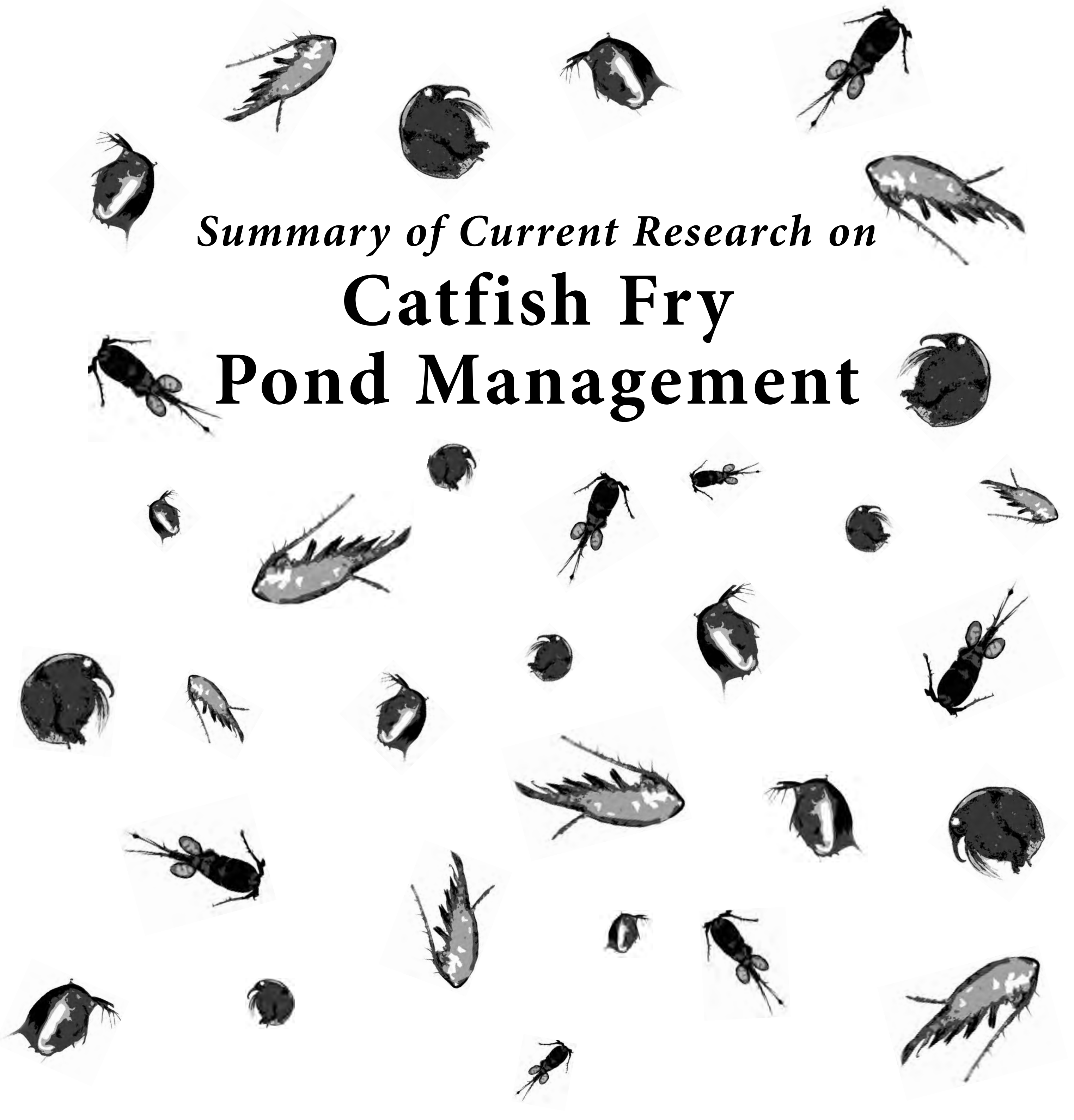
Bulletin 1196 September 2011

Summary of Current Research on
Catfish Fry Pond Management



Mississippi Agricultural & Forestry Experiment Station • George M. Hopper, Director
Mississippi State University • Mark E. Keenum, President • Gregory A. Bohach, Vice President

Summary of Current Research on Catfish Fry Pond Management

Charles C. Mischke
Research Professor
Delta Research and Extension Center
Mississippi State University

This report was approved for publication as MAFES Bulletin 1196 of the Mississippi Agricultural and Forestry Experiment Station. This bulletin was published by the Office of Agricultural Communications, a unit of the Division of Agriculture, Forestry, and Veterinary Medicine at Mississippi State University.

Summary of Current Research on Catfish Fry Pond Management

INTRODUCTION

About 70% of the total production of U.S. farm-raised channel catfish occurs in the Yazoo-Mississippi River floodplain ("the Delta"). In 2009, U.S. catfish growers had total sales of $373 million, with fingerling and fry sales of $13 million. Large numbers of fry are required to supply the industry's stocking needs, but survival of fry after stocking into ponds is not well documented, and reported values estimate the average to be from about 55–80%. Individual pond survival ranges from 0–100%.

Proper pond preparation management techniques can increase industry-wide survival rates and reduce survival variability within individual ponds. This bulletin reviews the latest information on pond preparation, with special emphasis on new information regarding fertilization practices and the importance of zooplankton to channel catfish fry.

