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Dietary Protein Concentration and Stocking Density

Edwin H. Robinson, Menghe H. Li, and Bruce B. Manning

Over the past 15 years or so, we have examined almost every aspect of the nutrition of channel catfish. Studies have been conducted to evaluate optimum dietary protein concentration, protein sources, fish meal replacements, all-plant protein diets, feeding strategies, relationship of nutrition to fish health, feed-borne toxins, practical vitamin and mineral requirements, optimum dietary energy to protein levels, and numerous other factors related to the nutrition of catfish. As far as possible, each study was conducted under conditions that reflected the culture methods used in the catfish industry. Although we were able to incorporate many of the typical practices used in commercial catfish culture into our research, one area that seemed to be a moving target was the best stocking density to use. Based on one set of criteria derived from research a stocking density of about 6,000 to 7,000 fish per acre appeared to be optimum, while using a set of criteria based on commercial catfish culture practices, considering fish loses and cash flow issues, a higher stocking density of 10,000 or more fish per acre appeared to be best. At any rate, we generally conducted our experiments stocking from 6,000 to 10,000 fish per acre.

The reason stocking density is an issue when conducting nutritional experiments has to do with the effect (if any) of stocking density on the nutritional requirements. That is, does the requirement for a particular nutrient change as stocking density increases? Even though it might seem logical at first thought that catfish may require more of a specific nutrient when stocked at high densities, unless there is some sort of severe stress associated with the higher stocking density it is unlikely that the nutrient requirements would change and even then additional nutrients are likely not to compensate for the detrimental effects of any stressors. Based on observation of studies conducted at different stocking densities the dietary requirement for a particular nutrient such as protein does not appear to change as stocking densities increase. This is evidenced by the data presented in Table 1 that were derived from a study conducted with channel catfish stocked at either 6,000, 12,000 or 18,000 fish per acre and fed

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Improving Catfish Spawning Success

Bill Wolters

Proper management and care of broodfish is critical for high spawning success. Many factors, such as water quality, stocking density, and off-season management, can affect catfish reproduction. Industry averages for spawning success are estimated to be around 30-40% and egg hatching around 60%. The following guidelines should improve spawning success and fry production.

- Spawning success in NWAC103 line catfish can be as high as 20-30% in 2-year old fish with best reproduction realized from 3 and 4-year old fish. Broodfish larger than 10 pounds are somewhat difficult to handle and result in lower fry production.
- Broodfish should be inventoried and sexed yearly during late winter while water temperatures are cool. Either a sex ratio of 1:1 or more females than males is desirable.
- Broodfish should be stocked at no more than 1,200 pounds per acre into ponds that have been drained, allowed to dry, and recently re-flooded. After the spawning season, broodfish can be moved and restocked into ponds at 3,000 to 4,000 pounds per acre.
- Leaving broodfish in the same pond two years in a row without draining / drying the pond or inventorying the fish will result in poor spawning success the second year.
- Feed a nutritionally complete, floating diet with at least 28% protein at 2% of body weight per day when temperatures are above 70°F and 1% per day with a slow-sinking pellet between 55º and 70ºF. Generally, no feed is offered below 50ºF. Forage fish (fathead minnows and tilapia) can be added for supplemental feed and may increase spawning success.
- Spawning activity will begin when water temperatures are consistently around 75ºF. Maintaining optimum water quality in spawning ponds is important because low dissolved oxygen levels and excessive algae and aquatic weed growth will inhibit spawning success.
- Spawning cans can be checked every 2 days during the spawning season. Eggs should not be crowded into transport containers and do not allow transport water to become warmer than 85ºF before transport to the hatchery.
- Water for hatching eggs should be well-water with temperatures between 75ºF and 82ºF. Dissolved oxygen levels should be maintained above 6.0 ppm, total water hardness and alkalinity > 20 ppm, pH between 6.5 and 8.5, and total gas pressure 100% of saturation or less.
- Control bacteria and fungal infections on eggs by maintaining optimum water temperatures, cleaning hatchery equipment, removing dead eggs, and using formalin and iodine as needed.
- If poor hatching success and greater than normal fry mortality occurs, send samples to diagnostic laboratories.
- Feed fry a suitable ration at least 12-24 times per day.

Spawning Success Data for Spring 2001

The table at right summarizes information from 239 spawns of NWAC103 line catfish in earthen ponds (0.1 to 1.0 acre) during spring 2001 at the USDA/ARS Catfish Genetics Research Unit, Thad Cochran National Warmwater Aquaculture Center, Stoneville, Mississippi. The overall average hatching success of eggs to sac-fry was 56%. The equation for determining the number of eggs per pound of spawn (based on these 239 spawns) is as follows:

Number of eggs per pound = 14,839 X Spawn Weight (lbs) + 1,593

Spawn Weight (lbs)	Number of Eggs	Number of Sac-Fry
0.5	9,013	5,047
1.0	16,432	9,202
1.5	23,852	13,357
2.0	31,271	17,512

Zooplankton Utilization by Chanel Catfish Fry

Charles C. Mischke and David J. Wise

While many university and governmental agencies have research programs to study various aspects of aquaculture, catfish fry and fingerling culture has received only limited investigation. One reason for the lack of research on fry culture is channel catfish fry are relatively hardy and readily accept commercial feeds. Much more research has been conducted on fry culture of gamefish species such as walleye, sauger, northern pike, striped bass, white bass and bluegill because they will not survive well on prepared feeds alone. Successful culture of these species is dependent on an adequate zooplankton forage base.

