this virus to emerge as a significant threat.

[1]Mississippi State University – Graduate Student
[2]Mississippi State University – MAFES
[3]Mississippi State University – CVM

Government Support of the U.S. Catfish Industry during the Coronavirus Pandemic of 2020

Jimmy Avery[1] and Ganesh Kumar[2]

On April 17, 2020, U.S. Secretary of Agriculture Sonny Perdue announced the Coronavirus Food Assistance Program (CFAP) to assist farmers, ranchers, and consumers in response to the COVID-19 national emergency. CFAP brings $9.5 billion in funding from the Coronavirus Aid, Relief, and Economic Security Act (CARES Act) and $6.5 billion from the Commodity Credit Corporation (CCC). The program is made of two components: direct payments to farmers and ranchers and food product purchases for distribution.

Section 32 Purchase Program

The USDA Agricultural Marketing Service (AMS) purchases over 200 different U.S. Department of Agriculture (USDA) commodities for distribution to various food nutrition assistance programs. These purchases are made under the authority of Section 32 Purchase Programs to encourage the continued domestic consumption of these products by diverting them from the normal channels of trade and commerce. The Section 32 purchasing account is funded by a permanent appropriation of 30% of the previous calendar year's customs receipts (tariffs, duties, etc.). In 2019, this funding source was used to purchase 590,000 pounds of catfish products for $2.66 million. The CARES Act included $3 billion dedicated to AMS for increased commodity purchases in 2020. On May 4, 2020, Secretary Perdue announced details of $30 million in Section 32 catfish purchases to occur in the third quarter of fiscal year 2020, in addition to purchases previously announced. From April 29, 2020 through August 12, 2020, USDA AMS purchased 4.76 million pounds of unbreaded catfish fillets and breaded catfish strips for $26.33 million. An additional 1.86 million pounds were solicited in June but not purchased due to vendor constraints. USDA AMS is currently soliciting the purchase of an additional 342,000 pounds in 2020.

Paycheck Protection Program (PPP)

The Paycheck Protection Program (PPP) was a $669-billion business loan program established by the CARES Act to help businesses pay for their payroll and certain other costs. The program was implemented by the U.S. Small Business Administration (SBA) and involved local lenders to administer the loans. The deadline to apply for a PPP loan was August 8, 2020. SBA only identified businesses that received loans over $150,000. Based on that data, 19 Mississippi catfish businesses (processors, farms, feedmills, etc.) protected 2,447 employees with a loan total of between $11.75 million and $28.15 million.

Coronavirus Food Assistance Program 1 (CFAP 1)

On May 19, USDA published their final rule outlining requirements and eligibility for direct payments under CFAP 1. Due to the lack of published data series and futures market data that are available for larger segments of agriculture, USDA initially sought additional information from industry in order to develop a coverage model. Catfish Farmers of America, with critical assistance from Auburn University, Mississippi State University, and private industry consultants, developed an economic analysis for responding to questions specified in the Notice of Funding Availability regarding catfish. The application period ended on September 11, 2020. U.S. catfish producers have received $10.35 million in CFAP 1 funds. Mississippi catfish foodfish producers received $4.97 million.

Coronavirus Food Assistance Program 2 (CFAP 2)

USDA has allotted $14 billion from the CARES Act and CCC for the CFAP 2 program, with the aim of helping producers who continue to face market disruptions and associated costs due to the pandemic. Sign up for CFAP 2 began on September 21. The deadline to sign up for the program is December 11, 2020.

CFAP 2 payment calculations will use a sales-based approach, where producers are paid based on five different payment percentages associated with their 2019 sales. Payments for CFAP 2 will be based on the catfish producer's 2019 sales of eligible commodities in a declining block format using the payment factors shown in **Table 1**. This will be equal to the sum of the portion of a producer's total eligible sales in the calendar year 2019 for each range listed in Table 1, multiplied by the payment rate for that range. Payments for aquaculture producers who began farming in 2020 and had no sales in 2019 will be based on the producer's actual 2020 sales as of the producer's application date.

To complete the CFAP 2 application, producers will need to reference their sales, inventory, and other records. However, since CFAP 2 is a self-certification program, this documentation will not need to be submitted with the application. Because applications are subject to the County Committee review and spot check, some producers will be required to provide documentation. You can get more information on CFAP2 at www.farmers.gov/cfap/aquaculture.

Mississippi Agriculture Stabilization Act (MASA)

The Mississippi Department of Agriculture and Commerce accepted applications for MASA from October 15 through November 16, 2020. MASA went into law on October 9, 2020, through Senate Bills 3058 and 3061, and provided roughly $13 million to assist producers in Mississippi with CARES Act funds. This program is a self-certified application program for assistance due to the negative effects of the COVID-19 pandemic on Mississippi agriculture producers. Qualified catfish producers could receive as much as $50,000, even if they have received CFAP 1 and CFAP 2, or as much as $100,000 if they were eligible for CFAP but did not apply.