INITIAL POND PREPARATION

Ideally, fry ponds should be drained and completely dried before filling and stocking with fry. This practice eliminates any undesirable fish from the pond and reduces the numbers of certain predacious insects. Predator fish generally cause more damage than all other predators combined; fish predators such as green sunfish can completely destroy a fry crop. Therefore, special attention must be given to keeping wild fish out of ponds. Draining ponds and using fish toxicants can remove wild fish already present. Proper construction of inlets and drains can prevent wild fish from entering the ponds.

It may not always be possible to completely drain a fry pond. In these cases, use fish toxicants to treat the entire pond or potholes that remain after draining. Rotenone, chlorine, and Antimycin A are registered fish toxicants.

Rotenone is generally used in the 5% liquid form and is applied at a rate of 0.5 to 2 parts per million (ppm) of product. This rate is equivalent to 1.2 to 4.8 pints per acre-foot of water. Rotenone is more toxic at higher temperatures and should only be used when temperatures are greater than 60°F. Certain fish species, such as bullheads and mosquito fish, are more resistant to rotenone and require the higher doses. One disadvantage of rotenone is that its toxicity may persist for 2 weeks or more — the cooler the temperature, the more persistent the toxicity. Potassium permanganate can be used to neutralize rotenone and ensure water is no longer toxic before stocking fry. To detoxify 1 ppm of rotenone product, apply 2 ppm of potassium permanganate. Rotenone will not control aquatic insect predators.

Chlorine will kill unwanted fish and aquatic insect predators. Calcium hypochlorite is 70% available chlorine and is used at a concentration of 39 pounds per acre-foot of water. Advantages of using chlorine are that it deteriorates rapidly and will kill both unwanted fish and unwanted predacious aquatic insects.

Antimycin A is a poison that has been used to eliminate scaled fish in the presence of catfish. Water chemistry and temperature greatly affect the activity of Antimycin A, so following the label directions is critical. Although this product is registered, the manufacturer has recently stopped making the chemical, and future availability is uncertain.

FERTILIZING THE PONDS

Catfish nursery ponds are fertilized for two reasons: (1) to increase zooplankton concentrations for fry to eat; and (2) to rapidly obtain a phytoplankton (algae) bloom to provide shade and prevent growth of rooted plants on the pond bottom. Addition of fertilizers to nursery ponds is common practice among all cultured species of fish. Fertilization increases dissolved nutrient concentrations in the pond water. The increased nutrients are then incorporated into biomass (algae and zooplankton) and through a complex web of nutrient assimilation and recycling, ultimately incorporated into fish growth. Several factors (climate, water and bottom soil characteristics, and pond morphology) can affect fertilizer application responses. In addition, management practices associated with different species (e.g., feeding and stocking rates) may affect fertilization responses.

Organic Fertilizers

Commonly used fertilizers are considered either organic or inorganic. Inorganic fertilizers are readily available and often used, but organic fertilizers have also been recommended and used for stimulating natural productivity in pond culture for many years. I do not recommend using organic fertilizers for preparing channel catfish fry ponds for the following reasons.

As organic fertilizers decompose, they not only stimulate production of algae, but also production of bacteria, fungi, and invertebrates. This is the premise behind using organic fertilizers. Some of the most commonly used organic fertilizers and their nutrient compositions are provided in Table 1. Some organic fertilizers contain low-quality materials that would otherwise go to waste. Under small-scale, extensive aquaculture conditions, organic fertilization could be an efficient and ecologically sound approach to culture. Under certain conditions, organic fertilizers may benefit various parts of the food web and can be readily available locally, reduce pond pH, and increase certain types of zooplankton. However, specific benefits of organic fertilizers are generally not applicable to catfish culture.

The methods used in intensive pond culture of catfish are unique and differ markedly from other types of aquaculture. Catfish fry are stocked at relatively high densities into newly filled earthen ponds. Prepared diets are offered to the fry immediately after stocking. Zooplankton populations are important in catfish fry culture during the first 3–4 weeks but diminish in importance as fry grow and seek the prepared diets. Therefore, the primary goal is to fertilize catfish fry ponds in a way that produces large stocks of large crustacean zooplankton for the first 3–4 weeks after stocking and establishes a phytoplankton bloom as quickly as possible to shade the pond bottom and prevent the growth of rooted aquatic plants.

Organic fertilizers are more labor-intensive to apply than inorganic fertilizers, primarily because of the low nutrient content of organic products (Table 1). On an equal-nitrogen basis, 290 pounds per acre of cottonseed meal would provide the same amount of nitrogen as only 58 pounds per acre of ammonium nitrate. In addition, organic fertilizers are often in a meal form that is easily blown by the wind. Catfish fry ponds tend to be larger than nursery ponds of many other cultured species, which would exacerbate the labor and application difficulties. Because of the low nutrient content and subsequent large quantities of organic fertilizers required to enhance natural pond productivity, the addition of organic fertilizers causes an additional oxygen demand in the pond. Significant reductions in dissolved oxygen have been commonly reported in ponds receiving organic fertilizers.

One assumed advantage of organic fertilizers is that they have a shorter production cycle than inorganic fertilizers. This means that zooplankton may feed directly on the organic matter, thus shortening the food chain. Research at the National Warmwater Aquaculture Center

Table 1. Commonly used organic fertilizers and approximate nutrient content (%).

