THAD COCHRAN NATIONAL WARMWATER AQUACULTURE CENTER

NWAC NEWS

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NWAC NEWS

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Streptococcal Infections in Channel Catfish

Sujita Balami[1], Taylor Heckman[2], Matt Griffin[1], David Wise[2], and Lester Khoo[1]

Streptococcosis is a significant cause of production losses in a wide range of cultured freshwater and marine fish worldwide. The most problematic streptococcal pathogens are *Streptococcus iniae* and *S. agalactiae*, but other species such as *S. dysgalactiae* have increasingly been associated with fish disease. Streptococcal infections can lead to high mortality rates or chronic, low-grade losses, depending on bacterial virulence, host susceptibility, and culture conditions. Historically, this disease has had minimal impact on catfish culture in the southeastern U.S. However, in recent years, infections by *Streptococcus* species have been associated with substantial losses in both male and female channel catfish brood and market-sized fish. In 2022 and 2023, *S. dysgalactiae* was identified as the etiological agents responsible for these cases in the Delta as well as East Mississippi. Molecular sequence typing revealed a high degree of similarity between these strains and those reported in fish kills in freshwater and marine cultured fish in Asia and South America, as well as outbreaks in feral carp and tilapia in the U.S. Clinical signs of *S. dysgalactiae* infections typically include swollen vents and prolapsed anus (**Figure 1**). *Streptococcus ictaluri* is another *Streptococcus* spp. that has been reported from catfish broodstock and is associated with ulceration around the jaw and fin bases with necrosis of underlying joints and articular surfaces.

Figure 1. *Clinical signs of* <u>Streptococcus dysgalactiae</u> *infection in channel catfish.*

The most severe manifestations have been observed in hatcheries during hybrid catfish production, particularly when female channel catfish are transported and confined in nets for hormone treatment to induce ovulation. The stress from prolonged confinement and handling is believed to trigger disease, resulting in poor egg quality and reduced hatching rates. Additionally, streptococcal infections have been identified in channel catfish broodfish involved in traditional pond spawning, though the impact on in-pond spawning success remains unclear. These infections pose a chronic threat to broodstock populations and represent a significant risk to catfish production, necessitating the development of effective control measures.

There are multiple strains and species of *Streptococcus* that can cause disease in fish. It is crucial to submit diseased brood-sized channel catfish to the Aquatic Research and Diagnostic Laboratory to assess the prevalence of this emerging disease and assess antigenic variations for vaccine development. NWAC scientists are currently exploring the feasibility of developing custom, farm-specific vaccines, as well as disinfection and handling procedures to limit disease during hybrid catfish production. Vectors and sources of *Streptococcus* will also be investigated, as these bacteria are known to persist in the environment and in sub-clinically infected carrier fish. Importantly, streptococcosis is an established disease in tilapia production, and while *S. iniae* and *S. agalactiae* are more common, several cases of *S. dysgalactiae* in tilapia have been confirmed by NWAC scientists, including cases from Louisiana in the late 1990s, Texas in 2016, and Alabama in 2022. *Streptococcus ictaluri* has not been found in tilapia. Until the reservoirs of catfish-pathogenic streptococci are identified, the use of tilapia as a nutritional supplement for broodstock is cautioned.

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Diagnostic Submissions Indicate Reduced Incidence of Antibiotic Resistance in the Mississippi Delta Catfish Industry

Matt Griffin[1], Lester Khoo[1], Maural Sowlat[1], Marsha Lewis[1], James Steadman[1], Divya Rose[1], Todd Byars[2], and David Wise[2]

Bacterial infections, particularly those caused by *Edwardsiella* species, are common and costly in Mississippi's catfish aquaculture. With limited antibiotics approved for use, selective pressures have driven the emergence of antibiotic resistance (ABR) on farms, limiting treatment options. As resistant pathogens become more prevalent, the efficacy of the available antibiotics diminishes, which can limit disease control. This can increase mortality rates and production costs and hinder growth performance. Therefore, reducing ABR is critical for sustainable catfish aquaculture, as it directly impacts fish health, food safety, environmental sustainability, and the industry's economic viability.

Judicious use of the available antibiotics remains crucial for maintaining their effectiveness.

Based on diagnostic submissions to the Aquatic Research and Diagnostic Laboratory (ARDL) at the NWAC, there has been a significant decline in ABR in the Delta over the past five years. While diagnostic submissions are only a proxy for the true prevalence of ABR in farm-raised catfish, these data are crucial indicators of current regional trends. ABR incidence was relatively stable from 2003 to 2012, with <1% of tested isolates showing resistance to antibiotics (**Figure 1**). However, reports of ABR began to increase in 2014, largely driven by resistance in *Edwardsiella* species, which account for 91.7% of ABR isolates since 2003. From 2014 to 2021, ~12% of isolates tested demonstrated ABR, representing a nearly 10-fold increase. It should be noted that many of these cases were repeat submissions from the same pond but on different days, so the numbers can be misleading. Nonetheless, the data indicates ABR was becoming a serious issue.

In 2019, an orally delivered, live attenuated *Edwardsiella ictaluri* vaccine became commercially available. Over the past five years, more than 16,000 acres have been vaccinated. While the proportion of *Edwardsiella* spp. cases submitted to ARDL has remained relatively stable, the number of ABR isolates reported has sharply declined, from 111 isolates in 2019 (15.8% of isolates tested) to 7 isolates (1.4%) in 2023. While the correlation between vaccination and decreased ABR may be circumstantial, these data suggest vaccination may reduce reliance on antibiotics and highlight the benefits of preventative approaches to managing bacterial diseases.

Judicious use of the available antibiotics remains crucial for maintaining their effectiveness. Although orally delivered vaccines are effective, not all fish eat every day, leaving a portion of the population vulnerable. Therefore, responsible antibiotic use is vital to preserving the efficacy of the few approved antibiotics, especially in cases of incomplete vaccine coverage or outbreaks of other bacterial disease.

