EXTENSION NEWSLETTER

Understanding the Disease Known as Ich

Anita M. Kelly, Alabama Fish Farming Center

Ichthyophthirus mutifiliis is a ciliated protozoan that causes “Ich” or “white spot disease” in fish. Alabama catfish producers have not really had significant outbreaks of Ich over the years. Unfortunately, in 2018 and 2019 the number of diagnostic cases of Ich drastically increased (Fig. 2). Already in 2020, the number of cases of Ich have surpassed those recorded in 2018 and 2019.

In order to effectively treat Ich, one must understand the life cycle and the stages that are vulnerable to treatment. Ich has three distinct life stages: 1. Trophont (feeding stage,which resides on the fish), 2. Tomont (environmental feeding stage), 3. Theront (infective, fish-seeking stage) (Fig. 3). The theront bores through the surface mucous and encyst in the skin and gills of fish where they feed on those tissues. The theront differentiates into the trophont stage. Because the trophont is covered by the skin and mucus, the trophont stage is protected from chemical treatment. Infected fish will have visible white bumps on the skin (Fig. 1). Once the trophont matures, it stops feeding, leaves the fish, and becomes a tomont. The tomont quickly secretes a gelatinous-walled outer cyst that allows it to stick to surfaces in the environment. The tomont divides quickly, forming hundreds of new “daughter” parasites called tomites within a single cyst. This can occur in a day or less at warmer water temperatures but takes longer in colder water. The gelatinous wall around the tomont protects it and the daughter tomites from chemical treatment. The tomites begin to develop and become theronts within the tomont cyst. Following a period of days (warm water temperatures) or weeks (cool water temperatures), the theronts break out of the tomont cyst and become free-swimming,

Fig. 1. Catfish infected with Ich. (Photo: USDA, Cindy Ledbetter)

infective parasites in search of a fish host. These infective theronts must find a live fish to complete the life cycle. This free-swimming phase is unprotected, and therefore, highly susceptible to chemicals. Treatment protocols must be designed to target this theront stage. Since not all the tomont cysts release the theronts at the same time, several treatments are necessary to eliminate the disease. Based on temperature, water chemistry, and the chemical used, these treatments will vary. Contact the Alabama Fish Farming Center to obtain recommendations on treatments.

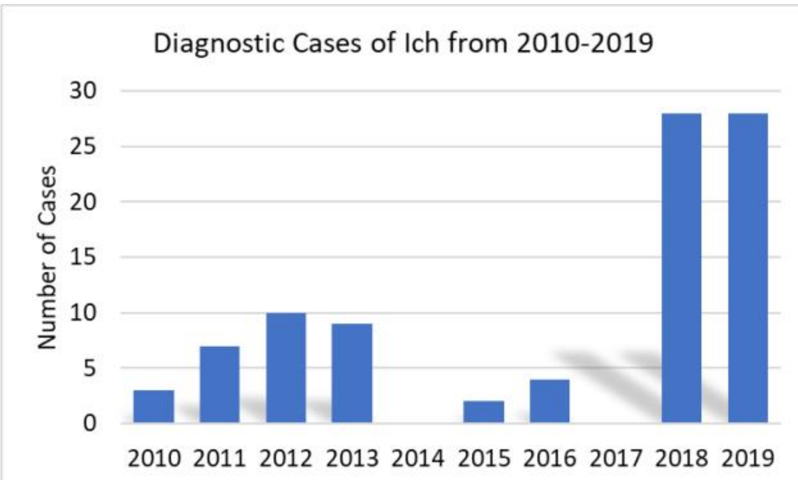

Fig. 2. Diagnostic cases of Ich recorded in Alabama from 2010-2019.

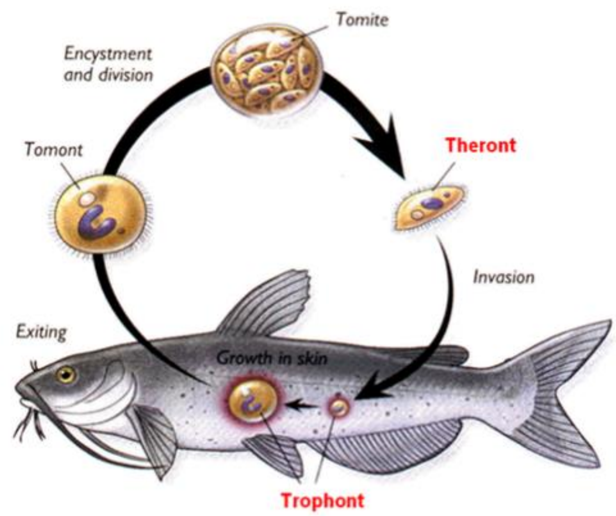

Fig. 3. Diagram shows life cycle of Ich (after, et.uga.edu).

Recreational Pond Management in the Springtime

Rusty Wright, School of Fisheries, Aquaculture and Aquatic Sciences, Auburn University

Spring is an important time of transition for recreational fishing ponds. As the weather warms, plants and algae begin to grow more rapidly, fish start to spawn, and angling gets active again. Spring rains become both a blessing by refilling the pond and a curse by flushing out the nutrients and sometimes the fish from the pond. Here are a few tasks that pond owners and managers should be focusing on this time of year.

For new and renovated ponds, now is the time to complete stocking of bream and bass. Ideally, fingerling bream (80% bluegill and 20% redear sunfish) should be stocked in the winter or early spring at about 1000-1200 per acre for a fertile pond. Largemouth bass should be stocked at about 75-100 per acre in late May or June.

For those who choose to fertilize their ponds, now is the time to start. Hopefully, the pond has an alkalinity and hardness of 20 ppm or greater. If it is lower than that, there is still time to lime the pond before fertilizing. We generally recommend waiting until the water temperature is at least 60º F to start fertilization. Also, control any significant weed problems (see below) and clear the pond water if it is muddy before fertilizing.

Spring is also the time to start pellet feeders to enhance the growth and attract the bream and catfish. Start with a small amount of feed once per day at the same place and time until the bream are actively feeding, then slowly increase the feeding to no more than the fish will eat in 10 minutes up to a few times per day during summer.

Aquatic plants (they become weeds if they start to cause problems!) will start to grow more actively in the spring. Make sure to start a control program early before the weeds cover a significant part of the pond. The best and least expensive form of weed control is prevention. Preventing weeds starts with good pond construction and maintenance. Keeping the edges of the pond sloped rapidly to at least 3-4 ft. of depth combined with appropriate fertilization will give the weeds less area to grow. Keeping a background stocking of grass carp in the pond (where legal) and being careful not to introduce weeds from ornamental ponds or from boats are also important prevention methods. If weeds do become established, it is important to identify the type of plant before applying a herbicide. Most weeds can be identified with a few good closeup pictures that can be emailed or texted to your Extension Regional Agent or Specialist who can also provide a good herbicide recommendation. Applying the wrong chemical is usually ineffective and can actually be harmful to both the fish and people applying the product. Always follow the label instructions with any chemical you choose to use. The label provides application rate and method, the plants the chemical will control, and the proper safety measures the applicator should take.

Just like with plants, different species of algae require different approaches for control. If the pond has a filamentous algae problem, always identify the algae before applying any chemical control. A small amount of algae around the edge of the pond may not require any control or just a spot treatment with an algaecide. This is especially true in the spring. Some species of algae only grow significantly in the spring and die back on their own as the water warms in summer. Other forms start in spring and become a problem throughout summer. The worst cases are species like *Lyngbya*, a cyanobacteria (bluegreen algae) that grows throughout the year and should be treated aggressively. Almost any chemical treatment of algae involves copper compounds, and copper can be toxic to fish if the alkalinity and hardness of the water is too low. So, it is also critical that the water be tested for alkalinity and hardness before using copper compounds. If the alkalinity is low, liming the pond with agricultural lime during the winter months is likely the best option. For low alkalinity ponds, the addition of hydrated lime at 50 – 100 lbs per acre will make the copper safer to use.