Fertilizer	N	P_2O_5
Cottonseed meal	6.6	2.5
Soybean meal	7.0	1.2
Rice bran	2.0	1.5
Alfalfa meal	2.9	0.4

Source: Tisdale and Nelson (1975), Qin et al. (1995a), and Ludwig (2002).

showed no effects of organic fertilizer (cottonseed meal — 75-pound-per-acre initial application) on water quality, phytoplankton, or zooplankton in channel catfish nursery ponds. Channel catfish fry and small fingerlings are fed frequently after stocking — up to two or three times daily for the first 2 weeks. Finely ground, high-protein feeds (45–50% protein) have been used in daily amounts up to 50% of the fry standing crop weight. Prepared diets have a relatively low (6-to-1) carbon-to-nitrogen (C:N) ratio compared with common organic fertilizers (e.g., distillers dried solubles [10-to-1] and rice bran [20-to-1]). Because of the lower C:N ratio in prepared diets, more rapid decomposition occurs, thus providing increased levels of bacteria available for crustacean zooplankton consumption. Offering high-protein feeds to ponds as soon as fry are stocked is a common method in channel catfish culture. The feed acts as an organic fertilizer, probably negating additional benefits from organic fertilizers such as cottonseed meal or rice bran.

Another theoretical benefit of organic fertilizers is that they decompose to liberate free carbon dioxide. Free CO_2 may be used directly during photosynthesis, or it may combine to form bicarbonates and carbonates, both storehouses for carbon. Carbon is the basic building block of all organic matter, but carbon availability is seldom the first environmental factor limiting plant growth in ponds. Phytoplankton has the ability to use bicarbonate directly as a source of carbon; therefore, carbon limitation of phytoplankton growth is less likely to occur in pond waters of high total alkalinity. Total alkalinity is the sum of titratable bases in water, and in most waters is predominantly from bicarbonate (HCO_3-) and carbonate (CO^{2}_{3}-). The benefit of organic fertilization as a carbon source may be realized in some regions with low-alkaline waters, but most catfish fry culture occurs in the Yazoo-Mississippi River floodplain. This region has total alkalinity that ranges from 150 to 500 mg/L as $CaCO_3$, so additions of organic fertilizers for use as a carbon source would be unnecessary. In addition, liming alkaline-deficient ponds provides adequate carbon in the form of bicarbonate to support abundant phytoplankton growth, negating the need to add decaying organic matter that increases oxygen demand.

Under certain conditions, organic fertilizers may be beneficial in providing forage for zooplankton and releasing carbon dioxide. However, these benefits are more applicable to other species and culture conditions. Channel catfish fry culture in the Yazoo-Mississippi floodplain is different in many ways: pond size, pond sediments, geographic location, source water chemistry, culture methods used, specific goals for catfish fry pond fertilization, and the natural food preferences of channel catfish fry.

Labor-intensive application, low nutrient content, and the high risk of low dissolved oxygen are disadvantages of organic fertilizer use in catfish culture. Although some researchers have reported increased zooplankton densities when using organic fertilizers, my data show that using high-nitrogen inorganic fertilizers increases preferred zooplankton of channel catfish fry more than using organic products. Any benefits seen from liberating free carbon dioxide from organic fertilizers under some culture conditions would be diminished in catfish nursery ponds because of the high alkalinity present in catfish culture waters.

Inorganic Fertilizers

Although channel catfish have been farmed in the United States for more than 50 years, research on fertilization practices specific to channel catfish nursery ponds in the Delta had not been conducted until recently. Recommendations for fertilization of channel catfish nursery ponds were the result of research conducted in Alabama during the 1930s and 1940s for bass-bream farm ponds. A recent recommendation for catfish fry ponds was to fertilize with high-phosphorus (10-34-0 or 13-38-0) inorganic fertilizer at 0.5 to 1 pound per acre every 2 days until a bloom develops. Also, some sources recommended organic fertilizer (rice bran, cottonseed meal, or alfalfa pellets) applications up to 250 pounds per acre followed by weekly applications of half the initial rate.

To determine if recommended fertilization practices are appropriate for the Delta, I evaluated phytoplankton and zooplankton responses to fertilization (addition of both organic and inorganic fertilizers) in channel catfish nursery ponds before fish stocking. I also evaluated responses to organic, inorganic, and a combination of both fertilizer types in newly constructed versus established catfish nursery ponds.

I determined that the previous recommendations for catfish fry pond fertilization were not appropriate for the Delta. In fact, there were no differences in water quality, phytoplankton blooms, or desirable zooplankton populations between ponds fertilized with those recommendations and ponds that were not fertilized at all.

Table 2. Commonly used inorganic fertilizers and approximate nutrient content (%).

Fertilizer	N	P_2O_5
Ammonium nitrate	34	0
Urea	45	0
Calcium nitrate	15	0
Superphosphate	0	18–20
Triple superphosphate	0	44–54

Source: Boyd (1990).

There is a widespread assumption that most freshwaters are phosphorus limited; therefore, fishpond fertilizer recommendations have assumed that phosphorus is the key ingredient in fertilizer and have recommended using a fertilizer with three times as much P_2O_5 as N. However, Delta soils historically have medium to high soil test levels of phosphorus. Through a series of laboratory studies, I determined that fishponds in the Delta were nitrogen limited and not phosphorous limited. Commonly available inorganic fertilizers and their nutrient contents are provided in Table 2.

When high-nitrogen fertilizers are applied to catfish nursery ponds rather than high-phosphorus fertilizers, benefits are realized. The phytoplankton population is shifted to desirable algal groups, and the zooplankton population is shifted to desirable large crustacean zooplankton. Therefore, nitrogen fertilization provides a quick algal bloom and adequate forage for fish fry without the use of organic fertilizers.