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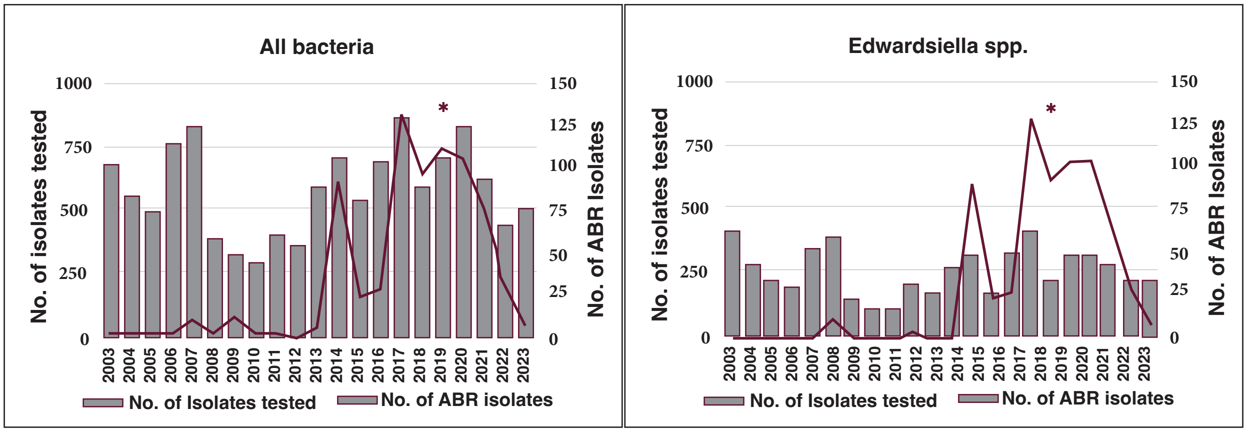
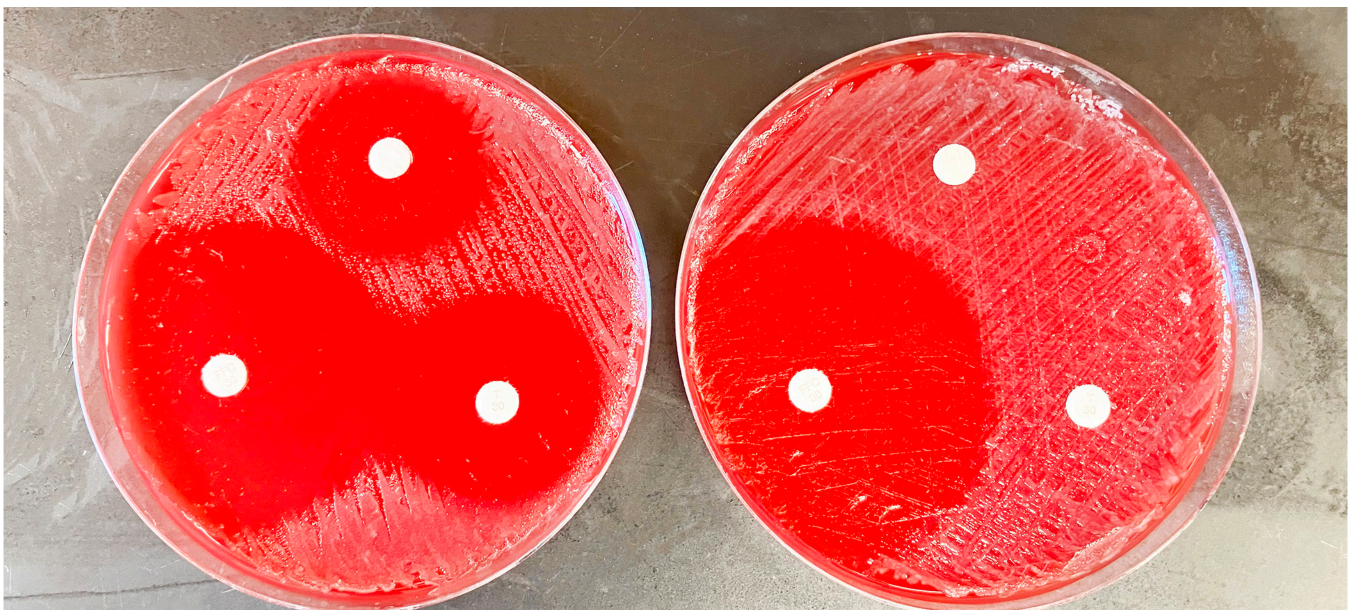


Figure 1. *Trends in incidence of antibiotic resistance from disease case submissions to the Aquatic Research and Diagnostic Laboratory at the Thad Cochran National Warmwater Aquaculture Center in Stoneville. The release of the orally delivered* Edwardsiella ictaluri *vaccine in 2019 is indicated by an asterisk (*).*



Antibiotic sensitivity testing: *The blood agar plate on the left demonstrates bacteria is responsive to all three FDA approved antibiotics, evinced by a lack of growth around the white antibiotic discs. The plate on the right demonstrates bacteria is unresponsive to 2 of 3 antibiotics, evident by growth up to the disc.*

Impact of pH on Ammonia Toxicity

Brian D. Ott[1]

Ammonia comes from multiple sources including fish excretion, sediment, and decomposition of phytoplankton, animals, and feed. Most ammonia is taken up by phytoplankton, while a smaller proportion may become trapped in the sediment or transformed by bacteria into nitrite and ultimately nitrate. Understanding ammonia in a catfish pond is a complex endeavor, however, the most important aspect that affects fish production is pH of the pond water.

When ammonia is measured by a kit, the values are usually returned as total ammonia nitrogen (TAN). Ammonia exists in two forms in water: ammonium (NH_4+) and ammonia (NH_3). Total ammonia is the sum of both forms and is reported in concentrations of nitrogen, so that it is easily compared across other forms of nitrogen (namely nitrite-nitrogen and nitrate-nitrogen). Ammonium is an ion and is non-toxic to fishes at most concentrations, whereas ammonia, also known as un-ionized or toxic ammonia, is a gas that easily crosses a fish's gills and is extremely toxic. The most important factor that determines the proportion of ammonium to ammonia is pond water pH, and to a much lesser extent, temperature. As either or both pH and temperature increases, the proportion of un-ionized ammonia also increases. At a given temperature, the proportion of toxic ammonia increases very rapidly between 8.5 and 9.5 pH (**Figure 1**). For example, at 86 °F (30 °C) the proportion of un-ionized ammonia is 20% at 8.5 pH and 72% at 9.5 pH.

Numerous research projects have been conducted to determine the concentration of ammonia that has either sub-lethal (such as decreased appetite or growth) or lethal effects. Overall, most studies conclude that un-ionized ammonia around 0.5 mg/L nitrogen may have sub-lethal effects on catfish, and un-ionized ammonia around 1.5 mg/L nitrogen over 24 hours is generally lethal for catfish. The concentration of total ammonia that impacts catfish varies greatly with pH, so it is critical to measure both TAN and pH to provide context for the TAN concentration. Ammonia test kits often have charts to estimate un-ionized ammonia, while more precise calculators can be found online.

Dissolved carbon dioxide (CO_2) concentration is the main factor that influences pH; it dissociates into carbonic acid and at higher concentrations water becomes more acidic and pH decreases. Pond pH changes daily in response to photosynthesis by phytoplankton, and if dissolved oxygen is high, pH is likely also high. The magnitude of this change depends on the pond's alkalinity, the size and health of the phytoplankton bloom, and weather. The highest pH during a sunny day in a pond with a healthy bloom will be in the late afternoon.

Although photosynthesis has the greatest impact on pH, the second most important factor is alkalinity. Ponds with high alkalinity will experience a narrower range of pH changes compared to ponds with low alkalinity (like many ponds in eastern Mississippi and western Alabama) may have larger swings in pH. In Stoneville, where our waters have high alkalinity (around 275 mg/L as $CaCO_3$), ponds can increase up to 1.0 pH units over the day, starting around 8.0 and finishing at 9.0. For a given total ammonia concentration (2.0 mg/L nitrogen in this instance) at these pH values, un-ionized ammonia would start at 0.15 mg/L nitrogen and finish at 0.89 mg/L nitrogen. Luckily, TAN usually decreases throughout the day as ammonia is assimilated by phytoplankton. However, since this decrease in TAN would be coupled with an increase in pond pH, a higher concentration of un-ionized ammonia may result in the afternoon.