Finally, spring is one of the best times to harvest largemouth bass. Mid-March through mid-May is the time when largemouth bass catch rates are at a peak for the year. While we encourage bass harvest throughout the year, it is simply most important to take out the appropriate pounds of bass to keep all the fish (bass and bream) growing well and reproducing. Extension recommends harvesting 25-30 lbs of largemouth bass per acre each year in a fertile pond and about 10 lbs per acre in an unfertilized system. Bass 14 inches long and under should be targeted to take out of the pond; however, it doesn't hurt to harvest a few larger bass if needed to meet the harvest goal.

To get more background on pond management, check out our Extension resources at our Extension website www.aces.edu/blog/tag/fisheries/?c=fish-water&orderby=title and our Fisheries and Pond Management Facebook Page www.facebook.com/ACESfishpond/. Getting a good start on pond maintenance in the spring will make management easier the rest of the year.

The Proper Use of Diuron

Anita M. Kelly & Luke Roy, Alabama Fish Farming Center

In the previous newsletter, we explained how to obtain the 24 (c) local special need labels for Diuron. We just want to remind producers that you can only apply Diuron (Karmex or Direx) to a pond **once every seven days**. No more than **nine** applications are permitted in a year. The restriction in application is primarily for prevention of residues within fillets. Your pesticide application records must show that you are adhering to the guidelines of the label. It is a violation of Federal law to use these products in a manner inconsistent with its labeling.

The "Big Fish" Problem and Possible Solutions in Marketing and Production

Gregory N. Whitis, Alabama Fish Farming Center

In the *U.S. Farm Raised Catfish* industry, the unintentional production of large fish over four pounds is common. When catfish supplies are tight, processing plants will process the bigger fish and waive producer-imposed pricing penalties. When fish are plentiful, producers may be penalized with reduced prices for large fish. Large fish, for most processors, are those over six pounds. To make matters worse, sometimes fish over six pounds aren't even processed but just put in the gut wagon. Our industry needs a concerted effort to find a stable market for over 13 million pounds of big fillets that could be sold at a price that does not penalize the producer.

It almost goes without saying that restaurants are extremely portion and cost conscious. I determined that a typical 11- to 16-ounce catfish fillet from a 3 to 5 lb fish can be cut into five to six 2.0- to 2.5-ounce strips. At several cooking demonstrations, there was general consumer acceptance when served longer, thicker, fried catfish strips. Why use the large fillets over the premium-sized fillets? Cost. The price savings for the bigger fillets can be more than a dollar per pound.

I am advocating that restaurant owners strip the fillets in order to realize the savings, not to mention that it takes less than a minute per fillet. The fillet should be stripped lengthwise into five to six strips, equally wide. I found that serving two of the longer fillet strips with one of the shorter fillet strips yields a 6- to 8-ounce pre-fried serving.

Thanks to a grant from the State Catfish Committee, I developed a protocol for smoking large catfish fillets. I can provide that protocol if someone wishes to explore a commercial smoking enterprise. The smoking protocol has been tested at a commercial smoking facility in central Wisconsin. By the way, the folks up there were really impressed with the product! Additionally, I also pursued other products made from large fish. A well-known caterer in Lee County has developed a catfish boudin and catfish breakfast sausage using nuggets from large fish. He plans on developing the boudin as a shelf ready item in the future. I also have protocols established for making catfish jerky; however, the marketing potential for this product needs to be explored.

On the production front, I am very excited about a project I will be working on with a private farm pond services company in Hale County. Last year, I worked with an Alabama Department of Natural Resources fish biologist who had experience shocking wild catfish. We purchased a Hummingbird fish locator that uses down and side scanning sonar. It can detect large fish and map out the contour lines of a pond bottom! If a catfish producer has a persistent problem with big fish, the fish locator will be able to detect where the large fish are in the pond. The fish locator is mounted on an electroshocking boat. The hope is to provide a service to the fish producer where the pond service company locates schools of big fish and shocks them out of the holes minutes before the pond is seined. Extended electrodes will drag through the holes. The goal is to shock the big ones out of the holes so they can be harvested AND NOT GROW ANY BIGGER. Plus, the service will provide a bottom contour map of the pond, allowing the producer to gauge if the pond should be scheduled for renovation. We hope this service will benefit the industry. If you are interested, please contact me at the Fish Center.

The 2019 Impact of Diseases in West Alabama and What to Watch For in 2020

Anita M. Kelly, Alabama Fish Farming Center

Based on the annual Alabama Catfish Disease Survey, the 2019 catfish production season suffered several losses due to disease. The survey was responded to by 72 of the 74 producers in west Alabama, representing a total of 17,293 acres of production, of which 3,272 acres were hybrid catfish. The survey showed that there were 1,532 ponds under commercial production with an average stocking rate of 7,656 head per acre. The reported total poundage lost to the five primary disease agents (Aeromonas, Edwardsiella, Columnaris, PGD, and Toxic releases) was significantly higher at slightly more than 7.9 million pounds of fish, compared to 5.7 million lost in 2018 (Fig. 1). The estimated loss in dollars, which included medicated feed costs, water treatment costs and lost feeding days costs, was approximately $12.5 million dollars, up from $9.7 million dollars in 2018. The primary cause of disease losses in Alabama continues to be from the bacterial diseases; *Aeromonas hydrophila* (2.9 million lbs) followed by Columnaris (2.0 million lbs) and Edwardsiella or ESC (0.4 million lbs). Losses due to unidentified toxins were 200,000 lbs, and losses due to

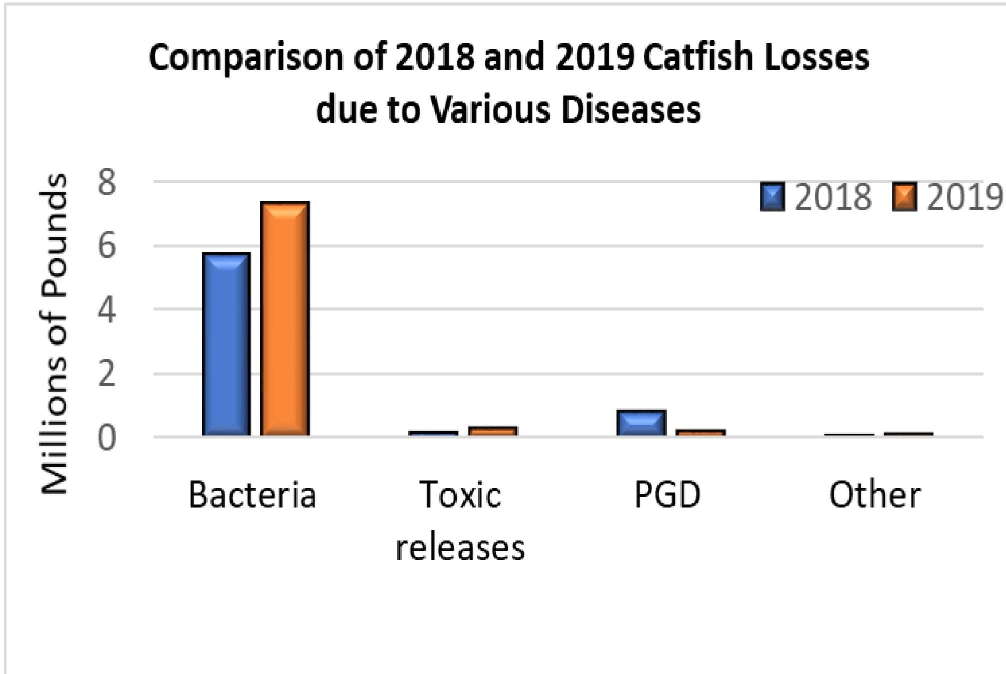

Fig.1. Losses of channel and hybrid catfish in 2018 and 2019 by disease category.