I suggest using only established ponds for fry culture, filling them 7–10 days before stocking, applying inorganic fertilizer at an initial rate of about 18 pounds of N per acre, and subsequently applying 9 pounds of N per acre each week for 3–4 weeks. If newly constructed ponds are used, higher fertilizer rates are probably necessary to achieve the same response. Also, continuing fertilization at lower rates until the fish begin eating commercial feeds may be helpful in sustaining zooplankton populations.

Nitrogen Sources

Primary nitrogen sources in pond fertilizers can be from urea, ammonium salts, nitrite, or nitrate. Various sources of nitrogen fertilizer in nursery ponds may affect water quality and plankton differently. I evaluated water quality variables and plankton population responses when using different nitrogen sources for nursery pond fertilization. The nitrogen treatments included calcium nitrate (12% N), sodium nitrite (20% N), ammonium chloride (26% N), ammonium nitrate (34% N), and urea (45% N). Each fertilizer type was added on an equal nitrogen basis to small enclosures within a pond.

Dissolved pH, soluble reactive phosphorus, and ammonia nitrogen were not affected by nitrogen source. Sodium-nitrate-fertilized ponds had higher concentrations of both nitrate and nitrite relative to the other treatments during the first week of sampling, but they returned to similar levels for the remainder of the study.

Green algae, diatoms, and cyanobacteria were present in all enclosures; however, there were no significant differences in phytoplankton among the various nitrogen treatments used. Individual zooplankton groups were not significantly different among treatments, but desirable zooplankton for catfish fry culture (i.e., the sum of adult copepods, cladocerans, and ostracods) did show a significant interaction between date and treatment. Enclosures treated with calcium nitrate tended to show a more rapid increase in the desirable zooplankton concentrations at the beginning of sampling, and urea-fertilized enclosures showed an increase in desirable zooplankton concentrations at the end of sampling.

Choice of nitrogen type for use as pond fertilizer depends on local availability, cost per unit of nitrogen, and the fertilizer's effectiveness at minimizing deleterious effects on water quality (e.g., changes in ammonia and nitrite concentrations) and increasing desirable phytoplankton and zooplankton concentrations in the pond.

At the nitrogen fertilization rate and the time frame used in this study, it appeared that different nitrogen sources — if applied at an equal-nitrogen basis — influenced the phytoplankton population similarly. However, urea-fertilized microcosms did have increased desirable zooplankton concentrations at the end of the study. Generally, catfish nursery ponds are filled and fertilized for about 3 weeks before fry are stocked. Therefore, urea may have an advantage over the other nitrogen fertilizers, providing higher desirable zooplankton concentrations at the time of stocking.

Although water quality was similar by the end of the study, using nitrite fertilizer did cause nitrite levels to increase slightly during the first week. Therefore, nitrite fertilizers may be less desirable for use in nursery ponds relative to the other nitrogen sources.

Any form of nitrogen used for pond fertilization should perform similarly without causing substantial water quality deterioration. Ammonium nitrate and urea contain a higher percentage of nitrogen than other nitrogen fertilizers, so a smaller amount of fertilizer would be required. Urea and ammonium nitrate are generally similar in cost per unit of nitrogen. However, ammonium nitrate can be more difficult to obtain and may require extensive record keeping because of its potential use in explosives. Urea is usually readily available and may increase the desirable zooplankton concentrations for catfish culture. If both urea and ammonium nitrate are available, I recommend using the one with the least cost per unit of nitrogen. In 2009, urea could be purchased from a local dealer (Greenville, Mississippi) for $17.50 per 50-pound bag (78 cents per pound of N), and ammonia nitrate could be purchased for $14.75 per 50-pound bag (87 cents per pound of N). If both types of fertilizer have an equal cost per pound of nitrogen, I recommend using urea because of the potential advantage of increasing desirable zooplankton concentrations.

ZOOPLANKTON

Although zooplankton are not considered to be critical for catfish production, these natural food organisms probably do play a role in catfish growth and survival. Many of the nutrients acquired by fry in ponds are probably derived from consumption of zooplankton. Commercial feed may serve primarily as a fertilizer to stimulate production of natural food organisms.

Zooplankton Preferences

While we assume that zooplankton are important for fry, we do not know which zooplankton the fry prefer to eat. Current recommendations are to stock the ponds with the greatest total zooplankton density first. I conducted studies to determine the zooplankton feeding preferences of channel catfish fry.

I conducted pond and laboratory experiments to determine the zooplankton selectivity by channel catfish fry. Although the taxonomic compositions of zooplankton communities in the experiments were different, fish in all three trials showed the same zooplankton preferences (Table 3). Channel catfish fry preferred large cladocerans (e.g., *Daphnia*, *Moina*, *Sida*) to all other groups of zooplankton (Fig. 1). Large cladocerans were rare in the 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 (Fig. 2). The fry consumed small cladocerans (e.g., *Bosmina*, *Alona*, *Chydorus*) but avoided them if larger prey were present (Fig. 3). Although rotifers and copepod nauplii were abundant in all experiments, fry never consumed them (Fig. 4).

Many species of fish fry 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.

Often, 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 abundance of zooplankton is stocked with fry first. However, because channel catfish fry consumed the largest zooplankton groups immediately at the swim-up stage and did not consume rotifers or copepod nauplii, basing pond

Table 3. Overall summary of zooplankton preferences of newly swim-up channel catfish fry in ponds and aquaria.[1]

Zooplankton group	Rank	Preference
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

[1] Zooplankton are arranged from most preferred to least preferred; ranks containing the same letters are not significantly different.