Given the importance of pH on ammonia toxicity, it is necessary to measure both ammonia and pH at the same time together, especially if you suspect a problem. Measurements of pH should be taken directly in the pond or quickly from a water bottle, as biological activity in a bottle can change pH over time. The afternoon may be the best time to measure ammonia, when pH will be the highest, but pH and ammonia should never be measured at separate times. If you are measuring high levels of TAN, it may foreshadow a spike of nitrite (usually about a week after an ammonia spike) or decreased dissolved oxygen (the main source of TAN spikes is a dead or dying phytoplankton bloom). High concentrations of TAN are hard to manage without drastic measures and often the best course of action is to wait until the phytoplankton bloom reestablishes itself. High levels of TAN may be harmless if pond pH is low enough, so always measure pH to provide full context of the current situation.

[1]USDA ARS Warmwater Aquaculture Research Unit

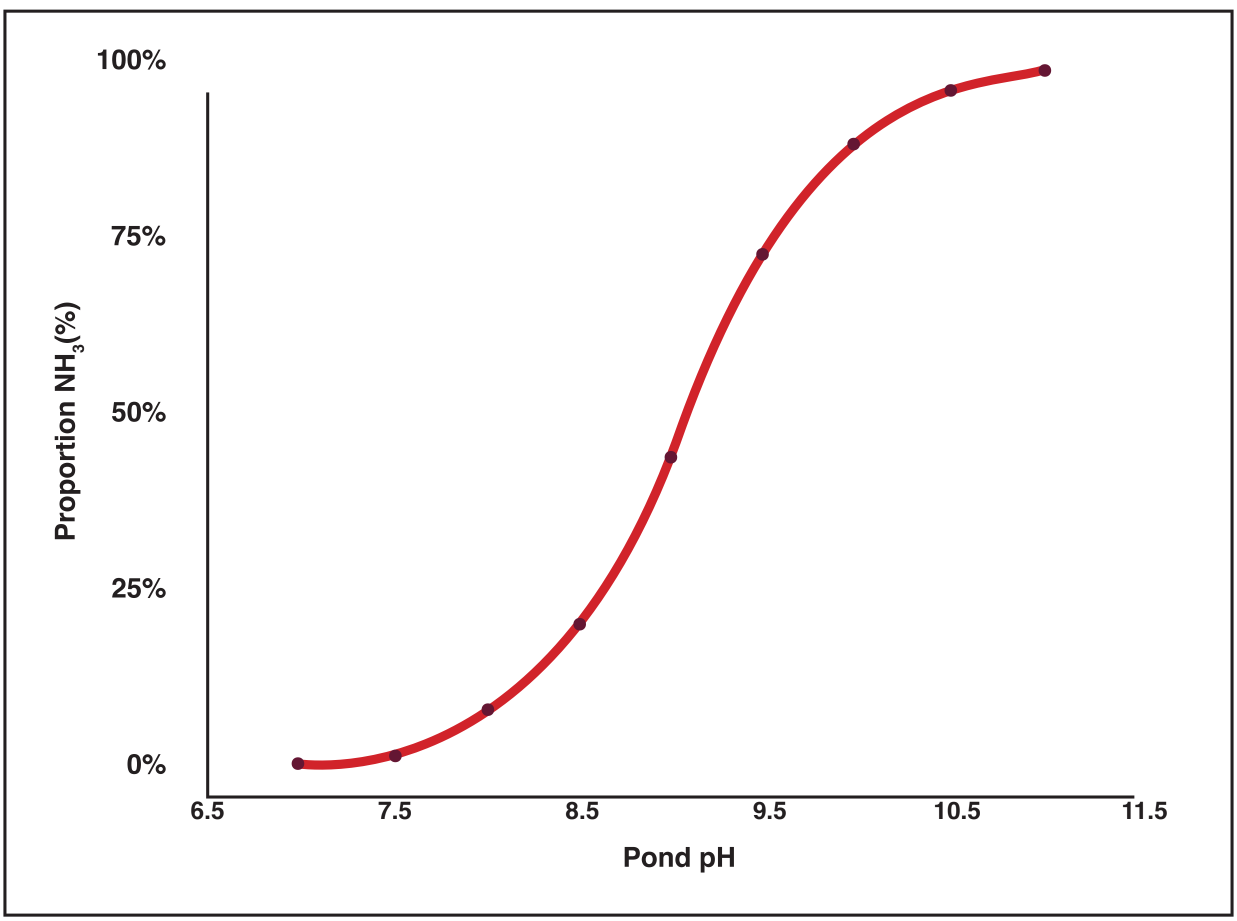


Figure 1. *Effect of pH on un-ionized ammonia at 86°F / 30°C.*

Stocking Larger Fingerlings Does Not Reduce Effects of Proliferative Gill Disease

Bradley Richardson[1], Noor Ul-Huda[2,3], Alvin Camus[4], Charles Walker[5], Caitlin Older[1], Fernando Yamamoto[5], Justin Stilwell[2], Cynthia Ware[2], David Marancik[3], David Wise[5], and Matt Griffin[2]

Proliferative gill disease (PGD) is the most common parasitic disease diagnosed at the Aquatic Research and Diagnostic Laboratory at the NWAC. Colloquially known as "Hamburger Gill", the disease is caused by the myxozoan parasite *Henneguya ictaluri*. Myxozoans are common parasites in freshwater and marine systems and follow a two-host life cycle, involving a myxospore stage in the fish host and an actinospore stage released by oligochaete worms inhabiting pond sediments.

In the case of *H. ictaluri*, the myxospore stage develops in the gills of channel catfish. Mature myxospores are released into the environment where they are ingested by the worm, *Dero digitata*. The actinospore stage is released by the worm back into the water where it enters the gills of channel (*Ictalurus punctatus*) and channel x blue (*I. furcatus*) hybrid catfish. Initial penetration and proliferation of the parasite in the gills elicits a destructive immune response, causing hemorrhaging, inflammation of the lamellae, and destruction of the gill cartilage (**Figure 1**). Though all size-classes are susceptible to the infection, outbreaks in fingerling catfish account for most case submissions, particularly during the spring when fish are being transitioned to grow-out ponds.

Previous work at NWAC has investigated chemical and biological control measures to reduce the number of *D. digitata* in pond sediments; however, these attempts have been largely unsuccessful. Increased aeration can provide some putative reprieve to fish during light and moderate infections, and moving fish to a parasite-free pond can promote recovery. However, this is often impractical due to limited pond space and increased losses associated with handling stress.

As such, one of the most effective management strategies to minimize losses to PGD is through selective pond stocking. Industry practices currently use sentinel fish exposures or molecular assays to estimate disease risk for a given pond prior to stocking. While these strategies are effective, they are time- and labor-intensive. Sentinel fish exposures are particularly difficult, requiring a source of disease-free fish, multiple net pens, a minimum of 1 week to assess risk, and an additional week of assessment to determine whether parasite density is increasing, decreasing or stable. This strategy is also easily disrupted by oxygen depletion, predators invading the net pens, and/or fish escape — all of which require a new exposure trial before stocking. An alternative to sentinel fish is the use of molecular techniques to assess parasite levels in the pond but requires technical expertise and equipment.