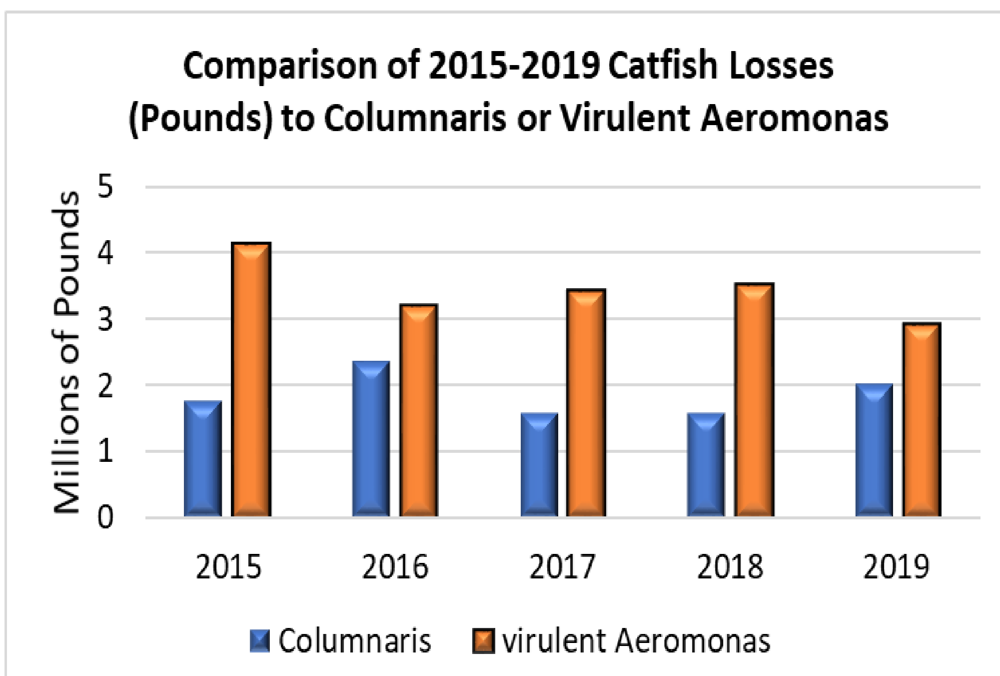

Fig. 2. Comparison of losses of channel catfish and hybrid catfish to *Flavobacterium columnare* (Columnaris) or virulent *Aeromonas hydrophila* (Aeromonas) from 2015 to 2019.

hamburger gill (PGD) were 130,000 lbs.

This year, the recorded losses of fish to Columnaris was the second highest year since 2015, while losses due to virulent Aeromonas was the lowest (Fig. 2). Although losses due to virulent Aeromonas decreased in 2019, the increase in Columnaris disease losses resulted in higher fish losses overall. Losses due to ESC have been steadily declining since 2015 (Fig. 3). Toxic releases were significantly lower the last two years (Fig. 4) and PGD was lower in 2019 compared to 2018 (Fig.5).

The outlook for disease outbreaks in 2020 is hard to tell, but initial cases in 2020 are indicating it might be another tough year. Virulent Aeromonas cases, which normally occur when the weather is warm, have already been documented in January and February. Ich has also been reported on several farms and caused massive mortalities.

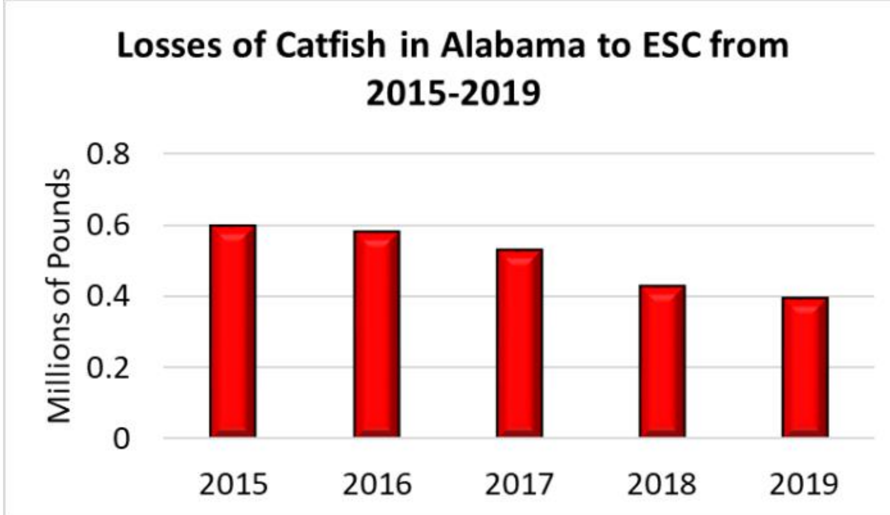

Fig. 3. Annual losses of channel catfish and hybrid catfish to ESC in Alabama from 2015-2019.

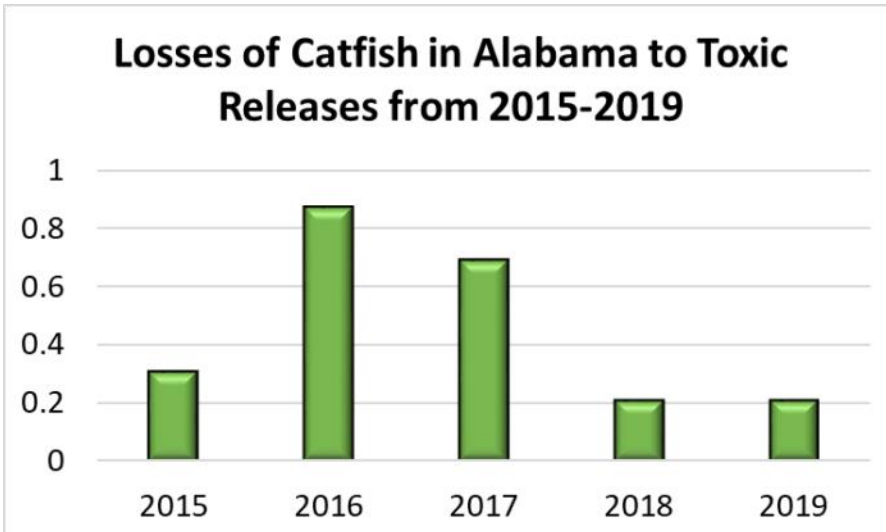

Fig. 4. Annual losses of channel catfish and hybrid catfish to toxic releases in Alabama from 2015-2019.

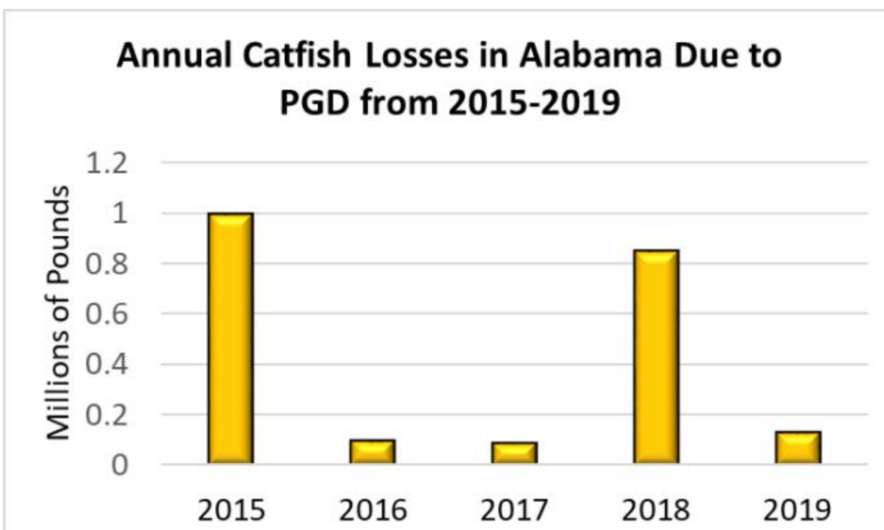

Fig. 5. Annual losses of channel catfish and hybrid catfish to ESC in Alabama from 2015-2019.

COVID-19 and AFFC

Personnel at the Alabama Fish Farming Center are still accessible to farmers, even though the center is temporarily closed due to the COVID-19 pandemic.