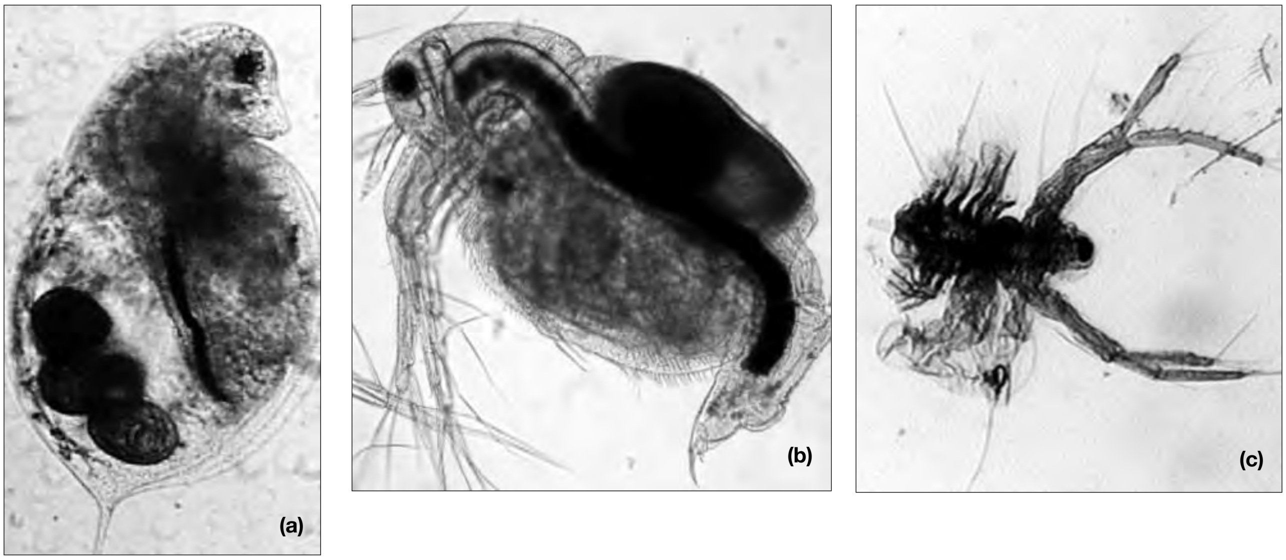


Figure 1. Large cladocerans such as (a) Daphnia, (b) Moina, and (c) Sida are the preferred zooplankton of catfish fry.

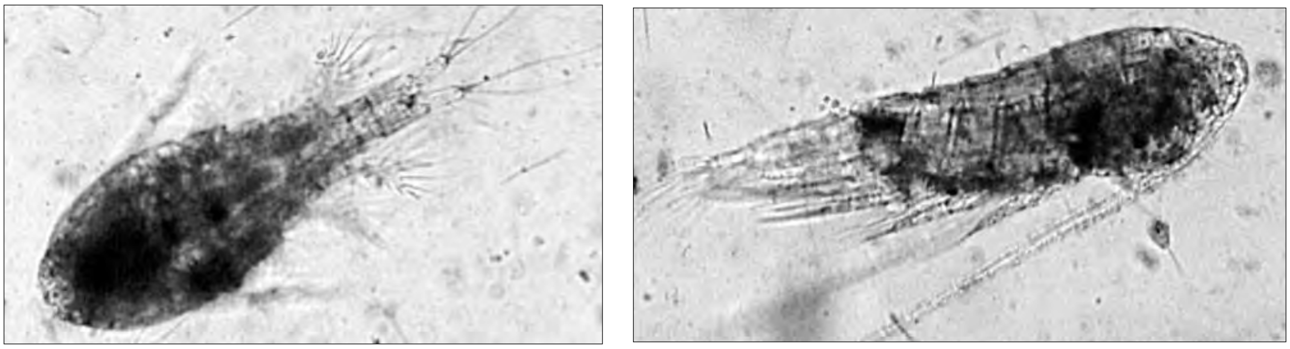


Figure 2. Catfish fry consume copepods in the same proportion in which the zooplankton occur in the ponds.

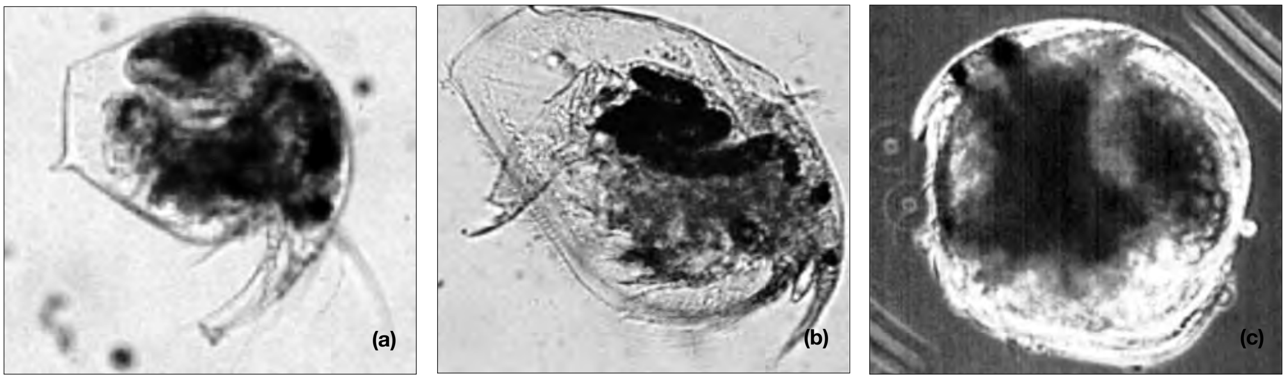


Figure 3. Catfish fry consume small cladocerans such as (a) Bosmina, (b) Alona, and (c) Chydorus, but they avoid these zooplankton if larger prey are present.