During the first few weeks in the nursery ponds, it is assumed that many nutrients acquired by catfish fry are derived from natural food organism consumption. Prepared feed serves primarily to fertilize the pond and stimulate food organism production.

While it is assumed zooplankton are the most important natural food organisms for catfish fry, it is not known which zooplankton species are utilized. Current stocking recommendations are to stock the ponds with the greatest total zooplankton density first. The following study was designed to determine channel catfish zooplankton feeding preferences.

Methods

Fry were stocked into ponds and aquaria with differing zooplankton communities and allowed to forage for 24 hours before sampling. Stomach contents were removed from sampled fry and examined microscopically. Zooplankton groups and numbers consumed by fry were compared with groups and numbers available in the water. Zooplankton preferences by catfish fry were determined using a diet preference software program (PREFER) that estimates the preference for each prey item based on usage and availability.

Results and Discussion

Although the zooplankton community taxonomic compositions in the experiments were different, fish in all three trials showed the same zooplankton preferences (Table 1). Channel catfish fry preferred large cladocerans (e.g., *Daphnia*, *Moina*, *Sida*) to all other groups of zooplankton. Large cladocerans were rare in the zooplankton samples taken from the water, but the fry actively sought these large zooplankton. Copepods (*Diaptomus*, *Halicyclops*, *Cyclops*) were generally consumed in the same proportion in which they occurred in the water. Small cladocerans (e.g., *Bosmina*, *Alona*, *Chydorus*) were consumed by fry, but were avoided if larger prey were present.

Rotifers and copepod nauplii, although abundant in all experiments, were never consumed by the fry. Many fish species will initially begin consuming small zooplankton such as copepod nauplii or rotifers, and, over time, switch to larger zooplankton groups. However, channel catfish fry consumed the largest zooplankton groups immediately at swim-up.

Many times, several ponds are available for stocking catfish fry on a given day, and the fish farmer must determine which pond is most suitable for fry culture. One method used by some catfish farmers involves collecting zooplankton samples from each pond in clear containers and visually comparing zooplankton abundance. The pond containing the greatest zooplankton abundance is stocked with fry first. However, because channel catfish fry consumed the largest zooplankton groups immediately at swim-up and did not consume rotifers or copepod nauplii, basing pond stocking order solely on total zooplankton abundance may not be the best approach. A large number of zooplankton in groups that are avoided by channel catfish is as undesirable as no zooplankton at all. Therefore, if several ponds are available for stocking, the stocking decision should be based on abundance of large cladocerans and copepods rather than total zooplankton abundance.

Table 1. Overall summary of zooplankton preferences of newly swim-up channel catfish fry in ponds and aquaria. Zooplankton are arranged from most preferred to least preferred; ranks containing the same letters are not significantly different.

Zooplankton Group	Rank	Preference/Avoidance
Large Cladocerans	1[a]	Preferred
Copepods	2[bc]	Neutral
Small Cladocerans	3[c]	Avoided
Copepod Nauplii	4[d]	Not consumed
Rotifers	4[d]	Not consumed

Chemical Treatments for Reducing Snail Populations in Commercial Catfish Ponds

Jimmy Avery

Recently, a new species of trematode has been reported in channel catfish from Louisiana, Mississippi, and Arkansas. The organism has been identified as *Bolbophorus confusus* and is transmitted by the American white pelican. Currently there is no therapeutic treatment for infected fish. Control is dependent on breaking the life cycle of the trematode by preventing pelican use on farms and reducing snail populations. Effective, long-term control of this organism requires a combination of chemical treatments, biological control, and aquatic weed control. For more information on this subject, contact the NWAC and request a copy of “New Trematode in Channel Catfish”, Factsheet #4 (Revised).

Pond-margin Treatments

Pond-margin treatments using hydrated lime (either dry or a slurry) or copper sulfate appear to be effective in reducing snail populations in the treated areas. These chemical treatments will not totally eradicate snail populations from a pond. Due to the limited kill, repeat treatments will probably be necessary.

Hydrated Lime. The application of hydrated lime has minimal impact to ponds with well-buffered waters (total alkalinity > 50 ppm) when used at the rates stated below. The treated area or swath width should be limited to 3 - 4 feet from the pond margin. Hydrated lime can be applied either as a dry material or as a slurry with water.

NWAC experiments indicate that an application of dry hydrated lime at a rate of 50 pounds every 75-100 feet of pond bank will give partial control of snail populations. The material is applied with an auger-equipped hopper mounted on a tractor. The end of the auger can be fitted with a flexible hose to allow an applicator walking behind the tractor to apply the material directly to the target area. The difficulty in applying this type of material is that the dry powder becomes airborne and can be caustic to the applicator.

Hydrated lime can also be applied as a slurry with water. The slurry is prepared at a commercial lime facility and delivered to commercial applicators or individual farmers. The bulk slurry is transferred to a large portable holding tank at the farm and subsequently pumped to smaller tanks for application. Formulation rates are 4.0 - 4.7 pounds of hydrated lime per gallon of water. Given this concentration, it is recommended that 20 gallons of slurry be applied per 100 feet of levee.

Copper Sulfate. Researchers at the Harry K. Dupree Stuttgart National Aquaculture Research Center have developed a treatment based on the margin application of copper sulfate. The formulation rate for this treatment is 10 pounds of copper sulfate + 1 pound of citric acid applied to 250 feet of pond margin. These dry materials should be mixed with a minimum of 70 gallons of water for each 250 feet of pond-margin treated. The finished formulation should be applied to a 6-foot band around the pond perimeter.