For disease issues, please call Dr. Anita Kelly at (334) 352-5705 or email amk0105@auburn.edu. For water quality and production issues, please call Greg Whitis at (334) 352-2482 or email whiting@auburn.edu or Dr. Luke Roy at (334) 218-9619 or email royluke@auburn.edu.

RESEARCH ROUND-UP

The Fertility Games: Effects of Male-Female Gametic Interactions on Fertility Potential

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For freshwater species, the window of sperm motility is remarkably short (often <1 min). Thus, fast swimmers are imperative for successful fertilization. With the biological clock ticking, each sperm cell has very limited time to locate an egg before motility stops. Interestingly, there is an outside factor that greatly influences this race: the presence of female ovarian fluid (OF). This fluid surrounds fish eggs after ovulation and can affect sperm swimming behavior for the better (by making sperm swim faster and longer), making it a determinant for fertility and a driving force for what is coined "cryptic female choice". This means that, evolutionarily, changes in sperm behavior to OF may have developed to select traits (both genetically and physically) that will most greatly benefit the next generation. Not only does the presence/absence of OF impact sperm performance and fertility but its properties also vary across/within species and even by individual females. This may be due to intrinsic differences in female quality, egg ripeness, or differences in OF composition. It's still puzzling exactly how OF enhances sperm motility and behavior, but its physical and biochemical properties are proposed candidates because they alter the activation micro-environment. These interactions, however important in driving fertility, are yet to be explored for certain cultured fishes such as channel and blue catfishes.

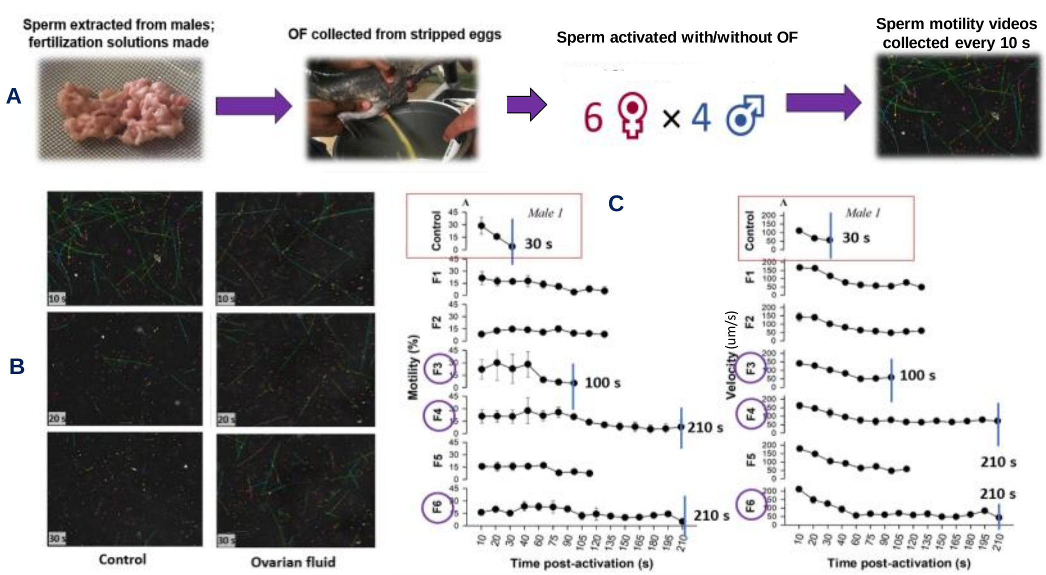

Fig. 1. Sperm from blue catfish males were activated with ovarian fluid from six channel catfish females, and sperm performance was assessed using CASA (A). Sperm motility and velocity were improved in OF treatments compared to the controls (B). Within each male, longevity of sperm varied greatly by female (C).

With the expansion of the channel × blue hybrid catfish industry, it is important to understand if gametic interactions occur between the two species during artificial fertilization and if specific male-female pairs perform better than others in the microscopic sperm Olympics, which could have potential impacts on fertilization success. To tackle these questions, this study was designed with the following objectives: 1) activate blue catfish sperm with/without channel catfish OF to see if sperm performance was enhanced and 2) assess if sperm behaved differently when exposed to OF from individual females.

To explain briefly, sperm from four males were activated under the microscope without OF (control) and with OF from six unique females, creating 24 experimental crosses (Fig 1A). Sperm motility (% of sperm moving in a frame) and velocity (swimming speed in µm/s) were analyzed during each trial using computer assisted sperm analysis (CASA) software. Videos were taken every 10 seconds until sperm motility ceased. The results showed that OF had an immediate positive impact on sperm velocity when compared to the control. Not only that but by 30 s post-activation when motility had ceased for all the controls, sperm were still readily moving for all the OF treatments (Fig. 1B). In all cases, OF always increased longevity, causing the sperm to swim for up to several minutes. An interesting thing to note was that longevity was greatly affected by the specific OF sperm was activated in (Fig. 1C). In other words, interactions between males and females greatly skewed sperm performance in each trial. Not all pairs performed equally, with differences in longevity of up to 100 seconds between the best and worst pairs.

So in conclusion, our overall results show that female channel catfish OF differentially enhances behavior of blue catfish sperm. From this study, we discovered how important female OF is during fertilization, although there are still questions to be answered on how and why these interactions occur. We can also ask if such differences in sperm performance affect fertilization and hatch success for fry production. Do the best-performing pairs also have higher fertility? Only future research could tell us for sure. On a broader scale perspective, this knowledge can hopefully be applied to improve hybrid catfish aquaculture and also expand on our current knowledge of the remarkable reproductive strategies found in freshwater fishes both in hatcheries and the wild.

Improving Catfish Pond Water Quality by Reducing Planktivorous Fish Abundance

Angelea Belfiore & Alan E. Wilson,School of Fisheries, Aquaculture, and Aquatic Sciences, Auburn University

In highly productive aquaculture ponds, conditions for phytoplankton blooms are intensified. The presence of increased nutrient availability, shallow waters with regular mixing through aeration, warm temperatures, and high intensity sunlight common in these settings often leads to dense blooms of phytoplankton throughout most of year. However, cyanobacteria (also commonly called, blue-green algae) often dominate the phytoplankton community during the growing season (May-October) and can negatively affect aquaculture production through the release of off-flavor compounds, such as geosmin and 2-methylisoborneol (MIB), and toxins, such as the liver toxin microcystin and/or neurotoxin saxitoxin. In extreme cases, phytoplankton blooms can promote hypoxic conditions when they degrade and lead to fish kills that can devastate producers' livelihood. Catfish aquaculture ponds may include catfish of mixed sizes due to incomplete harvesting as well as intentionally or unintentionally introduced planktivorous fish, such as threadfin shad, gizzard shad, bluegill, green sunfish, and/or fathead minnows. Reports suggest that some planktivorous fish eat and possibly control phytoplankton, although there is a long history of research that shows that these fish eat zooplankton (small animals that consume phytoplank-