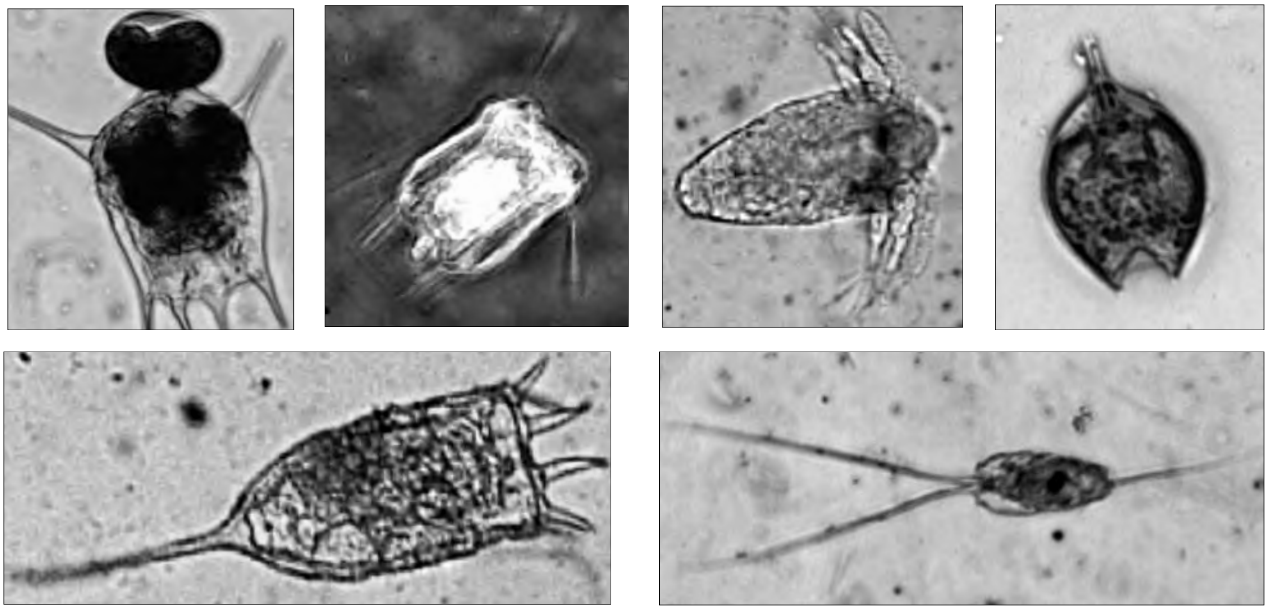


Figure 4. Catfish fry avoid small zooplankton such as rotifers and copepod nauplii, even though these zooplankton are typically abundant in nursery ponds.

stocking order solely on total zooplankton abundance may not be the best approach. A large number of zooplankton taxa 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 the abundance of large cladocerans and copepods rather than total zooplankton abundance.

Zooplankton Nutritional Value

Although some studies have determined nutritional value of specific zooplankton — typically cultured zooplankton — I determined the nutritional value of wild zooplankton that are consumed by channel catfish fry and small fingerlings. Zooplankton captured in this study included copepods, cladocerans, and ostracods.

Catfish fry raised from swim-up to about 1 week of age require 58% protein for maximum growth. The minimum protein requirement appears to decline with fish growth and size to about 55% at 0.2 gram and to 46–50% from 3–5 grams. Zooplankton captured from nursery ponds contained 65% crude protein on a dry matter basis (Table 4), which was more than the protein requirement determined for channel catfish fry. Zooplankton contained about 9% fat, which is slightly lower than the fat content in typical catfish starter diets and higher than that in typical fingerling feeds.

Mineral analyses from the zooplankton samples are presented in Table 4. All analyzed minerals except cobalt (the requirement for cobalt by channel catfish

Table 4. Proximate nutrient and mineral composition (dry matter) of zooplankton from fertilized catfish nursery ponds.

Nutrient or Mineral	Composition	Requirement
Proximate nutrients (%)		
Crude Fat	9.09 ± 0.96	ND
Crude Protein	65.24 ± 6.32	ND
Minerals		
Calcium (%)	3.33	None[1]
Phosphorus (%)	1.01	0.3-0.4
Cobalt (ppm)	<1.5	ND
Copper (ppm)	42.4	4.8
Iron (ppm)	1,000	20
Manganese (ppm)	135	2.4
Selenium (ppm)	0.80	0.25
Zinc (ppm)	100	20

[1] Not required if the rearing water contains sufficient calcium.

Table 5. Amino acid composition (% of protein) of zooplankton from fertilized catfish nursery ponds.