Due to concerns about copper toxicity in low alkalinity waters, farmers should not to make treatments in ponds with less than 150 ppm total alkalinity. Farmers should avoid treating ponds smaller than 7 acres regardless of total alkalinity concentration. Using copper sulfate in ponds with heavy blooms can also cause severe oxygen depletions.

Whole-pond Treatment

A molluscicide, Bayluscide 70 WP, has been given a Section 18 Emergency Exemption in Mississippi for control of ram’s horn snail in catfish ponds. Bayluscide 70 WP is applied at a rate of 1.5 pounds per acre-foot of water. The required amount of Bayluscide must be mixed in sufficient water to enable uniform application to the pond.

Unlike hydrated lime and copper sulfate, Bayluscide is a whole-pond treatment. Bayluscide should only be used in those circumstances where loss of catfish is no longer a concern. One example of this situation is when the trematode infection has reduced fish stocks to a level where it is no longer economically feasible to continue production. Another example would be controlling snail populations in a pond prior to stocking fry.

Applications of Bayluscide must be made 5 to 7 days prior to stocking catfish. Do not harvest from a pond until 12 months after application of Bayluscide. Discharge of pond waters to surface waters is prohibited until 7 days after application. Bayluscide 70 WP is for retail sale to and use only by certified applicators or persons under their direct supervision.

Drop-Fill Water Managment Schemes for Catfish Ponds

John A. Hargreaves, Donnie Rutherford, Thomas P. Cathcart[a] and Craig S. Tucker
[a]MSU Dept. of Ag Engineering

Several years ago, researchers at MSU developed a model for a simple pond water management practice that can dramatically reduce the need for pumped water in catfish farming. The approach is based on what has become known as a "drop-fill" scheme. We have expanded on this earlier effort by exploring additional drop-fill water management options.

In drop-fill schemes, water is not added to a pond until the water level falls to a certain level below the top of the standpipe. Then, the pond is not re-filled completely, but water is added to allow the maintenance of some rainfall storage capacity. By capturing as much rainfall as possible, you partially offset future need for pumped water and minimize the loss of rainfall through overflow.

Why Conserve Water?

Water conservation in ponds can have a large impact on the discharge of nutrients and organic matter. This is important because, as many of you are aware, the U.S. Environmental Protection Agency is reviewing Effluent Limitation Guidelines for all aquaculture production systems in the country, including those that apply to the discharge of effluents from catfish ponds.

Water conservation is intimately linked to the volume of pond effluent because every gallon of water that is not discharged from a pond helps offset the future need for pumped water. This link is especially important because reducing effluent volume may be the most effective and technically feasible way to improve the environmental performance of catfish farming.

In drought years, more water than normal must be pumped to maintain pond water levels. In general, increasing the volume of groundwater pumped will result in some small increase in the costs of catfish production. Thus, improving the efficiency of water use can also improve potential profitability by reducing the production costs associated with pumping water.

Pond Water Budgets

Similar to financial budgets that consist of lists of income and expenses, a water budget can be prepared for catfish ponds. Once a pond is filled, any additional "income" of water comes from rainfall and that pumped from wells. Water is "expended" or lost from the pond by evaporation, seepage and overflow from any rainfall event that exceeds the existing storage capacity in the pond. Thus, at any one time, the water level in a pond can be estimated from the rates of water input and loss processes.

All the components of a pond water budget were incorporated into a model to evaluate groundwater use and effluent discharge (from overflow) for various drop-fill schemes from a 17 acre catfish pond. A 28-year record of rainfall from Stoneville was used to estimate water inputs from rainfall.

A wide range of drop-fill schemes was evaluated. Drops ranged from 2 to 18 inches and fills ranged from 2 to 6 inches. For example, a 10-6 drop-fill scheme means that water would not be added to the pond until the water level fell to 10 inches below the top of the standpipe. Then, 6 inches of water would be added. This 4 inches of storage would capture a large proportion of rainfall events, most of which are less than 4 inches.

Rainfall Storage Capacity

In general, the volumes of water pumped and water discharged decreased as the water storage capacity in the pond increased. Water usage with the 2-2 scheme was about 26 inches per year, but was reduced to only about 15 inches per year with the 6-2 scheme, a 42% reduction. Effluent discharge with the 2-2 schemes was about 29 inches per year, but was only about 18 inches per year with the 6-2 schemes, a 38% reduction.

Further reduction in groundwater use or effluent discharged can be achieved by additional increases in pond storage capacity. Average water use over the 28-year period for any of the 18 inch drop schemes was only 6-7 inches per year. Average effluent discharge over the 28-year period for any of the 18 inch drop schemes was only 8-10 inches per year.

Ponds discharge more water than is pumped from the ground because the seasons of maximum water demand and greatest rainfall do not coincide. Most water is pumped during summer, when evaporation rates are high, but most water is discharged during winter, when rainfall tends to be more frequent and

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Annual Fish Diagnostic Laboratory Report for 2000

Lester Khoo

It was another busy year for the Fish Diagnostic Laboratory at Stoneville. We appreciate those of you who have entrusted us with your cases and we will endeavor to enhance our services this year. Let me encourage those of you who have not utilized our services to submit your cases. Your submissions will not only help you but will also help others as it will allow us to build the database on the clinical importance of each disease. That information will help us focus our research and enhance our ability to assist the industry. Let me also reassure you that the confidentiality of each case is maintained. I would like to acknowledge the dedication of the staff of research assistants and veterinary interns who make this work possible. Ms. Cyndi Ware has again diligently reviewed the case submissions for this report.