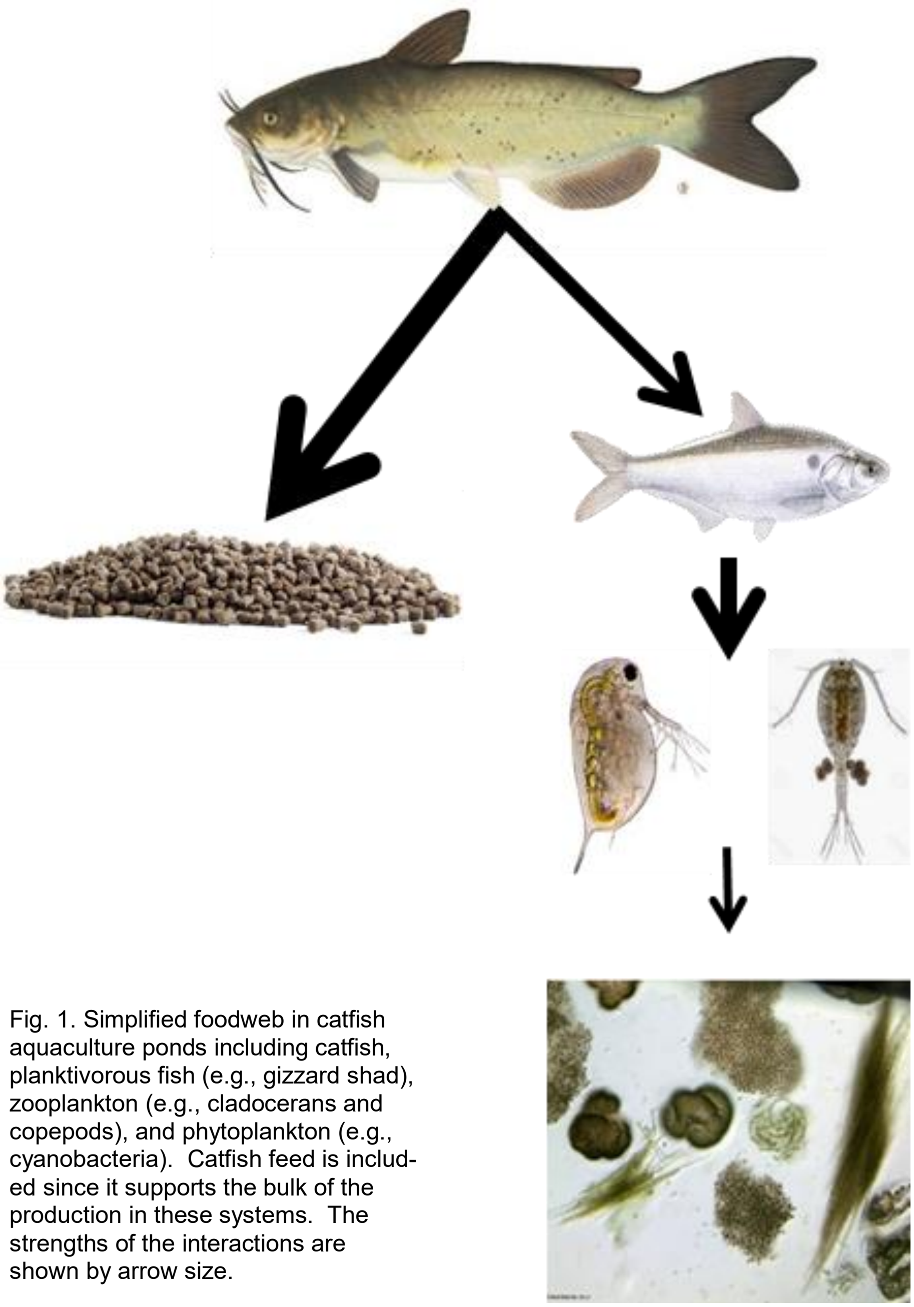

Fig. 1. Simplified foodweb in catfish aquaculture ponds including catfish, planktivorous fish (e.g., gizzard shad), zooplankton (e.g., cladocerans and copepods), and phytoplankton (e.g., cyanobacteria). Catfish feed is included since it supports the bulk of the production in these systems. The strengths of the interactions are shown by arrow size.

ton; Fig. 1 and 2), especially large-bodied taxa (e.g., *Daphnia*) that have been shown to heavily consume phytoplankton, including cyanobacteria. When planktivorous fish are present in a pond, their primary diet consists of zooplankton although they may eat residual feed not consumed by catfish. The catfish feed contains nutrients, such as nitrogen and phosphorus, that become available for phytoplankton after passing through fish or as the feed degrades. However, when the planktivorous fish are absent, zooplankton thrive and may control phytoplankton (also called a trophic cascade). When one level of the ecosystem has been altered, it will directly and indirectly affect the rest of the system.

Over the past two years, our sampling efforts of more than 20 catfish production ponds in which several have reduced or eliminated planktivorous fish prior to stocking show strong and clear effects of these foodweb manipulations, namely that ponds with less planktivorous fish lead to higher densities of large-bodied zooplankton and clear water, whereas ponds with abundant planktivorous fish have less zooplankton and much higher concentrations of phytoplankton (Fig. 2). There are numerous factors that influence the development and persistence of phytoplankton blooms, such as excess nutrients and elevated temperatures (both common features of catfish production ponds); however, we contend that the presence of small planktivorous fish are an important and feasible component that can be managed (i.e., remove planktivorous fish) to reduce phytoplankton blooms by allowing the natural control of phytoplankton in highly productive systems thus significantly improving the water quality in the ponds by affecting the formation, frequency, and intensity of cyanobacterial blooms.

Although we argue that foodweb manipulations that reduce or eliminate planktivorous fish should be considered as a pond management tool in aquaculture, we acknowledge the important role that phytoplankton can play in maintaining a healthy pond environment, namely by producing dissolved oxygen through photosynthesis or taking dissolved nutrients that can poison fish, such as ammonia and nitrite. Green productive pond water is not necessarily indicative of a bad system; however there is a chance, especially in the summer months, a bloom of cyanobacteria could be present. Thus, we encourage producers to work closely with extension personnel and researchers to monitor water quality to avoid situations that could harm fish especially considering that relatively clear aquaculture ponds are unusual at most farms. Our lab doors are always open to support aquaculture farmers.

Fig. 2. Zooplankton (second level) and phytoplankton (third level) samples from aquaculture ponds with abundant small, planktivorous fishes (such as gizzard shad; left side) or few to no planktivorous fishes (right side). Zooplankton photos were taken at the same sample volume and magnification (see scale bar for reference) from green or clear ponds. Zooplankton in green ponds were less abundant and dominated by copepods compared to clear ponds that included abundant, ambient large-bodied zooplankton, such as *Daphnia*.

Determination of the Age of Hybrid Catfish and Channel Catfish from Commercial Fish Farms and Economically Evaluating Three Management Strategies to Control Big Fish

Daniel Creel, Terry Hanson, Luke Roy, Steve Sammons, School of Fisheries, Aquaculture, and Aquatic Sciences, Auburn University

Fig.1. 40 lb hybrid compared to a market-sized hybrid from the same pond.

Big Fish (> 4 lb) have had a negative impact on farm profitability for many years. Both farmers and processors have been unable to find a viable long-term solution to this problem. Processing plants cannot readily sell fillets from large catfish causing them to pay a reduced price and sometimes no compensation at all for Big Fish. Many factors can lead to Big Fish including rangy fingerlings (wide size distribution), uneven pond bottoms that prevent efficient seining, and commercial seining practices. In the summer of 2018, otoliths were collected from 287 catfish (153 channel catfish and 134 hybrid) ranging from 2 - 46 lb from commercial catfish farms to determine the age and growth of catfish of different size classes. Based on our findings, channel catfish and hybrid catfish are 2 years old when they are harvested at the end of the first production cycle. Catfish missed at harvest for multiple years will lead to a wide size variation of fish present in the pond (Fig. 1) that negatively impact the farm by increasing FCRs, increasing feed costs, and may lead to the predation of smaller catfish in the pond. The oldest channel catfish sampled during our study was a 7-year old channel catfish weighing 11 pounds. Based on the average number of harvests a pond receives per year (2 harvests per year) and the average seine pulls at harvest (2 seine pulls per harvest), this 7-year old catfish could have been missed up to 24 times before being harvested. Missed catfish can present a greater problem to farmers who raise hybrid catfish due to their faster growth rate compared to channel catfish. A small percentage of hybrid catfish will reach Big Fish size at the end of 1 production cycle. Additionally, the majority of hybrid catfish missed after the first production cycle will reach Big Fish size by the end of the second production cycle. Hybrid catfish were able to grow to 10+ lb in 3 years and up to 46 lb in 6 years (Fig. 2).