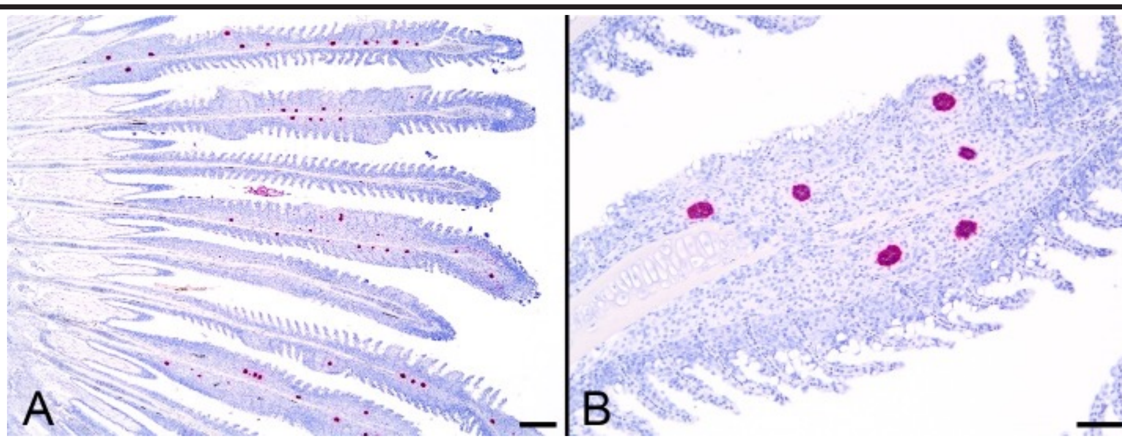
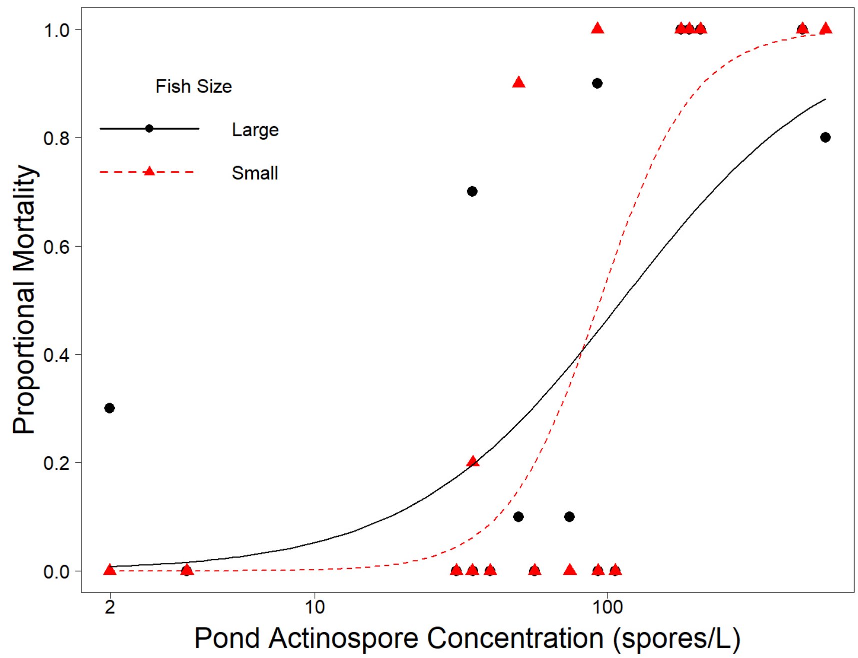


Figure 1. *Gill histology slides of channel catfish fingerlings showing inflammation, fusion of lamellar troughs, broken cartilage, and other lesions caused by H. ictaluri infection. Red pigments show locations of H. ictaluri cysts based on in situ hybridization. Photo credit: J. Stilwell.*

Figure 2. Survival curves for large (circles; solid line) and small (triangles; dashed line) channel catfish fingerlings exposed to H. ictaluri in pond water.



In response to stakeholder inquiries, NWAC scientists in collaboration with researchers at MSU's College of Veterinary Medicine, St. George's University, and the University of Georgia, conducted a field study using sentinel channel catfish fingerlings to assess variation in PGD severity in different sized fish stocked into the same ponds. Fingerling catfish representing two industry-relevant size-classes (40 lbs/1000 [small] and 120 lbs/1000 [large]) were placed into net pens and distributed across ponds with varying levels of *H. ictaluri* concentrations in the water. Two separate trials were carried out over successive weeks, conducted across 19 ponds containing channel catfish. In each study, survival was assessed after 7 days, and all surviving fish were sampled to evaluate histopathology and parasite burden within the gills.

Survival was similar between both size-classes. While the mortality curve was steeper for smaller fish, overall mortality was comparable and there was no observed benefit to stocking larger fingerlings in terms of PGD-related mortalities (**Figure 2**). Fish size also had no effect on any sublethal gill pathology. Parasite burden was the best predictor of gill damage and disease severity. Relative gill damage and parasite life stages were used as measures of parasite burden in surviving fish. Identification of parasites found in the gill tissues of surviving fish was confirmed to be *H. ictaluri* by a species-specific *in situ* hybridization assay developed by members of the research team (**Figure 1**). One counterintuitive finding was an increase in sublethal gill pathology with decreasing parasite concentrations in pond water. This is likely due to survivor bias as fish in ponds with the highest *H. ictaluri* concentrations had the highest risk of mortality and dead fish could not be evaluated. Conversely, fish placed in ponds with lower parasite concentrations were more likely to survive infection, and in turn, were more likely to be available for assessment.

Data from the present study also provides support for the approximated threshold guidelines currently used in qPCR assessments of pond water for springtime stocking and developed by NWAC scientists for the detection of *H. ictaluri* DNA in pond water. In short, water analysis by molecular diagnostic assays can inform pond management and prevent fish losses at the time of fish stocking. The approximate thresholds categorize mortality risk based on spore concentrations in the water. The findings of this study corroborate those thresholds and provide deeper understanding of the sublethal damage caused to surviving fish.

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2022 MSU CVM Aquatic Research and Diagnostic Laboratory Report

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

The Aquatic Research and Diagnostic Laboratory in Stoneville, MS received a total of 451 case submissions in 2022. Of these, 434 were submitted by producers and 17 were submitted by USDA and Mississippi State University researchers. There were also 419 water samples submitted for analysis.

Of the catfish cases, 248 were hybrid catfish, 198 were channel catfish, and 4 were blue catfish (**Table 1**), continuing the trend of more hybrid catfish than channel catfish submissions. Bacterial diseases continue to be the predominant diagnoses with 205 cases of Columnaris Disease, 179 cases of Enteric Septicemia of Catfish (ESC) caused by *Edwardsiella ictaluri*, and 49 cases of *Edwardsiella piscicida* (formerly *E. tarda*) (**Figure 1**). Columnaris disease remains the most prevalent disease diagnosed, accounting for 45.5% of cases, down from 56% of case submissions in 2021 (**Table 2**).

Columnaris disease and ESC continue to be primarily an issue for channel catfish representing 68.8 and 69.8% respectively for these diseases. Comparably, *E. piscicida* continues to predominantly affect hybrid catfish, which account for 87.8% of all *E. piscicida* cases. There were 8 cases of *Aeromonas hydrophila*, 6 of which had lesions consistent with the atypical *A. hydrophila* (aAh) associated with catastrophic outbreaks, but biochemical codes (BBL Crystal Enteric Non-Fermenter Kits) were more consistent with typical *A. hydrophila*.