There were 2,594 case submissions to the Fish Diagnostic Laboratory at Stoneville for the year 2000. This represents an increase of approximately 16% over 1999 (2225 cases). Similar definitions for cases and disease entities were used as in past reports. Each case reported represents fish submitted from one pond for that day. Standard operating procedures for routine diagnostics include gill clips, fin and skin scrapes, necropsy, touch impressions of lesions when indicated, bacterial cultures of brain and posterior kidney, viral cultures utilizing samples collected from the spleen, posterior and anterior kidney, and histopathology. The following are some of the criteria used in the diagnostic process:

- Enteric septicemia of catfish (ESC) – the isolation of *Edwardsiella ictaluri* on blood agar from brain and posterior kidney cultures.
- Columnaris – isolation of *Flavobacterium columnare* on dilute Mueller Hinton agar. External Columnaris is based upon microscopic identification of the typical slender filamentous bacteria on skin, fin or mouth scrapes or gill clips. The latter grouping is included with the positive cases for this report.
- Proliferative gill disease (PGD) or Hamburger gill – microscopic identification of breaks in the gill cartilage of wet mount or on histopathology sections.
- Channel catfish virus disease (CCV) – observation of cytopathic effects in channel catfish ovary cell cultures inoculated with tissue suspensions of spleen, posterior and anterior kidney.
- Channel catfish anemia (CCA) – condition where packed cell volume (PCV) is less than 10% in stocker and food-sized fish.
- Saprolegnia (winter fungus) – microscopic identification of typical fungal hyphae from gill clips or fin/skin scrapes.
- Branchiomyces (gill fungus) – microscopic identification of typical fungal hyphae that are usually deep within the gill tissue.
- Trematode – microscopic identification of metacecariae from subdermal nodules or nodules on fins or internal organs. Only those identified as *Bulbophorus confusus* were taken into account.
- Toxic algae – microscopic identification of the algae as well as biological testing of the water samples (injecting fish with the suspected water or placing fish in the water).

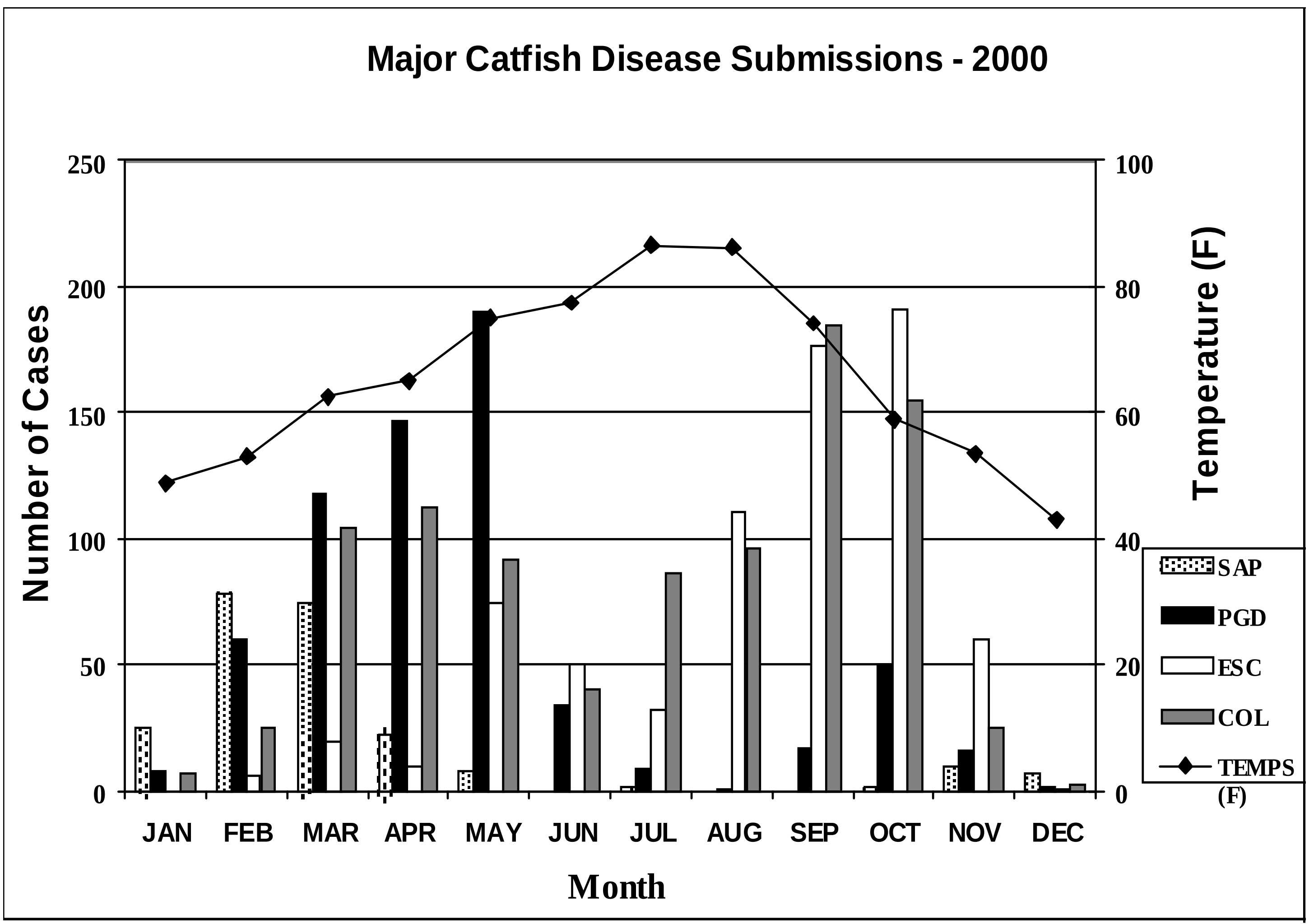
Bacterial diseases are still the most common prevalent diseases. There were more cases of Columnaris (933) than ESC (734) which is a similar trend in the last few years. Despite the rise in bacterial cases, there were very few antibiotic resistant cases (two ESC cases and one *Aeromonas hydrophila* case). Like the previous years, PGD was still the third most common disease diagnosis which had an increase from 602 cases in 1999 to 653 in 2000. Saprolegnia, the fourth most commonly diagnosed disease rose from 175 to 230 this past year. The number of CCV cases returned to the same level as in 1998 after a low in 1999 of 36. There was also a marked increase in anemia cases from 53 to 108. Also increasing dramatically were the numbers of *Ichthyophthirus multifilis* (Ich or white spot) cases from 15 to 59. lthough some of these cases reflect rechecks to see the efficacy of treatments, there was still a pronounced increase. The trematode cases also increased from 34 to 124 in 2000. Part of this may be attributable to the heightened awareness of the problem.