In production years 2017 and 2018 for the U.S. catfish industry, Big Fish decreased gross revenue from catfish sales by an estimated $12 million and $15 million dollars, respectively. The Big Fish problem has a significant economic impact on farm profitability every few years and appears to be directly tied to the supply and demand for fish. If there is an undersupply of catfish on the market, processing plants will pay a higher price for Big Fish compared to years when there is an oversupply of catfish. Big Fish represent a key inefficiency for commercial catfish farms regardless of the price paid by processing plants in a given year. A survey titled "2019 Big Fish survey of the Alabama catfish industry" was mailed to every catfish producer in Alabama to determine the scope of the Big Fish problem on each farm and the different management strategies used to control Big Fish. Based on the survey data, an estimated 75% of premium-sized catfish (1-4 lb) and 25% Big Fish were harvested from channel catfish farms compared to 87% premium and 13% Big Fish from hybrid catfish farms. The different control strategies implemented by farmers ranged from using gill nets to selectively capture Big Fish to seining more often and burying the Big Fish. Using survey data, we were able to establish the costs and benefits of three management strategies commonly used by farmers to control Big Fish (Fig. 3). Each developed strategy focused on how to remove Big Fish before the next stocking. The most cost-effective solution is to seine more often by hiring a custom seine crew for additional seining followed by using rotenone to zero-out the pond and lastly, completely draining the pond and reworking the pond bottom. Each management strategy needs to be tailored to the specific farm depending on the species cultured, farm size, and pond conditions.

Based on farmer interviews and from survey results, we believe the best long-term solution forward in regard to Big Fish is to eventually re-work the pond bottoms, as the opportunity arises and cash flow permits, to increase seining efficiency leading to improved commercial seining practices. Due to the common use of multiple-batch production systems and the cost of renovations, the average time between pond renovations in farmers that responded to the survey was 20 years. These old ponds are hard to seine due to the accumulation of mud, holes and depressions, or the presence of large trenches. There is no easy solution to the Big Fish problem and will likely require a multifaceted approach. Thank you for your help on this project, and we hope to continue working with farmers on this problem to find a viable long-term solution.

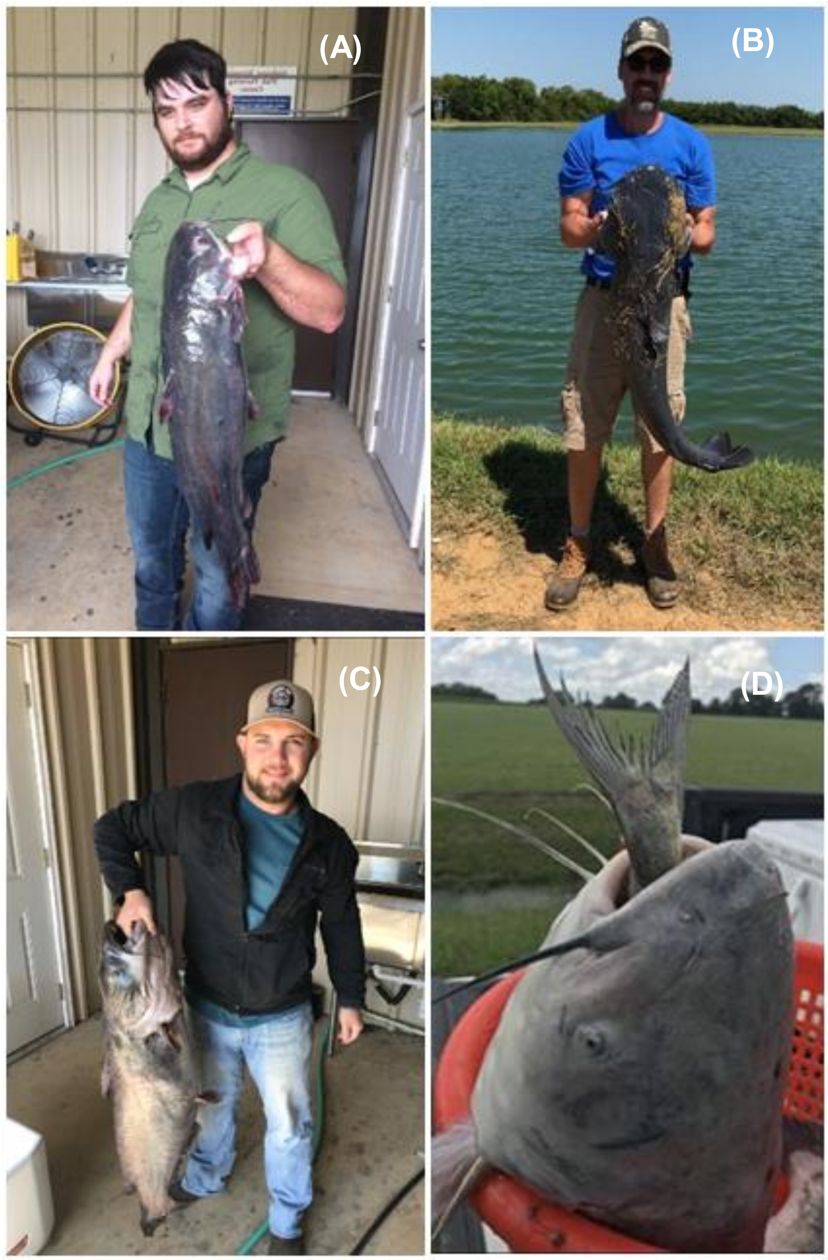

Fig. 2. Largest specimens of hybrid catfish collected from commercial catfish ponds in west Alabama. (A) Length: 36 in; Weight: 33 lb; Age: 4 years old, (B) Length: 42 in; Weight: 40 lb; Age: 6 years old (C) Length: 42 in; Weight: 46 lb; Age: 6 years (D) 29 lb hybrid with market-sized fish in its mouth

Management Strategy	Cost	Benefit
Hiring a custom seiner for additional seining	~ $150/hour including harvest and transport[a]	Increased revenue by harvesting additional market-sized fish
Using rotenone to zero-out pond	~ $3,850 for the average pond in West Alabama	Eliminates all the Big Fish in the pond
Completely draining the pond and re-working the pond bottom	~ $1,500/acre[b]	Will increase seining efficiency leading to a higher % of market-sized fish at harvest

Fig. 3. Costs and benefits of 3 management strategies to control Big Fish

[a] Total price will vary depending on pond size and distance to processing plant
[b] Only use as a last resort due to the time needed for renovations and the lost revenue from that pond during renovations

Every Catfish Sperm is Sacred

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Artificial fertilization (human controlled spawning) is a technique commonly implemented in hatcheries for fish species that do not spawn readily in captivity. Sperm density, or specifically how much sperm is used to fertilize a batch of eggs, can cause great changes in fertility and consequential hatch success. The optimal sperm to egg ratio varies depending on the species and its associated reproductive physiology, specific mating strategies, and features of their unique gametes. Hybrid catfish aquaculture depends on the success of artificial fertilization to produce the annual cohort of fry, which is limited by the lack of natural hybridization between channel and blue catfish. Unfortunately, this requires blue catfish males to be sacrificed to extract their valuable sperm and carry on their legacy to the next generation. Therefore, dad's resources must be used efficiently by using the minimum quantity of sperm possible on each egg batch. After all, every sperm is sacred! Still, enough must be used to obtain high fry output. A previous report from near the turn of the century found that sperm densities lower than 50,000 sperm per egg caused a significant reduction in fertilization success, while much higher densities of 12.5 million to 120 million sperm per egg did not negatively affect fertility. Since then, it is currently recommended that producers use ~12 million sperm per egg. Based on these prior findings, the optimal sperm density for fertilization falls within a vast range and may drastically exceed the actual amount required to obtain a desirable high hatch.