Antibiotic resistance remains a threat to the utility of approved medicated feeds. Twenty (11.2%) of the 179 cases of *E. ictaluri* had isolates deemed resistant to one or more antibiotics. This is a reduction from the previous year (26.3%) and continues a downward trend over the past two years. Six of these cases (30%) represent repeat submissions from the same pond on different days. There were 9 cases (18.4%) of *E. piscicida* with resistance to at least one antibiotic, an increase from 2021 when 14.3% of isolates showed resistance. Antimicrobial resistance to one or two antibiotics was also observed in 3 cases (1.5%) of *Flavobacterium columnare*. These numbers are a continual reminder of the importance of appropriate antibiotic stewardship in treating bacterial infections.

Proliferative gill disease (PGD) continues to be a leading parasitic disease with 62 cases in 2022. However, the majority of cases were seen in

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

Disease	Total # Disease Cases	% Total Disease Cases	Channel	Hybrid	Blue	Other
Columnaris	205	45.5%	141	62	1	1
ESC	179	39.7%	125	54		
PGD	62	13.7%	24	38		
E. piscicida	49	10.9%	5	43	1	
Bolbophorus	13	2.9%	7	6		
Anemia	16	3.5%	7	7	2	
Saprolegnia	11	2.4%	10	1		
CCVD	4	0.9%	1	3		
Brown Blood	5	1.1%	2	3		
Ich	0	0.0%				
VTC[2]	4	0.9%	4			

[1] A case may be represented by more than one disease.
[2] Including suspect cases (unconfirmed by bioassay)

hybrid catfish. There were also 13 cases of *Bolbophorus damnificus* trematode, which were almost equally split between channel and hybrid catfish. There were no cases of *Ichthyophthyrius multifilis* (Ich), after the 10-year high in 2021.

There were 11 cases of Saprolegnia (winter fungus), 16 cases of anemia, and 4 suspect cases of visceral toxicosis of catfish (VTC) based on lesions (we were unable to confirm via bioassay). There were 5 cases of brown blood and 4 cases of channel catfish virus disease (CCVD).

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*

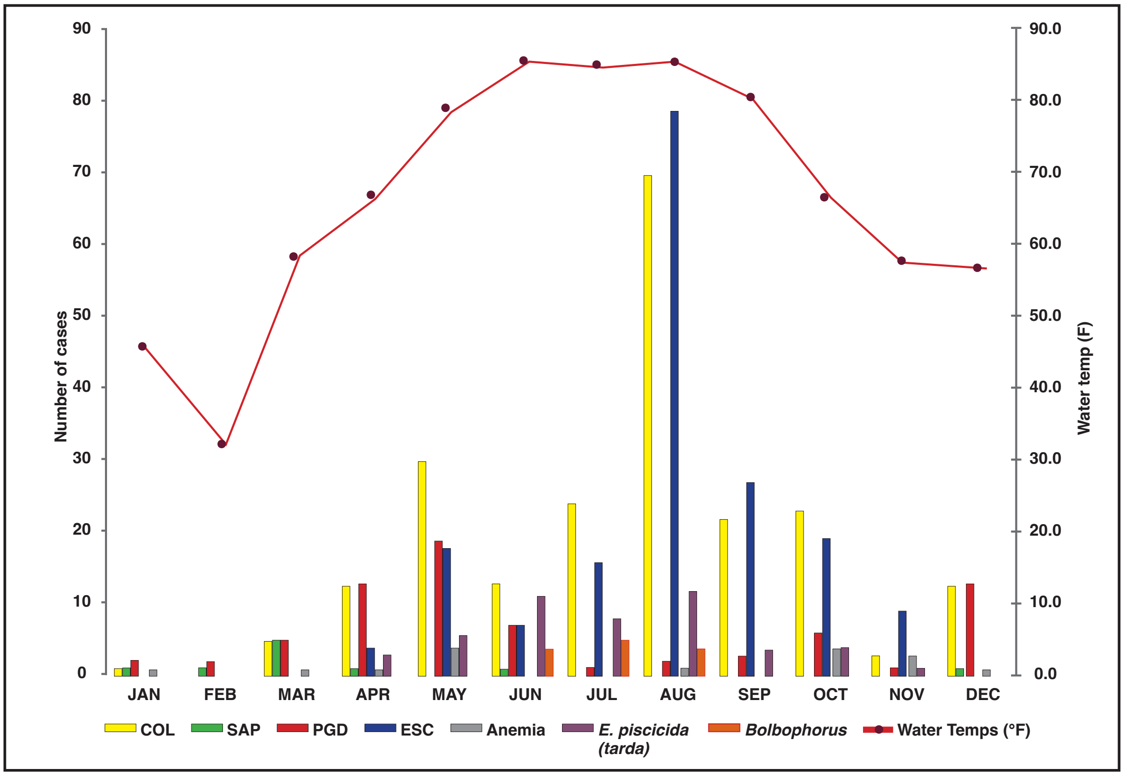


Figure 1. *2022 case submissions to the MSU CVM Aquatic Research and Diagnostic Laboratory.*

Table 2. *Ten-year trend of case submissions to the MSU CVM Aquatic Research and Diagnostic Laboratory.*

Disease	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Average
Columnaris	24.0	34.7	49.9	54.3	40.7	45.5	49.1	48	63.6	56	45.5	51.1%
ESC	21.4	30.9	45.6	27	39.2	41.5	28.8	34.3	36.8	41.5	39.7	38.7%
E. piscicidia	1.7	1.0	1.6	2.0	6.9	8.4	7.1	11.1	6.2	7.2	10.9	6.4%
PGD	14.1	11.6	15.8	9.2	11	10.3	9.5	6.7	13.4	9.9	13.7	12.5%
Saprolegnia	5.4	1.2	3.4	3.7	1.9	3.5	6.4	3.6	5.6	2	2.4	3.9%
CCV	0.9	1	0.6	1.7	1.5	0	0.2	0.4	0.8	0	0.9	0.8%
Anemia	3.2	4.4	1.9	2.7	3.1	3	2	2.6	2.1	1.9	3.5	3.0%
Ich	0	0.1	0	0.3	0.3	0.5	0.3	0.4	0.8	3.4	0	0.6%
Bolbophorus	2.3	9.2	4.7	2.3	6.2	3.9	5	8.5	7.5	4.9	2.9	5.7%
VTC	6.1	0	0.6	0.2	0	0.2	0.5	0.3	0.1	0.2	0.9	0.9%
No Pathogens Identified	17.9	20.4	11.6	13.9	7.8	13.5	13.2	7.9	6.7	11.8	14	13.9%
Number of Cases	**772**	**867**	**701**	**599**	**744**	**861**	**660**	**721**	**763**	**586**	**451**	**772.5**

2023 MSU CVM Aquatic Research and Diagnostic Laboratory Report

Lester Khoo[1] and Matt Griffin[1]

The Aquatic Research and Diagnostic Laboratory in Stoneville, MS, received a total of 547 case submissions in 2023. Of these, 531 were submitted by producers and 16 were submitted by USDA and Mississippi State University researchers.

Of the cases submitted, 295 were channel catfish, 241 were hybrid catfish and 2 were blue catfish, contrasting previous years which saw more hybrid catfish than channel catfish submissions (**Table 1**). Bacterial diseases continue to be the predominant diagnoses with 258 cases of Columnaris Disease, 187 cases of Enteric Septicemia of Catfish (ESC) caused by *Edwardsiella ictaluri*, and 49 cases of *Edwardsiella piscicida* (formerly *E. tarda*) (**Figure 1**). Columnaris disease remains the most prevalent disease diagnosed, accounting for 47.2% of cases, a slight increase from 45.5% of case submissions in 2022 (**Table 2**).