Not adequately captured in the data is **Visceral toxicosis of catfish** (what was formally called **Spring mortality of food fish and brood fish**). This entity was first diagnosed on internal lesions that are usually evident in these fish. However, we are now able to diagnose this problem based on biological testing (injecting the serum of affected fish into test fish). We will be using this biological test as the gold standard for the diagnosis of this entity.

Branchiomyces (gill fungus) cases held steady with 12 cases in both 1999 and 2000. The affected fish are fry that have no external gross lesions but usually present as fish that are gasping for air. These cases usually occur in the early part of the summer. Only 4 cases of losses due to toxic bloom were recorded in 2000. Besides a clinical history (usually a heavy blue-green algal bloom that has crashed recently and fish remain on the surface even when the dissolved oxygen levels are restored), the fish usually have no gross lesions although a few may have hemorrhage in the gills. Confirmation thus far has been limited to identifying the algae as well as injecting and/or placing fish in the affected pond water. However, methods have been developed by USDA/ARS scientists at Stoneville to detect specific algal toxins and these are now being used in conjunction with the above to confirm these algal bloom losses.

Water quality testing also increased from 823 to 888. This represents water samples from 392 farms. The usual water quality parameters of total ammonia, nitrite, chloride, alkalinity, pH, and hardness were determined for these samples.

One additional piece of information requested was the number of clients who use the laboratory in order to see if the increase in case submission was due to new producers utilizing our laboratory. In 2000, there were 159 clients (both producers and researchers) who submitted cases.



Safety of Farm-Raised Fish

Craig Tucker and Sarah Harris
Southern Regional Aquaculture Center

The last few years have been difficult for aquaculture public relations. Interest groups have made many irresponsible statements about aquaculture, ranging from claims of poor environmental stewardship to reports of widespread dioxin contamination in farm-raised salmon. In the first few months of this year, hardly a week passed without negative press coverage about seafood safety or environmental problems attributed to aquaculture. Then, to top things off, Federal and State Agencies issued advisories against eating certain fish because of metal or pesticide contamination.

The first advisory was issued last winter by the United States Environmental Protection Agency and the Food and Drug Administration. The Federal advisory cautioned against eating certain fish because of mercury contamination. Then, in June of this year, the Mississippi Department of Environmental Quality issued an advisory against eating catfish and other species from Mississippi Delta lakes and streams.

Although the Federal and State advisories acknowledged that farm-raised fish are considered safe, that message is easily lost in the media frenzy that surrounds news on health-related issues. Contaminants such as mercury and pesticides are derived from the environment – either directly from the water or from food items. Therefore, the level of contamination in fish depends on how much of the chemical is present in the environment. In that regard, controlled pond environments are clearly different than public waters, many of which receive discharges of industrial effluents of runoff from pesticide-contaminated fields. Logically, then, fish products from aquaculture should pose less risk to consumers than certain products from capture fisheries. Until recently, however, there was little scientific information to confirm or deny that conclusion.

For more information on this and other projects, visit the SRAC website at :

http://www.msstate.edu/dept/srac

In addition to the wide variety of information offered, you can print copies of all SRAC publications, obtain the address of your State Aquaculture Extension Specialist and link to many other useful aquaculture sites.

Beginning in 1992, the Southern Regional Aquaculture Center (SRAC) funded a 3-year study to answer this question: Are aquaculture products produced in the southeast safe to eat. The answer was a resounding "Yes".

Twelve scientists from six states cooperated in this project which was entitled "Aquaculture Food Safety-Residues". They collected samples of channel catfish, rainbow trout, and crawfish from commercial farms throughout the region and carefully analyzed the samples for 34 pesticide residues.

Most of the pesticides were not detected in any of the samples and only one pesticide – DDT – was found in more than 10% of the samples. The finding that DDT and its breakdown products were the most prevalent pesticide residues is not surprising considering the extreme persistence of the chemical in the environment and its widespread use over three decades ending in the 1970's.

In the few samples where pesticide residues were detected, they were far below U.S. Food and Drug Administration "action limits." For example, the average concentration of DDT and its breakdown products in catfish was more than one hundred times lower than the FDA action limit for those compounds. Even the highest level of DDT found in catfish was still only 6% of the FDA action limit.

The same samples were also analyzed for nine "heavy metals" that are indicators of pollution and potential food safety problems. Most of the metals were found in only a small percentage of the samples and all were far below recommended safety limits. For example, the average residue of mercury in channel catfish was more than one hundred times lower than the FDA action limit.