Amino acid	Composition	Requirement
Indispensible		
Arginine	5.92 ± 0.12	4.3
Histidine	2.21 ± 0.05	1.5
Isoleucine	3.91 ± 0.13	2.6
Leucine	6.74 ± 0.29	3.5
Lysine	6.51 ± 0.30	5.1
Methionine + Cystine	3.31 ± 0.15	2.3
Phenylalanine + Tyrosine	10.10 ± 0.81	5.0
Threonine	4.21 ± 0.17	2.0
Tryptophan	1.26 ± 0.16	0.5
Valine	5.37 ± 0.28	3.0
Dispensable		
Alanine	7.12 ± 0.41	N/A
Aspartic Acid	8.75 ± 0.29	N/A
Glutamic Acid	12.74 ± 0.46	N/A
Glycine	4.92 ± 0.26	N/A
Proline	4.71 ± 0.47	N/A
Serine	3.69 ± 0.15	N/A

has not been determined) were in excess of the requirements determined for catfish fingerlings.

All indispensable amino acids are in excess of the requirement determined for fingerling catfish (Table 5). The table represents total amino acid composition and not available amino acids; digestibility of these zooplankters is not known. However, protein digestibility of rotifers is reported to be high — 89–94%. Assuming digestibility of these zooplankton is 80% or greater, all amino acid requirements for channel catfish fingerlings are met.

Dominant fatty acids were 16:0, 18:1, and 20:5n-3 (Table 6). The essential fatty acid content of living foods is the principal factor in their dietary value. Channel catfish do not appear to be as sensitive to fatty acid deficiency as some other species, but they require n-3 highly unsaturated fatty acids (HUFA) for optimum growth. It appears that 1–2% dietary linolenic acid (18:3 n-3) or 0.75% n-3 HUFA will satisfy the n-3 fatty acid requirement of fingerling catfish. The n-3 HUFA from zooplankton in this study averaged 18% of total fat or 1.6% of dry matter, which exceeds the requirement. The large size fraction of zooplankton captured from catfish nursery ponds compares favorably to other n-3 HUFA sources.

Analysis of vitamin samples is presented in Table 7. The zooplankton captured in this study were excellent sources of niacin and vitamin E with concentrations several times higher than the requirements determined for fingerlings. Other vitamins were either at or slightly above the requirement levels.

The large zooplankton present in channel catfish nursery ponds are excellent nutritional sources for fry. Zooplankton composition from fertilized ponds meet or exceed all nutritional requirements for channel catfish.

Because of the high nutritional value of zooplankton in channel catfish nursery ponds, the standard practice of feeding fry prepared diets as soon as they are stocked may not be necessary. If fertilization practices maintain large numbers of zooplankton, the natural biota should meet all fry nutritional requirements. Additionally, it may be beneficial to offer zooplankton to fry while still in the hatchery. These large zooplankton are high in protein, contain essential amino and fatty acids, and are excellent sources of vitamins and minerals.

Diet Supplementation with Zooplankton

Although prepared diets are considered nutritionally complete for hatchery fish, prepared diet supplementation has been shown to increase fry growth. In one study, fry fed diets supplemented with

Table 6. Fatty acid composition (% of total fat) of zooplankton from fertilized nursery ponds.

Fatty acids	Composition
C14:0	2.01 ± 1.58
C16:0	17.22 ± 1.14
C16:1	0.89 ± 0.94
C18:0	6.70 ± 0.42
C18:1	12.94 ± 4.67
C18:2 n-6	5.86 ± 1.46
C18:3 n-6	0.53 ± 0.35
C18:3 n-3	11.05 ± 5.56
C18:4 n-3	1.08 ± 0.48
C20:0	0.46 ± 0.14
C20:1	0.40 ± 0.14
C20:2 n-6	0.58 ± 0.05
C20:3 n-6	0.49 ± 0.28
C20:4 n-6	3.95 ± 0.59b
C20:4 n-3	0.64 ± 0.24
C20:5 n-3	9.69 ± 1.67
C22:5 n-6	2.27 ± 1.58
C22:5 n-3	0.95 ± 0.56
C22:6 n-3	6.29 ± 4.39
n-3 HUFA	17.56 ± 5.17
n-6 HUFA	6.22 ± 2.03

Table 7. Vitamin composition (dry matter) of zooplankton from fertilized catfish nursery ponds.

Vitamin (ppm)	Composition	Requirement
Folic Acid	2.24	1.5
Niacin	107.52	7.4-14
Pantothenic Acid	13.62	10-15
Vitamin B6	6.26	3
Ascorbic Acid	18.33	11-60
Vitamin E	109.40	25-50 IU
Thiamin	2.05	1
Riboflavin	16.66	6-9

decapsulated brine shrimp (*Artemia* sp.) cysts were shown to gain 61–98% more weight than fry fed only a catfish starter diet. Krill meal is also used as a dietary supplement in some hatcheries. While brine shrimp is commercially available, the increased demand and variable yearly harvest due to changes in environmental conditions have dramatically increased the cost of brine shrimp cysts.

Natural foods are not available in hatcheries, but channel catfish fry will readily consume zooplankton and selectively forage on the larger organisms such as copepods, cladocerans, and ostracods when given the opportunity. Fry older than 2 weeks consume cladocerans and ostracods, as well as chironomid larvae, and 5-week-old fry continue to consume natural foods. In addition, the zooplankton selected by catfish fry meet or exceed all nutritional requirements of the fry, providing an excellent source of protein, fatty acids, and vitamins.

Because of previous improvements in fry growth through diet supplementation and the excellent nutritional value of zooplankton, it may be assumed that zooplankton would contribute to fry growth. However, positive impacts of including zooplankton in catfish fry hatchery diets had not been previously demonstrated. I evaluated the effects of feeding zooplankton on the growth of catfish fry.