Submitted applications will be evaluated based on sales, inventory, and other records. However, since MASA is a self-certification program, this documentation may not need to be submitted in its entirety with the application. Applications are subject to review and spot check audits; some producers will be required to provide documentation later to substantiate their claims. Producers should retain the records and documentation they use to complete their applications.

Producers may apply at www.mscaresact.com and must be submitted online. If application requests exceed available funding, funds will be awarded on a first-come, first-serve basis. All funds must be dispersed by the Department no later than December 15, 2020.

[1]*Mississippi State University – ES*
[2]*Mississippi State University – MAFES*

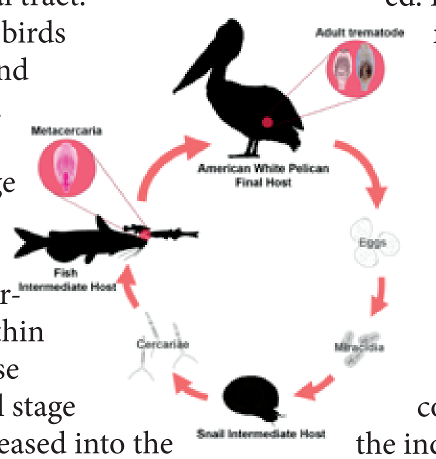
Table 1. *CFAP 2 payment rates for each sales range.*

2019 Sales Range	Percent Payment Factor of Producer's 2019 Sales
$0 to $49,999	10.6%
$50,000 to $99,999	9.9%
$100,000 to $499,999	9.7%
$500,000 to $999,999	9.0%
>$1,000,000	8.8%

Trematode Issues in Farm-raised Catfish

Graham Rosser[1], Matt Griffin[2], and David J. Wise[1]

The production of farm-raised US catfish is plagued by recurrent losses due to infectious diseases. Of these, parasitic trematodes present a complex and uniquely challenging problem. As catfish ponds are open to external environmental input, they provide ideal setting for the completion and propagation of trematode life cycles **(Figure 1)**. Trematodes affecting catfish generally follow a life history strategy utilizing fish-eating birds as the final hosts, with adult parasites harbored in their gastrointestinal tract. When foraging on catfish, these birds inevitably defecate, leaving behind feces laden with trematode eggs. These eggs develop and hatch into a free-swimming larval stage (miracidium) that must quickly infect aquatic snail hosts, which are endemic on commercial operations. Parasite development within the snail host ultimately gives rise to another free-swimming larval stage called cercaria. Cercariae are released into the water and penetrate fish. Within the fish, the parasite develops into a dormant encysted stage known as metacercaria. These metacercariae can remain dormant in a fish for months, even years, until they are consumed by a fish-eating bird – thus completing and beginning a new developmental cycle. The prolonged release of cercariae by infected snails and their subsequent invasion of the fish host results in significant economic losses due to direct mortality, but also more insidious losses due to parasite-induced anorexia and in-creased susceptibility to secondary bacterial infections.



In the absence of approved antiparasitics, the most common route of mitigating these losses is through integrated pest management strategies focused on reducing and eradicating avian and snail hosts. Harassment and lethal removal of birds remains a challenge due to federal regulatory constraints and is often not economically feasible. Alternatively, eradication of the snail hosts by limiting aquatic vegetation and application of chemotherapeutics along pond margins (hydrated lime or copper sulfate) or as whole pond treatments (copper sulfate) have been effective in controlling trematode infections by reducing snail populations. However, even when treated, ponds require recurrent monitoring for signs of new infections as treatments are rarely 100% effective and snail populations can rebound quickly. Trematode eggs hatch quickly at warm temperatures and provided birds (namely pelicans) have migrated out of the area, newly hatched snails will likely not be infected. However, they will serve to propagate new infections when pelicans return during their biannual migration.

As such, control is dependent on continued monitoring and treatment when necessary, even if the trematode life cycle has been temporarily interrupted. A general understand-ing of the trematodes that infect catfish and their life cycles is necessary to manage the continued threat of these parasites to the industry. Over the years, researchers with the Mississippi State Uni-versity College of Veterinary Medicine, in collaboration with MAFES and NWAC scientists, have investigated the threat of these trematodes in birds and snails commonly associated with catfish aq-uaculture systems. To date the birds of greatest concern in regard to pounds of fish consumed and risk of parasite transmission are the American White Pelican *Pelecanus erythrorhynchos* and the Double-crested Cormorant *Phalacrocorax auritus,* while the most problematic snails are the marsh ram's horn snail *Planorbella trivolvis,* and the ghost ram's horn snail *Biomphalaria havanensis.* Current research to develop more proactive, rather than reactive management strategies for control-ling snail populations in catfish production ponds is ongoing. **Table 1** summarizes known hosts for trematode species capable of infecting catfish **(Figure 2)** and associated disease impacts.