One important finding, which was true across the spectrum of residues that were tested, was that farm-raised fish have lower residue levels than their wild-caught counterparts. The best example is mercury, which accounts for well over half of all fish consumption advisories issued by State and Federal agencies. The average mercury level in various wild-caught fish as reported in various other studies is 30 times greater than that found in channel catfish in the SRAC study. And, as a specific example that should be familiar to most people, the average concentration of mercury in canned tuna is 20 times higher than the average level in pond-raised channel catfish.

The finding that pond-raised channel catfish are amazingly "clean" with respect to potential environmental contaminants should not come as a surprise. Most chemical contaminants are associated with soils, and fish farmers avoid sites with a history of pesticide use. Even if the soil does contain low levels of pesticides, they are present only in the topmost layer of soil, which is removed and used to form levees during pond construction. Also, nearly all catfish ponds in Mississippi use pesticide-free groundwater to fill ponds, making it impossible to contaminate ponds with water-borne pollutants.

The growth and feeding habits of farm-raised catfish also minimize the opportunity for accumulation of pesticide and metal residues, even if there are residues in the soil. Farm-raised catfish feed almost entirely on carefully prepared feeds rather than foraging on natural foods. This minimizes the possibility for "biomagnification" of pesticides through the food chain, as happens in natural settings.

The results of this study point to the need to differentiate the source of fish when discussing food safety issues because the risk of obtaining contaminated fish is much lower for farm-raised fish than for wild fish. If consumers are concerned about levels of pesticide and metal residues in seafood, farm-raised catfish, trout, and crawfish are healthy alternatives.

The results of this study have been published in the following scientific articles:

Santerre, C. R., Ingram, R., Lewis, G. W., Davis, J. T., Lane, L. G., Grodner, R. M., Wei, C. I., Bush, D. H., Shelton, J., Alley, E. G., and Hinshaw, J. M. 2000. Organochlorines, organophosphates, and pyrethroids in channel catfish, rainbow trout and red swamp crayfish from aquaculture facilities. Journal of Food Science, Vol. 65, No. 2, pages 231-235.

Santerre, C. R., Bush, P. B., Xu, D. H., Lewis, G. W., Davis, J. T., Grodner, R. M., Ingram, R., Wei, C. I., and Hinshaw, J. M. 2001. Metal residues in farm-raised channel catfish, rainbow trout and red swamp crayfish from the southern U. S. Journal of Food Science, Vol. 66, No. 2, pages 270-273.

Water Management Schemes

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intense. Maintaining a greater storage capacity (drop) at the end of the growing season may allow capture of the generally more abundant winter rainfall.

Selecting a Drop-Fill Scheme

So, what is the optimum drop-fill scheme? From the standpoint of groundwater conservation, pumping costs and overflow volume, the greater the storage capacity maintained in the pond, the greater the cost savings and the greater the reduction in water volume pumped or discharged. In practice, the drop, which reflects the capacity of the pond to store rainfall, will be constrained within several limits associated with practical considerations. These considerations include maintaining a pond depth that will allow seining (usually 4 feet) and minimizing the exposure of bare-soil levee that is subject to erosion.

Selection of a drop-fill scheme will also be constrained by operation of wells for reasonable durations. What is a "reasonable" duration? Many wells are placed to supply water to four ponds. A well supplying 1000 gpm can add 1 inch of water to a 17-acre pond in about 7.7 hours. Put another way, the same well can add slightly more than 6 inches of water in 2 days. Assuming that the well is sequentially operated for each of the four ponds serviced by the well, then 8 days will be required to add 6 inches of water to all four ponds. Thus, the fill should be limited to 6 inches or less. Ponds with lower capacity wells should limit the fill during a pumping event to 4 inches.

Based on the results of the model, a drop between 8 to 12 inches can reduce groundwater volume pumped and effluent volume discharged by 40 to 60%. Fills between 4 and 6 inches will minimize the time required to run wells, particularly those supplying four ponds.

Factors Affecting Catfish Egg Hatching Success

Brian C. Small, WIlliam R. Wolters, and Terry D. Bates

Many people believe catfish eggs have a high hatching success because direct visual observation of egg masses indicates that most eggs are developing and small fish can be observed in individual eggs close to hatching. However, measurements of hatching success on individual spawns in research and commercial hatcheries have demonstrated a high degree of variability. This spawning season (spring 2001) hatching success of individual egg masses at the USDA/ARS Catfish Genetics Research Unit in Stoneville ranged from 0 - 100% with an average of 56%. Commercial farmers typically report average hatch rates of 60 - 70%. Although variability in hatch rates may be due to both genetic and environmental factors, practical solutions are available to increase hatching success. A number of different environmental factors greatly influence hatching success, and optimizing hatchery management practices will increase realized numbers of fry. Here we discuss a series of experiments to examine the effects of temperature, egg stage at collection, transport delays during egg collection, and prophylactic chemical treatment on hatching success.

Temperature

We conducted two studies to determine the effect of temperature on hatching success. In the first study, catfish eggs were collected from outdoor ponds then subjected to low incubation temperatures ranging from 39 to 79°F. The secondary objective of this study was to determine whether catfish eggs could be stored long-term at refrigeration temperatures, however, all eggs died at temperatures below 61°F. Interestingly, survival of embryos at 61°F depended on the developmental stage of the eggs at the time of acclimation to 61°F. Eggs acclimated prior to 36 hours post-spawn all died while older egg masses survived to hatch 21 days later but were abnormally developed and died shortly after hatching. Fry hatched at 70°F developed normally, but hatching success decreased at temperatures below 79°F (Figure 1).