Columnaris disease and ESC were primarily issues for channel catfish, which accounted for 67.1 and 73.3% of these diagnoses, respectively. Comparably, *E. piscicida* continues to predominantly affect hybrid catfish, with hybrids accounting for 90% of all *E. piscicida* cases. There were 13 cases of *Aeromonas hydrophila*, all of which had lesions consistent with the atypical *A. hydrophila* (aAh), or "hot" *Aeromonas* associated with catastrophic outbreaks.

There was a marked reduction in the number of isolates demonstrating resistance to one or more antibiotics, continuing a trend of declining numbers of resistant isolates. In 2023, only 7 resistant isolates were identified, marking an approximately 95% decrease from a peak of 131 isolates in 2017. Among these, four *Edwardsiella ictaluri* isolates and two *E. piscicida* isolates were resistant to two different antibiotics, while one *E. piscicida* isolate was resistant to a single antibiotic. Despite this improvement, it remains crucial to stay vigilant and practice effective antibiotic stewardship to preserve the efficacy of the limited number of approved antibiotics available to the industry.

Proliferative gill disease (PGD), or "hamburger gill," continues to be a leading parasitic disease, with 88 cases in 2023. PGD primarily affects channel catfish, which are diagnosed with PGD almost twice as often (63.6% of cases)

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

Disease	Total # Disease Cases[(1)]	% Total Disease Cases	Channel	Hybrid	Blue
Columnaris	258	47.2%	173	84	1
ESC	187	34.2%	137	50	
PGD	88	16.1%	56	32	
E. piscicida	49	9.0%	4	45	
Bolbophorus	5	0.9%	4	1	
Anemia	27	4.9%	11	16	
Saprolegnia	42	7.7%	34	8	
CCV	6	1.1%	6		
Brown Blood	12	2.2%	2	10	
Ich	0	0.0%			
VTC[2]	5	0.9%	5		

[1]A case may be represented by more than one disease.
[2]Including suspect cases (unconfirmed by bioassay)

as hybrid catfish (36.4% of cases). This is supported by research indicating development of the PGD agent (*Henneguya ictaluri*) is arrested in hybrid catfish, although catastrophic outbreaks in hybrid catfish can still occur. There were only 5 cases of *Bolbophorus damnificus* trematode, a significant decline from recent years. However, continued diligence in managing snail populations in ponds is warranted. No cases of *Ichthyophthyrius multifilis* (ich) were submitted.

There were 42 cases of Saprolegnia (winter fungus) and 27 cases of idiopathic catfish anemia. There were 5 suspect cases of visceral toxicosis of catfish (VTC), although these diagnoses were based on lesions alone and could not be confirmed by bioassay. There were also 12 cases of methemoglobinemia ("brown blood") due to nitrite toxicity. It is important to maintain adequate chloride levels in ponds (80 to100 ppm), especially during periods of high feeding activity. There were also 6 cases of channel catfish virus disease (CCVD).

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

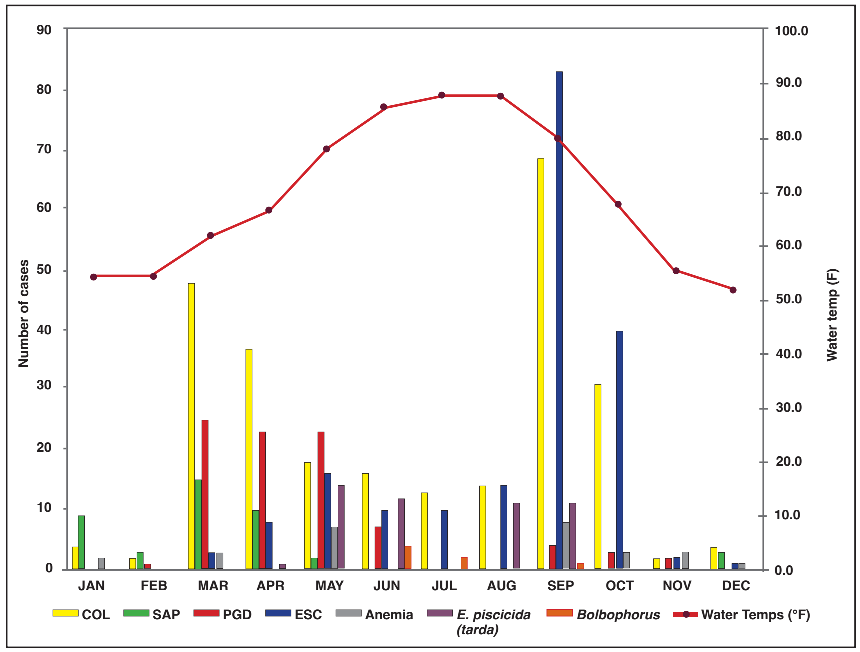


Figure 1. *2023 case submissions to the MSU CVM Aquatic Research and Diagnostic Laboratory.*

Table 2. *Ten-year trend of case submissions to the MSU CVM Aquatic Research and Diagnostic Laboratory.*

Disease	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Average
Columnaris	34.7	49.9	54.3	40.7	45.5	49.1	48	63.6	56	45.5	47.2	53.5%
ESC	30.9	45.6	27	39.2	41.5	28.8	34.3	36.8	41.5	39.7	34.2	40.0%
E. piscicidia	1.0	1 .6	2.0	6.9	8.4	7.1	11.1	6.2	7.2	10.9	9	7.1%
PGD	11.6	15.8	9.2	11	10.3	9.5	6.7	13.4	9.9	13.7	16.1	12.7%
Saprolegnia	1.2	3.4	3.7	1.9	3.5	6.4	3.6	5.6	2	2.4	7.7	4.1%
CCV	1	0.6	1.7	1.5	0	0.2	0.4	0.8	0	0.9	1.1	0.8%
Anemia	4.4	1.9	2.7	3.1	3	2	2.6	2.1	1.9	3.5	4.9	3.2%
Ich	0.1	0	0.3	0.3	0.5	0.3	0.4	0.8	3.4	0	0	0.6%
Bolbophorus	9.2	4.7	2.3	6.2	3.9	5	8.5	7.5	4.9	2.9	0.9	5.6%
VTC	0	0.6	0.2	0	0.2	0.5	0.3	0.1	0.2	0.9	0.9	0.4%
No Pathogens Identified	20.4	11.6	13.9	7.8	13.5	13.2	7.9	6.7	11.8	14	11.2	13.2%
Number of Cases	**867**	**701**	**599**	**744**	**861**	**660**	**721**	**763**	**586**	**451**	**547**	**750**

A Novel Protein Ingredient for Catfish Feeds

Fernando Yamamoto[1]

The U.S. is the leading global fuel ethanol producer, and the primary substrate for ethanol production is starch from corn kernels. After fermentation, corn stillage is produced in substantial volumes, which can be directed to the livestock feed industry and aquaculture. This co-product can also be subjected to mechanical separation processes and refined into corn fermented protein (CFP) (**Figure 1**), where most of the fiber is removed, and corn oil is extracted, concentrating the residual proteins from the grains and yeast. The CFP has a relatively high protein concentration (>48% crude protein; 3-5% fat; <8% crude fiber, as-fed), comparable to the nutritional values of soybean meal but with limited concentrations of lysine and arginine (**Figure 2**).