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

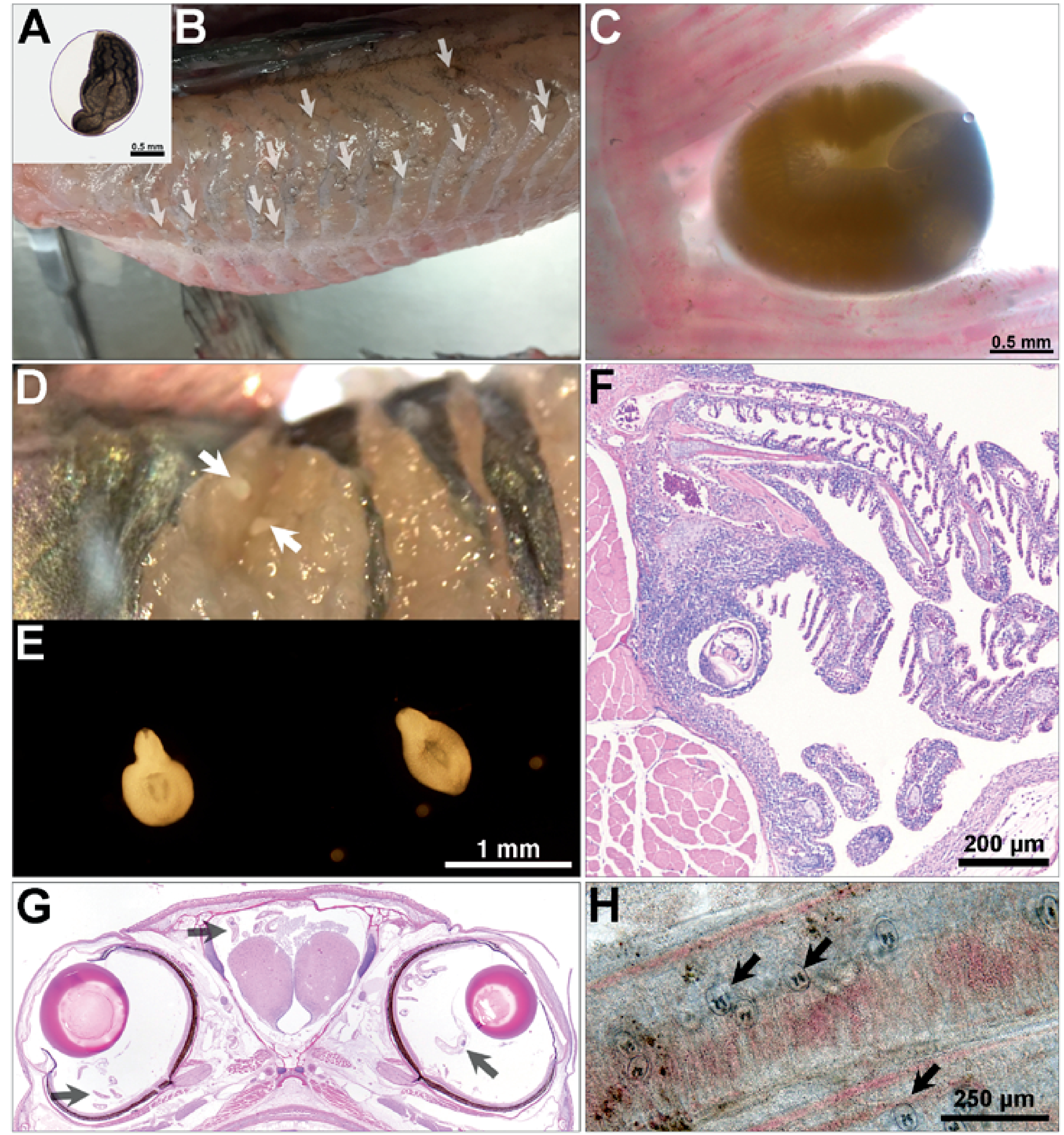


Figure 2. *Larval metacercariae of trematodes capable of infecting catfish. (A–B) Photomicrograph of Bolbophorus damnificus metacercaria and encysted metacercariae (arrows) grossly visible in catfish musculature. (C) Photomicrograph of a "yellow grub" metacercaria of Clinostomum marginatum. (D–E) Photomicrograph of Hysteromorpha corti metacercariae and metacercariae (arrows) in catfish musculature. (F) Photomicrograph of an encysted Drepanocephalus spathans metacercaria in histological cross section of the cranial region. (G) Photomicrograph Austrodiplostomum compactum metacercariae (arrows) in the eyes and brain of an experimentally infected catfish. (H) Photomicrograph of Echinochasmus sp. metacercaria encysted in catfish gills.*