Higher hatchery and pond water temperatures late in the spawning season have been proposed to cause developmental abnormalities such as tripletail and jaw deformities. In a second study we are evaluating the effects of egg incubation temperatures up to 93°F on hatching success and frequency of deformities. Preliminary data supports a decrease in the time from spawn to hatch as temperature increases (Figure 2), and hatching success is greatly decreased at water temperatures of 93°F (Figure 1). The fish surviving from the high temperature incubation treatments will be cultured and monitored for deformities.

Egg Stage

Preliminary data from last year's spawning season (spring 2000) suggested that the developmental stage of embryos when an egg mass is collected from the pond and moved to the hatchery may correlate to hatching success. That data suggested eggs collected within the first 36 hours after spawning were likely to have a lower percent hatch. This year, 300 spawns were staged at the time of collection and hatching success was determined. Egg masses were collected on Monday, Wednesday, and Friday and ranged in development from newly fertilized to nearly eyed embryos. Developmental stage did not affect hatching success.

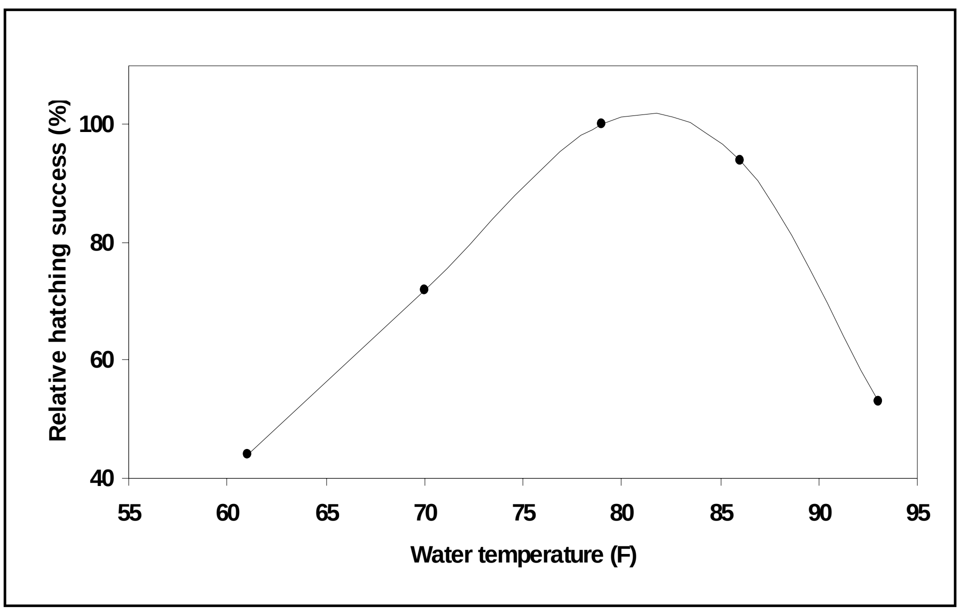

Figure 1. Relative hatching success of catfish egg masses incubated at 61, 70, 79, 86, and 93°F.

Transport Delays

Even though it is generally recommended that eggs not be retained at pond side for more than 30 minutes, eggs often remain in cans or in transport containers for longer periods of time during days when large numbers of spawns are being collected. It is assumed that long transport times and poor water conditions during transport (i.e. high water temperature and low dissolved oxygen (DO)) result in low hatching success. In a recent study, egg masses were left in cans at pond side for up to 1 hour. One-third of the egg mass was removed to the hatchery at 0, 30 and 60 minutes. Air temperature was in the mid-eighties ($^{\circ}$F). On average, water temperature in the spawning container increased 2.5°F and DO dropped 2 ppm over the hour. Under these conditions, we observed a 10 to 30% decrease in hatching success from eggs left at pond side for 1 hour. Holding eggs for longer periods of time (>1 hour) may decrease hatching success more than 10-30%.

Chemotherapeutics

Catfish eggs can become infected with aquatic fungi or bacteria that lower hatching success. Unfertilized or dead eggs and buildup of organic matter in culture systems provide excellent substrates for these pathogens. Currently, hatchery managers are limited to one FDA approved therapeutic (formalin) and a few Low Regulatory Priority compounds to control infections on eggs. We recently compared the effectiveness of once daily (until eyed) hydrogen peroxide treatments to the use of 1.7 ppm formalin or no daily therapeutic treatments. During treatment, flow of well water to the tanks was stopped, and after 15 minutes the flow of water was restored. All egg masses were collected from ponds and transported in well water (79° F) containing 100 ppm iodine (Aquadyne). Hydrogen peroxide concentrations of 500 ppm (mg/L) in a daily 15 minute bath, appeared to dissolve the membrane matrix of the eggs causing premature release of the developing embryos and poor survival. At half that dose (250 ppm) percent hatch was significantly improved compared to both untreated and formalin treated eggs (Figure 3).

Summary

- Hatching success is highest between 79 and 83°F.
- Catfish eggs cannot be cold-stored at refrigeration temperatures.
- Extended delays in transporting eggs to the hatchery result in lowered hatching success.
- Egg stage when collected from the pond and moved to the hatchery does not affect hatching success.
- Use of once daily hydrogen peroxide (250 ppm) baths until eyed to control egg infections improves hatching success. (Note: During treatment, water flow to the tanks was stopped, and then restored after 15 minutes; 250 ppm = 9.3 oz 35% hydrogen peroxide per 100 gallons hatchery water.)