Our objective was to look into this matter and reassess the important sperm to egg ratio, utilizing modern artificial fertilization techniques that address advancements in egg and sperm quality from donor fish as well as industrial protocols. When it comes to fish reproduction, the strength in numbers strategy often prevails. We hypothesized that hatch success would increase when more sperm were tossed into the sparring ring but the benefit of adding more would diminish and taper out as the total number of sperm cells approached the number required to fertilize all of the eggs in a batch. In this study, channel catfish eggs from nine females were collected from two study locations (Auburn University, AL and the USDA-ARS facility in Stoneville, MS) and fertilized with six different sperm to egg ratios ranging from 1,000 to 100,000 sperm per egg. Embryos were then incubated under common environmental conditions until hatch. Average hatch success for the nine females across the sperm density gradient ranged from 18.3% to 48.8% (Fig.1). Hatch for the lowest performing female ranged from a measly 0% to 12.5%, while the highest ranged from 22.7 to 81.9% with much greater variability due to sperm density. It is no secret that females matter when it comes to their egg quality, and maternal effects were dominant factors influencing hatch variability (up to 94%). Overall, the effects of sperm density reflected our hypothesis. Hatch success for all females significantly increased from 5,000 to 10,000 sperm per egg (Fig. 1). Thereafter, adding more spermatic contenders to the race did not increase hatch. When analyzing the results at each location individually (to see if results held true under different spawning and rearing conditions), hatch ranged from 18.2% to 57.3% at Auburn University and 18.6% to 32.3% at the USDA-ARS in Stoneville. Also, at Auburn, the optimal ratio was the same as the overall results, but at Stoneville this density threshold was lower, in which 5,000 sperm per egg was the magic ratio. Thus, lower sperm densities may be optimal under certain conditions.

CONCLUSIONS - As a conservative measure, we suggest that hatcheries use 10,000 sperm per egg as the golden standard for hybrid catfish production, which could potentially cause a 12-fold increase in productivity for each male.

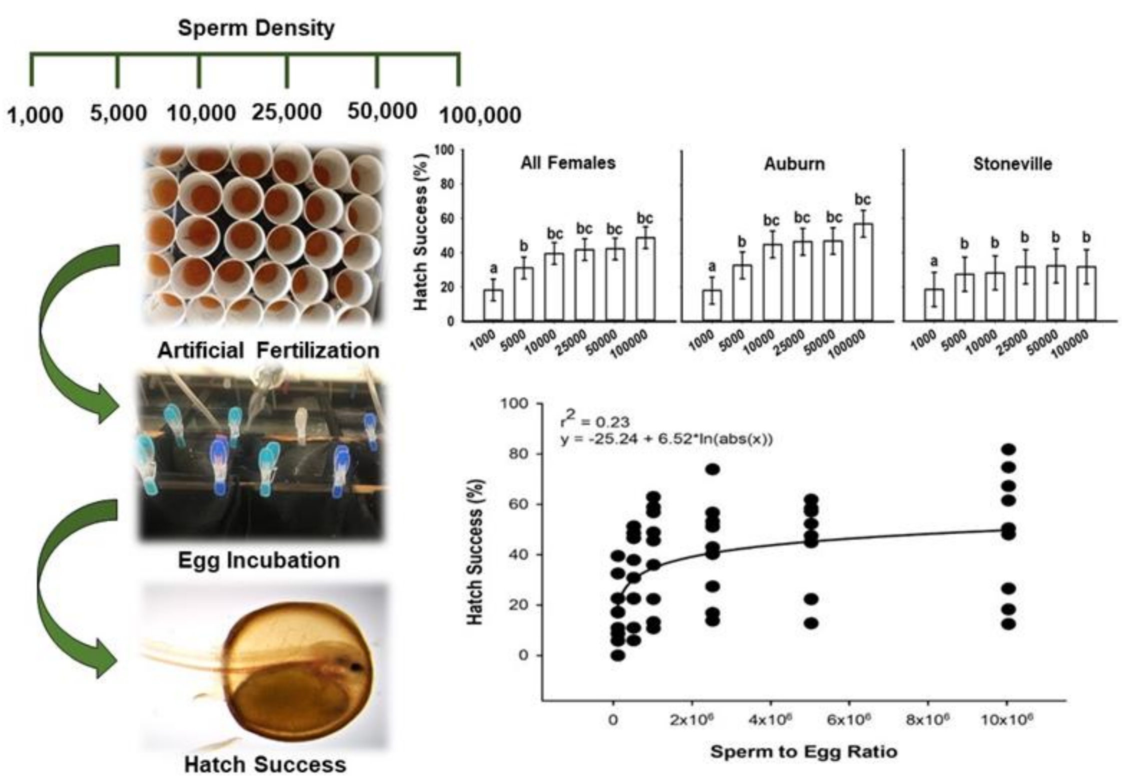

Fig. 1. Egg batches of hybrid channel catfish (*Ictalurus punctatus*) ♀ × blue catfish (*I. furcatus*) ♂ were fertilized with one of six sperm to egg ratios and incubated until hatch. Mean hatch success using sperm densities ranging from 1,000 to 100,000 sperm per egg. Sperm to egg ratios with different letters are significantly different. Below, the relationship of the data fit a logarithmic equation, where each point represents hatch success for a single female (n = 9).

New Research Estimating the Impact of Avian Predators on Low Salinity Shrimp Aquaculture

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Shrimp are one of the most popular and heavily consumed seafood products in the U.S. The shrimp market is sourced from shrimp aquaculture farms and wild shrimp catch; farmed shrimp currently dominate the market. The top producers of farm-raised shrimp (Pacific white shrimp, *Litopenaeus vannamei*) in the U.S. include Texas, Alabama, and Florida, producing nearly 4 million pounds per year. In recent decades, the U.S. shrimp industry has been negatively impacted by foreign imports and increasing production costs including feed which has limited growth of the industry. Shrimp farmers that use semi-intensive earthen ponds continue to face negative factors that influence production one of which is depredation of shrimp by birds. Alabama shrimp farmers utilize a unique artesian inland low salinity ground water source to produce marine shrimp in traditional earthen ponds, very similar to the ponds frequented by an array of wading birds and other waterfowl documented on catfish and other aquaculture (Fig. 1-2). Total shrimp production in Alabama typically ranges between 250,000-300,000 lbs each year. Wading birds commonly occupy and predate shrimp in earthen ponds, but the total loss due to predation during the shrimp production season remains unknown. Understanding which birds are primary causes of depredation loss, when it occurs, and the gross loss from avian predation can provide information for their management and potentially improve the total yield from harvest.

In the southeastern U.S., the shrimp growing season occurs from late spring to early fall. Wildlife and fisheries researchers at Auburn University are combining efforts with bird experts at the USDA's National Wildlife Research Center (Starkville, Mississippi Field Station) to examine the impacts of wading birds on shrimp aquaculture in Alabama and Florida during the spring-fall of 2020-2021. Wading birds such as Great Blue Herons and Little Blue Herons, Great Egrets and other waterfowl species inhabit wetlands and lowlands of Alabama and Florida's coastal plains, and their diets consist of small fish, hard

Fig.1. Farm-raised Pacific white shrimp, Greene County, Alabama.

shelled crustaceans such as shrimp, and aquatic arthropods. Because shrimp are a normal part of wading bird diets, finding these birds near aquaculture facilities is not uncommon. Aquaculture facilities provide wading birds with easy access to prey with minimum effort. Commercial shrimp farmers have directly observed wading birds consuming shrimp on their operations. Our study intends to measure the impact these birds may have on shrimp production. The objectives of this research are to: 1) assess the distribution and abundance of shrimp-eating birds on shrimp farms in Alabama and Florida, 2) quantify the diet of these predator birds, and 3) estimate the total abundance of shrimp consumed annually by predatory birds. These objectives will assist in determining the impact avian species have on shrimp aquaculture and help producers better understand the economic effects birds have on production.

Researchers will conduct field observations every two weeks from May through September, of 2020 and 2021; the observations will take place at two commercial shrimp farms. The team will count wading bird species at both farm locations. We will be observing wading birds such as: Great Blue Herons, Little Blue Herons, Great Egrets, Double-crested Cormorants, and other waterfowl using the ponds and possibly consuming shrimp. These observations determine which species will be collected during sampling. Similar methods have been used for avian sampling over baitfish aquaculture in the southeast.