SRAC is Funding Vital Research Needs in the Region

Jimmy Avery[1,2]

The mission of the USDA-NIFA Southern Regional Aquaculture Center (SRAC) is to support aquaculture research, development, demonstration, and education to enhance viable and profitable U.S. aquaculture production to benefit consumers, producers, service industries, and the American economy. Projects that are developed and funded are based on industry needs and are designed to directly impact commercial aquaculture development in the southern region and the nation. Results of these projects will be made available to aquaculturists through refereed journal publications, articles in trade journals, conferences, and Southern Regional Aquaculture Center fact sheets. For more information on these or other SRAC projects, go to http://www.srac.msstate.edu/projectreports.html.

These three projects started in 2020:

Reduction of Artemia Use – Researchers at four regional universities and centers have been awarded $300,000 over three years to pursue several different approaches to reduce dependence on *Artemia salina* as a live food organism for feeding various larval fish species. Some of these research activities include developing an automated live-feeding and monitoring system, a system to harvest live foods from ponds, and evaluating various artificial diets which are commercially available. Another line of investigation will strive to enhance the nutritional value of rotifers and other live food organisms as well as improve the techniques for nutritional augmentation.

Understanding the Grocery Marketplace for Southern Aquaculture Products – Researchers at three regional universities have been awarded $300,000 over three years to analyze large datasets on seafood consumption to develop a better understanding of the grocery marketplace for southern aquaculture products (including catfish, trout, crawfish, clams, and salmon). The two databases are derived from seafood product barcode scanning data. One database will be used for analyzing grocery store sales of the products at 37 major geographical markets; and the other for analyzing household-level seafood consumption. By analyzing these databases, the project will develop, describe, and document in detail the characteristics of sales quantities/demand, prices, market shares and expenditure patterns of southern aquaculture products. Farmers and processors will be able to request customized market reports about the performance of their products.

Emergence of Vibriosis in Catfish Hatcheries – Over the past several years, spontaneous mortality events have occurred in catfish hatcheries. The suspect causative agent is a Vibrio spp., phenotypically consistent with *V. cholerae*. Preliminary genetic analysis suggests these fish-associated strains are different from those typically attributed to human disease. Researchers at three regional universities and the USDA ARS Warmwater Aquaculture Research Unit have been awarded $60,000 over two years to investigate this putative emergent pathogen. The multi-state team will determine relationships between fish strains and those deemed a risk to human health. In addition, the microbial communities of select catfish brood ponds, broodstock, their progeny, and the hatchery environment will be investigated to identify the source of *Vibrio* spp. Assessment of compromised egg masses and diseased fry will characterize pathology associated with disease.

These two projects have started this year:

Rapid Detection Methods for Emerging Aquatic Animal Pathogens (EAPPs) – SRAC's Board of Directors has authorized up to $200,000 for a 2-year project to develop rapid detection methods for emerging aquatic animal pathogens threatening southern region aquaculture. EAAPs are of notable economic significance causing mass mortality epizootics in aquaculture stocks. Unfortunately, research to combat EAAPs including proper biosecurity procedures, vaccines, chemotherapeutics, and validated detection methods are mostly lacking. To fill this industry need, the development and validation of rapid, sensitive, and specific assays capable of detecting EAAPs in samples from symptomatic foodfish, ornamentals, baitfish, and shrimp or shellfish is requested.

Vaccines for Columnaris in the U.S. Catfish Industry – SRAC's Board of Directors has authorized up to $300,000 for a 3-year project to develop effective vaccines for *Flavobacterium columnare* (Columnaris) in the U.S. catfish industry. Successful applicants will develop and identify vaccine candidates (feed based or immersion), conduct safety testing, and develop optimal delivery methods. The last objective Development and testing of vaccine protocols under experimental pond conditions.

The following projects are also ongoing:

- Publications, Videos, and Computer Software
- Economic Impact and Technology Adoption in the U.S. Catfish Industry
- *Edwardsiella piscicida* -Septicemia in Hybrid Catfish and other Fish Species
- Evaluation of Protein and Lipid Concentrations in Tilapia Feeds
- Commercial Production of Native Freshwater Ornamental Species
- Management Strategies for *Edwardsiella ictaluri* in Ornamental Fish
- Utilization of Probiotics in Finfish Hatcheries to Improve Survival
- Implications of Changes in Federal Authority of the Lacy Act

[1] *USDA NIFA SRAC*
[2] *Mississippi State University– ES*

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