Soybean meal (SBM) has been the major protein ingredient in catfish diets; however, SBM price and supply fluctuated over the past few years, driven by global conflicts and supply chain disruptions caused by the COVID-19 pandemic, leading feed prices to an all-time high. The production costs have been a concern with feeds reaching over $500, and affordable alternative ingredients, such as CFP, can be an attractive replacement to stabilize feed prices. CFP is produced in the U.S., and it may find a niche market and supply an internal demand for protein ingredients by the U.S. catfish aquaculture industry. In the past, increased growth was observed when distillers dried grains with solubles (DDGS) replaced SBM in feeds for channel catfish fingerlings. However, there has been significant technological improvement in refining co-products from the distiller industry and manufacturing ingredients with superior nutritional quality and consistency, such as the CFP.

Last year, we evaluated the replacement of SBM with CFP in fingerling diets, and found up to 50% of the SBM protein could be replaced without a growth decrease (**Figure 3**). In addition, phosphorus was twice as available from CFP when compared to SBM. During fermentation, the distillers supplement phytase, making the phosphorus more digestible to the catfish. Inclusion levels over 26%

Figure 1. *Corn fermented protein as-is and ready to be mixed with other feed ingredients.*

(75% replacement), presented a decline in growth, which could be associated with a lower lysine digestibility. In order to dry the stillage after the fermentation process, the ingredient is subjected to high temperatures, which could affect the digestibility of this amino acid. On the other hand, documented immunostimulatory properties from dietary yeast have been reported for other farmed fish species, and this product contains a good fraction of this microorganism. So, not only can corn-fermented protein provide more protein than soybean meal, but it may also confer better disease resistance.

This year, we are carrying out feeding trials in 1-acre ponds and periodically sampling fish to ensure that the change in the feed formulation will not compromise the catfish fillets. More results will follow at the end of this year.

[1]*Mississippi State University – MAFES*

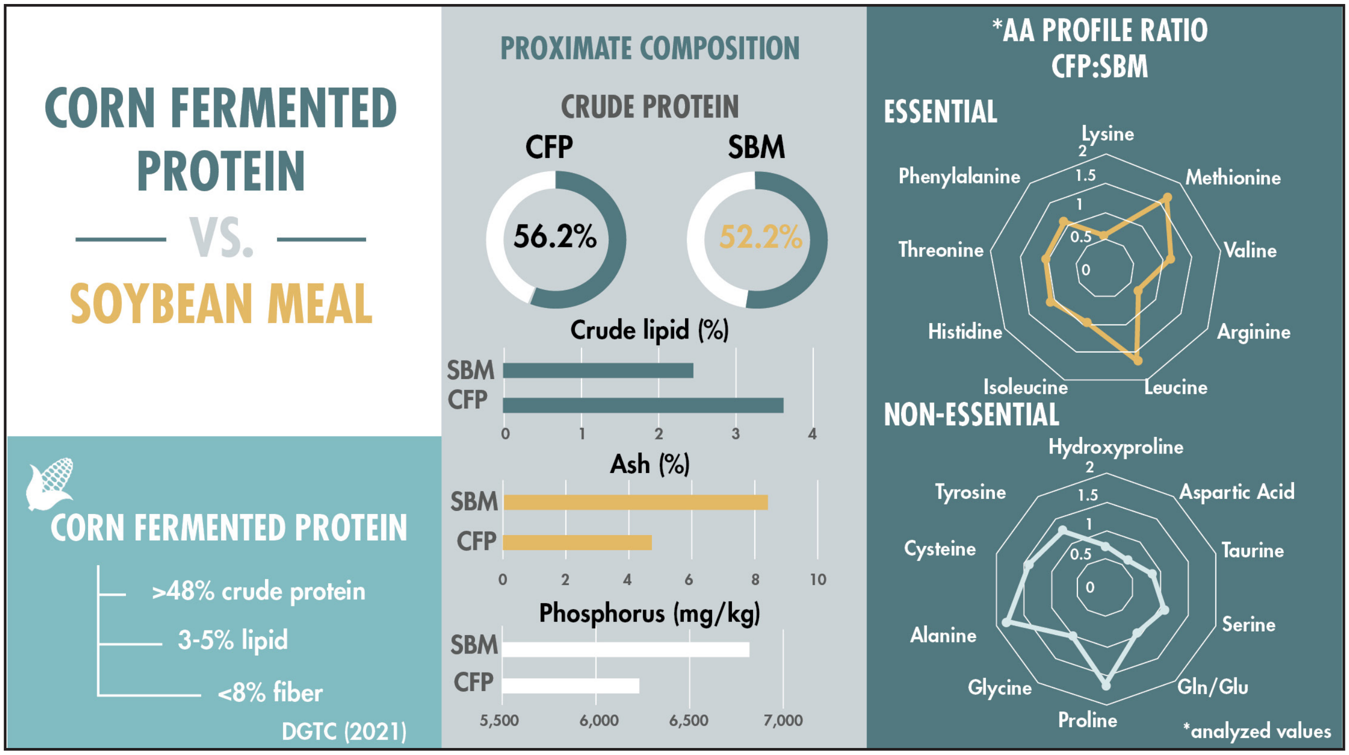


Figure 2. *The comparison of nutrient composition between corn fermented protein and soybean meal. The amino acid comparison entails that 1 would be similar, 0.5 would be half, and 2 would be double.*

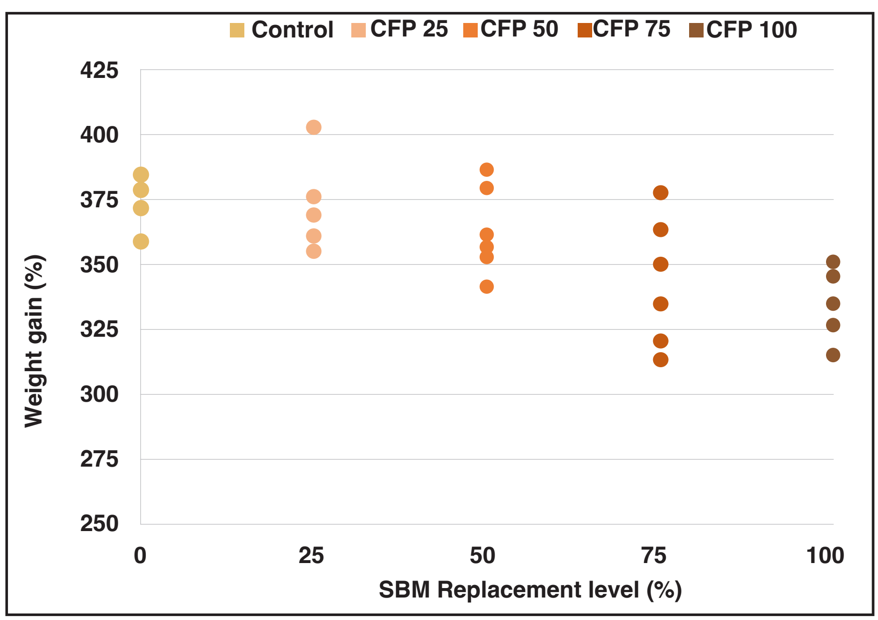


Figure 3. *Growth performance of channel catfish fingerlings fed diets containing various replacement levels of soybean meal for corn fermented protein.*

New Faces at NWAC

Jimmy Avery[1] and Lester Khoo[2]

Dr. Taylor Heckman was hired by Mississippi State's Mississippi Agricultural and Forestry Experiment Station to fill the new Aquatic One Health position and started working at Stoneville in August 2024. Dr. Heckman is originally from Hawaii but moved to the mainland for her undergraduate education. She obtained her bachelor's degree in Biology in 2017 from Willamette University in Oregon, and her doctorate in Microbiology from the University of California, Davis (UCD) in 2021. Since 2021, she has been a Postdoctoral Scholar at UCD with the Aquatic Animal Health Laboratory in the Department of Medicine and Epidemiology, School of Veterinary Medicine. Heckman is broadly interested in applied aquatic microbiology and immunology, with a specialty in warmwater bacterial diseases. Her studies have resulted in improved tools and methodologies for more widely efficacious disease management, including development of novel vaccines, diagnostic assays, and antimicrobial treatment and disinfection protocols. Her efforts have been recognized by several regional and national awards, and through fellowship and scholarship support. At MSU, she aims to more directly support the catfish industry by working with farmers to characterize emerging pathogens and to develop sustainable, practical tools to reduce the burden of infectious disease.