After observational surveys, we will collect bird samples by shooting individuals that have been feeding at a pond for 5-10 minutes. Once collected, we will preserve the samples for transport back to our lab facilities for analysis. The main objective of our surveys and sample collection is to determine the most abundant species of birds and the amount of shrimp they consume. The data we collect during field studies will help us estimate which bird species inhabit shrimp ponds, if shrimp are a major part of the bird's diets, and the economic impact avian predation has on the shrimp stocked in commercial ponds. Collaboration between Auburn, USDA, and the private landowners will help us estimate the financial impact of total shrimp loss during the production season. Long term, these analyses will help shrimp farmers understand the degree of financial losses caused by avian predation.

This research will be one of the first efforts to help aquaculture experts understand the impact caused by avian predators on shrimp aquaculture. Continuing to study the relationship between aquaculture and water birds is important for both consumers and wildlife in hopes that we can decrease this human-wildlife conflict while promoting positive coexistence between the two. Through the partnership with Auburn University, USDA Wildlife Services, and private landowners we intend to strengthen the future of the U.S. aquaculture industry.

Fig. 2. Commercial shrimp harvest, Greene County, Alabama.

Bioeconomic Analysis of *Flavobacterium columnare* Vaccine Pond Trials for Channel Catfish *Ictalurus punctatus*

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Disease pressure in the catfish industry is due primarily to Columnaris (*Flavobacterium columnare*), Enteric Septicemia (ESC, *Edwardsiella ictaluri*), and virulent *Aeromonas hydrophila* (vAh). A 2018 survey of 74 farms in West Alabama found Columnaris was the cause for 24% of mortalities (Hemstreet 2018). The responsible pathogen, *Flavobacterium columnare*, is an opportunistic pathogen found on immune-compromised fish or as a secondary infection. Due to the ubiquitous nature of this pathogen in commercial ponds, Auburn researchers have been working to boost catfish immunity rather than eradicate the pathogen. In lab trials with a live-attenuated vaccine, results revealed found a 17% increase in survival of channel catfish fingerlings (Olivares-Fuster 2010). However, commercial production in ponds adds many additional variables. In April of 2018, we continued testing of Cova Arias' 17-23 Columnaris vaccine in pond trials at the E.W. Shell Fisheries station in Auburn, AL. We assessed the vaccine effect by analyzing production factors including survival, feed conversion, and total harvest weight between control and vaccinated fingerlings.

Trial Goals

The hypothesis tested in this study was that vaccinated catfish would have an increase in survival; improvement in feed conversion ratio (FCR); and increase in total weight harvested from vaccinated ponds in comparison to non-vaccinated ponds.

Pond Study

The live-attenuated vaccine was administered to 6" channel catfish fingerlings free of specific pathogens, that is, they were reared in an environment that had never been exposed to Columnaris before the trial. Half of the fingerlings were immersed in a vaccine bath while in the hauling tank for one hour. The control or non-vaccinated fingerlings did not receive the vaccine bath. Both treatments were stocked into five (0.1-acre) ponds.

Channel catfish fingerlings were stocked in April and harvested in October, in order to expose fish to seasonal Columnaris outbreak peaks in April and September. One 0.5 hp aerator was placed in each pond and ran from 6pm to 8am daily. Mortalities were recorded and removed twice daily. Fish were fed once daily with a 32% crude protein floating pellet, via the 90/7 method. For this method, each pond was fed individually to satiation on day one, and for the next 6 days, 90% of the satiation amount was fed to the respective ponds. By reassessing feeding rates every seven days, we were able to avoid wasted feed and overfeeding on an individual pond basis. Monthly samplings recorded length and weight of 30 fish from each pond. At harvest, seine nets and complete pond draining were used to account for every fish and the total fish weight removed from each pond.

Results

We found no significant difference in survival between vaccinated (85.3%) and control (83.8%) populations during this study. However, it should be noted that no acute fish kill occurred at any point during

Production Parameters	Vaccinated	Control
Avg. Stocking Rate (fish/acre)	7,772	7,414
Avg. Wt. at Stocking (lb/1,000 fish)	61	61
Total Weight Stocked (lb/acre)	472	450
Survival (%)	85	84
Total Feed Fed (lb/acre)	6,420	7,442
Total Weight Harvested (lb/acre)	5,240	3,959
Avg. Weight at Harvest (lb/fish)	0.79	0.64
Feed Conversion Ratio - FCR	1.35	2.12

Table 1. Results from experimental trials using columnaris vaccinated fingerlings for channel catfish grow out, Auburn, Alabama 2019.

the trials, so the effect of vaccine on survival could not be evaluated.

On a per acre basis, vaccinated ponds were fed a total of 6,420 lbs, which is 1,022 lbs less than the control ponds (7,442 lbs) (Table 1). An additional 1,281 lbs of fish was harvested from vaccinated ponds as well. From this information, we calculated that the control (non-vaccinated) ponds had an average FCR of 2.12, while the vaccinated ponds had an average FCR of 1.3, a 37% improvement over the control group. Feed conversion efficiency improved in the vaccinated catfish treatment.

Economic Assessment

On a per acre basis, our partial budget analysis displays the benefits (left column) and costs (right column) of using vaccinated fingerlings over control (non-vaccinated) fingerlings in the grow out of channel catfish to food size fish (Table 2). The total benefit ($1,590) was due to income from harvesting an additional 1,281 lbs of vaccinated fish, plus the cost reduction from feeding 1,022 lbs less than control ponds. Total costs ($107) were a result of vaccination cost, harvest and transport of additional fish, and operation loan interest for these additional costs. Subtracting costs from our benefits, there was a positive net return of $1,482 indicating that the use of vaccinated fingerlings to produce food size catfish would benefit the producer.

Using the same method, we can extrapolate a partial budget for a 250-acre farm, like many found in West Alabama. In this scenario, we would expect a potential total benefit of $397,425 due to an increase in harvest weight plus a decrease in feed cost. Costs now total $26,811 as we would expect to vaccinate over 1.94 million fingerlings and account for additional transport and loan interest. The net return remains positive, predicting a $370,614 benefit to the farm ($1,482/acre).

Citations

Hemstreet, B. 2018. “Disease Impact in West Alabama Aquaculture in 2018.” Presented at the 2018 Catfish Update Meeting, Demopolis, AL, December 4.

Olivares-Fuster, O. 2010. “Development, Characterization and Early Evaluation of New Modified Live Vaccines Against Columnaris Disease” Auburn University Master of Science Thesis. Access: https://etd.auburn.edu/bitstream/handle/10415/2076/Olivares-Fuster%20MS%20-%2004-07-2010.pdf?

Partial Enterprise Budget					
Research Results of Producing *F. columnare* Vaccinated Channel Catfish from Non-Vaccinated Channel Catfish					
Benefits			**Costs**		
A. Additional Income			**A. Reduced Income**		
Difference in Weight (lb) Harvested	Unit Price, $/lb	Value	None		Value
1,281	$ 1.089	$ 1,395			$ -
B. Reduced Cost			**B. Increased Cost**		
I. Feed			*I. Vaccine*		
Additional Feed Fed to Control Fish (lb)	Unit Price, $/lb	Value	Number of Fish Vaccinated	Unit Price, $/each	Value
1,022	$ 0.191	$ 195	7,772	$ 0.005	$ 39
			*II. Harvest and Transport**		
			Difference in Weight Harvested (lb)	Unit Price, $/lb	Value
			1,281	$ 0.05	$ 64
			III. Interest on Variable Cost		
			Sum of I, II	Interest on a Short-term Loan (%)	Value
			$103	4.21	$ 4
Total Benefits		$ 1,590	**Total Costs**		$ 107
Total Benefits - Total Costs =		$ 1,482			
Therefore, benefits are greater than the cost so we would accept the change to vaccinated fish.					

** The difference in mean harvest total weight of vaccinated minus control treatments.*

Table 2. Partial enterprise budget changing from traditional non-vaccinated fingerlings to columnaris vaccinated fingerlings for channel catfish production on a per acre basis, Auburn, Alabama 2019.

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