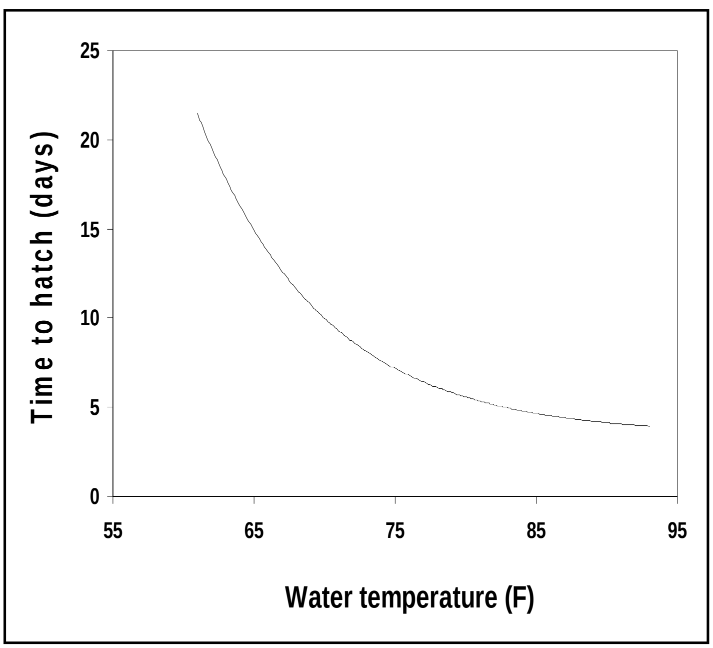

Figure 2. Effect of water temperature on time to hatch channel catfish fry.

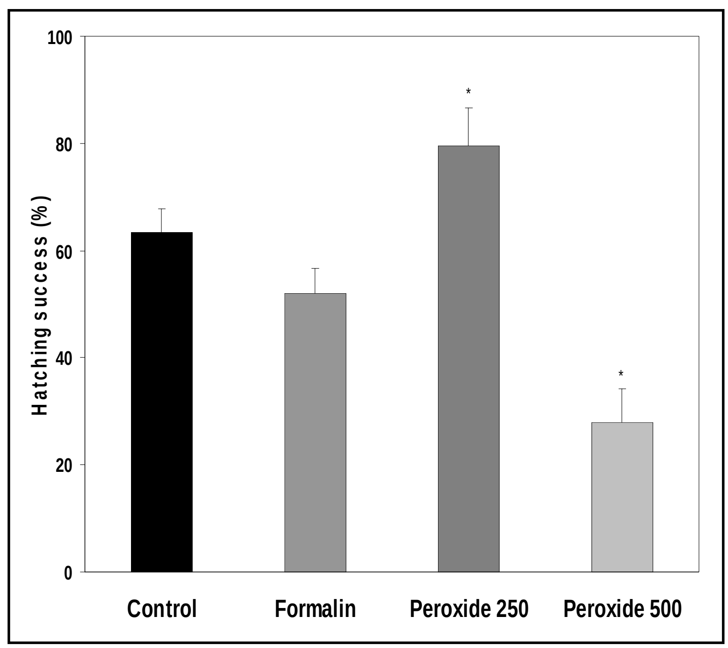

Figure 3. Hatching success of untreated eggs (control) compared to those treated with formalin (1.7 ppm) or hydrogen peroxide (250 or 500 ppm) ($n \geq 3$). Treatments with an asterisk (*) are significantly different from controls (P<0.05).

Protein and Stocking Density

continued from page 1

either a 28% or 32% protein diet daily to apparent satiation for two growing seasons. In this study, there were no differences in net production, feed consumption, weight gain per fish, feed conversion ratio, survival, or any other variable evaluated between fish fed a 28% and 32% protein diet. However, stocking density did affect certain variables (Table 1). Net production increased as stocking density increased, but the fish were smaller at harvest. Also, the feed conversion ratio increased and survival decreased in fish stocked at 18,000 per acre.

In conclusion, the data from this study and observations from other studies indicate that the requirement for a specific amount of nutrient is not influenced dramatically by increasing stocking density. However, if feed is severely restricted it may be that a diet containing a lower concentration of a particular nutrient may not meet the nutrient needs of the fish because they can not consume enough feed to meet the requirement even though their requirement for that nutrient remains the same. Thus, in this case a more nutrient dense diet may be more appropriate. As in this study, we have observed from several other studies that as stocking density increases net production increases but the fish are generally smaller at harvest when stocked at the higher densities. In general, given the market demand for larger fish, lower stocking densities (6,000 or so fish per acre) may be preferable and as long as feeding rates are near 100 lbs feed per acre per day a 28% protein diet is more than sufficient. However, there are many considerations that must be taken into account, and thus individual catfish farmers should stock at a density and feed a diet that is most profitable for them.

Table 1. Production data[1] of pond-raised channel catfish stocked at three densities and fed a 28% or a 32% protein diet for two growing seasons.

Stocking density (fish/ha)	Dietary protein (%)	Net production (lbs/acre)	Feed Consumption (lbs/fish)	Weight gain[2] (lbs/fish)	Feed conversion (feed/gain)	Survival (%)
6,000		12,108 c	3.64 a	2.05 a	1.79 b	98.1 a
12,000		17,712 b	2.77 b	1.50 b	1.85 b	98.2 a
18,000		23,675 a	2.83 b	1.43 b	1.98 a	92.2 b
	28	17,844	3.09	1.65	1.88	96.1
	32	17,819	3.07	1.67	1.86	96.2

[1] Means within a column followed by different letters were found to differ at the 0.05 probability level by a least significant difference procedure.
[2] Mean initial weight was 107 pounds per 1,000 fish

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