Heckman is a member of the World Aquaculture Society, the American Fisheries Society, and the American Society for Microbiology. She can be contacted at tih33@msstate.edu or 662-686-3243.

Dr. Maural Sowlat was hired by Mississippi State's College of Veterinary Medicine as our new veterinary faculty who is providing diagnostic services and conducting research at the Aquatic Research & Diagnostic Laboratory (ARDL). She started working in Stoneville on July 1, 2024. Sowlat is originally from Illinois but left the state to attend the University of Delaware where she obtained her bachelor's degree in Marine Science. She returned to Illinois for veterinary school and earned her Doctorate of Veterinary Medicine from the University of Illinois College of Veterinary Medicine. While in veterinary school, she sought to increase her veterinary knowledge of non-domestic animals and she completed numerous veterinary externships at the Brookfield Zoo in Chicago, IL, the National Aquarium in Baltimore MD, Shedd Aquarium in Chicago, IL, the Vancouver Aquarium, Vancouver, British Columbia as well as with the ARDL. She is also an alumna of the AQUAVET® program and has completed both AQUAVET® I (Introduction to Aquatic Veterinary Medicine) and II (Comparative Pathology of Aquatic Animals) courses. Her diverse externship experiences together with the knowledge and skills gleaned from veterinary school will allow her to be an effective and competent diagnostician and researcher.

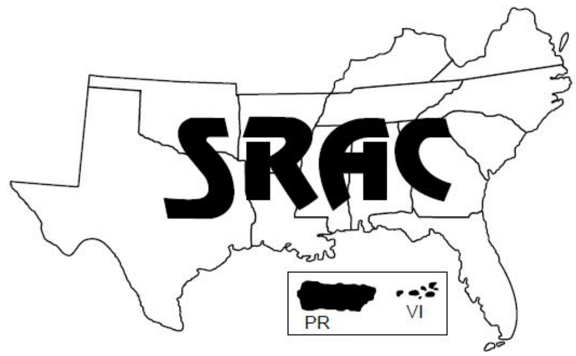
Sowlat is a member of the American Association of Fish Veterinarians and the World Aquatic Veterinary Medical Association. She can be contacted at gms317@msstate.edu or 662-686-3237.

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

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 https://www.srac.msstate.edu/projectreports.html.



These three projects started in 2024:

Restaurant and Supermarket Demand for Important Aquaculture Species

In the Southeastern U.S. there is minimal market information available for most aquaculture species and there is generally limited information on seafood consumption trends in both the grocery and restaurant sector, and this lack of data limits the industry's ability to increase consumption in existing markets and expand markets to new geographic areas, markets outlets, and consumer segments.

Researchers at three institutions in the Gulf states will collaborate to characterize demand characteristics and identify market outlets with the greatest potential for increasing sales of U.S. farmed products. A better understanding of preferences for red drum, oysters, and crawfish will assist the industries and policymakers in developing strategies to expand sales.

First Steps Towards Genetic Improvement of Red Drum Stocks

Red drum of diverse genetic backgrounds will be collected and spawned to generate fingerlings that will be evaluated for genetic traits during grow out production to produce a future broodstock population. Information critical to planning the future breeding program, including trait heritability, will also be calculated, as well as exploration of the genomic architecture for the traits. As part of the project, a guidance document will be developed for current and future red drum producers to demonstrate how to implement a selective breeding program using multiple possible strategies.

Vaccinating Catfish Against Channel Catfish Virus and Blue Catfish Alloherpesvirus

The feasibility and efficacy of an oral vaccine against CCV and blue catfish alloherpesvirus will be evaluated. Oral delivery of a CCV vaccine would facilitate immunization at an age when fish can mount long-term specific immunity, mirroring the success of the orally delivered live attenuated *E. ictaluri* vaccine which uses an in-line, mechanized delivery system. Oral delivery facilitates in-pond delivery, targeting older, more immunocompetent fish. Cross-protection between CCV and blue catfish alloherpesvirus in fingerling blue catfish has been shown.

These four projects were selected for development at the SRAC Annual meeting in October 2024:

Increasing Protein Retention and Managing Ammonia Levels in Hybrid Striped Bass and Catfish

Given that protein is the most expensive component of fish diets, it is critical to maximize its utilization and retention in cultured fish. One objective is to evaluate alternative carbon sources to control unionized ammonia in hybrid striped bass pond culture. A second objective is to evaluate the supplementation of diets with additives to improve protein digestion and nitrogen retention.

Optimal Protein:Energy Ratios for Hybrid Catfish

Despite the production of hybrid catfish for more than 20 years, little is known about their nutritional requirements. Channel catfish feeds are still being provided to the hybrids assuming that they will meet their nutritional requirements. Digestibility of nutrients and energy of commonly used ingredients will be estimated for hybrid catfish. Feeding trials in aquaria and in ponds will be conducted, evaluating different digestible protein and energy ratios.

Mitigating Cold Water Effects in Marine Foodfish and Ornamentals

Major freeze events dramatically impacted the production of tropical, sub-tropical, and marine fish species. Producers in these industries need more tools and resources to mitigate the effects of freeze events on farm and prevent massive fish losses. This project seeks engineering solutions to maintain temperatures in outdoor systems and identification of cold tolerant ornamental broodstock.

Catfish Fingerling Transport and Pond Acclimation

This project aims to develop hauling practices that improve fingerling survival and performance during and after hauling. Specifically, this research will examine the optimal oxygen levels in fiberglass hauling tanks with venting or off-gassing vs. no venting/off-gassing and subsequent fingerling performance in ponds. Finally, determining the ideal acclimation time for fish at various hauling and pond temperature differences is needed.

The following projects are also ongoing:

- Optimizing Production Systems for Removal of Ammonia
- Evaluation of Bird Depredation of Traditional and Non-Traditional Species
- Utilizing Feed Modifiers to Improve Larval Feeding Performance of Ornamental Fish Species
- Development of Training Videos on Animal Care, Biosecurity, and Food Safety
- Rapid Detection Methods for Emerging Aquatic Animal Pathogens
- Vaccines for Columnaris in the U.S. Catfish Industry 

[1] USDA NIFA SRAC
[2] MSU – Extension Service

THAD COCHRAN NATIONAL WARMWATER AQUACULTURE CENTER

NWAC NEWS

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