Results from the first study showed the combination of zooplankton (either live or dry) with the commercial diet resulted in larger fry than just commercial feed alone (Figure 5). However, fry that received only zooplankton weighed significantly less ($P<0.05$) than fry fed other diet treatments. Because zooplankton alone did not produce desirable results, the zooplankton-only treatments were not used in the second study.

As in the first study, supplementing the diet with zooplankton increased fry growth (Figure 6). After 14 days of feeding, fry that had been fed dry zooplankton (292 mg) or live zooplankton (312 mg) with the commercial diet were significantly (P<0.05) heavier and weighed 40% and 50% more, respectively, than fry fed the commercial diet alone (209 mg).

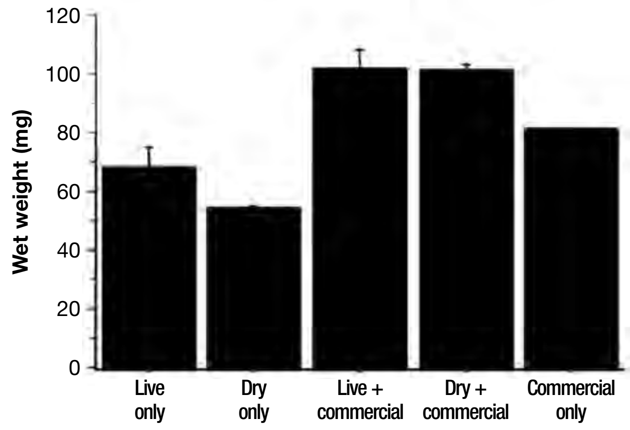


Figure 5. Final mean weight (mg) of channel catfish fry fed live zooplankton only, dry zooplankton only, live + commercial diet, dry + commercial diet, and the commercial diet only for 6 days.

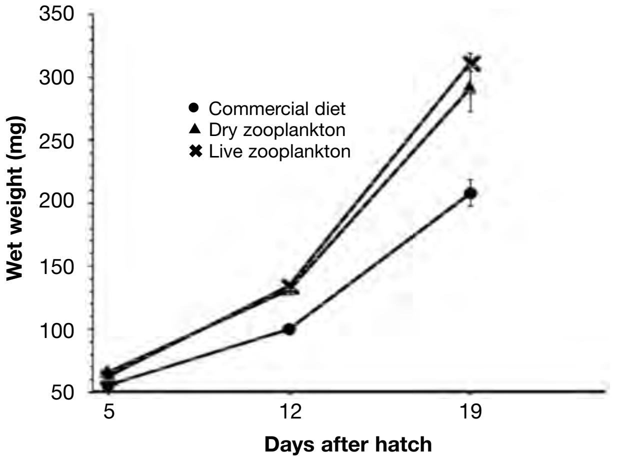


Figure 6. Mean weight (mg) of channel catfish fry fed the commercial diet, the commercial diet supplemented with dried zooplankton, and the commercial diet supplemented with live zooplankton for 14 days. Means with different letters at a given sampling time are significantly different (P<0.05).

Zooplankton-only diets were clearly inadequate for catfish fry, resulting in reduced growth compared with all other diets. Zooplankton from channel catfish nursery ponds contain 65% crude protein and 9% fat on a dry matter basis. Swim-up catfish fry require 58% protein for maximum growth up to about 1 week of age. The dietary energy-protein ratio of zooplankton may be too low for optimal growth of catfish fry when zooplankton are the only food source. Estimated digestible energy [kcal/g = 4 x (protein + nonfiber CHO) + 9 x (fat)] to protein ratio of zooplankton is 5.14, compared with 6.89 for the commercial diet.

Another possible reason for reduced growth in zooplankton-only diets is the difference in bulkiness between zooplankton and commercial feed. Zooplankton are about three times more bulky compared with the commercial diet (60.4 g/100 mL vs. 18.2 g/100 mL, respectively).

It is not clear why supplementation with zooplankton led to increased fry growth. Commercial diets are considered to be complete, but many species commonly experience poor growth when fed prepared diets during the early stages of fry development. Poor growth under commercial diets may be due to lack of ingestion, digestion, or assimilation of these feeds. Lack of growth in larvae striped bass fed prepared diets was attributed to a deficiency of growth factors supplied in live foods. Ingestion of prepared diets is not a problem with catfish fry, so zooplankton in the diet must in some way aid in digestion or assimilation of the feed.

Fry are typically held in the hatchery 7–14 days after hatching to increase size and vigor before pond stocking. Commercial hatchery diets are considered to be nutritionally complete and to promote optimal survival; however, they may not support optimal growth. My data supports other findings that supplementation of commercial diets with natural feeds can improve catfish fry growth. Also, fry tend to show increased growth when proper zooplankton are abundant in ponds. When stocked into small pools at 2 or 7 days after hatching, fry were larger than when stocked at 14 days after hatching with no differences in survival rate. This increase in growth has been attributed to fry consuming zooplankton in the ponds.

Zooplankton may serve as a sustainable and reliable supplement during hatchery production. These data reaffirm the importance of zooplankton as a feed source in channel catfish fry growth. Historically, little attention has been placed on pond preparation in terms of selecting for optimal numbers and taxa of zooplankton. Based on this study, managing fry ponds for increased zooplankton densities may increase fry growth during the nursery phase of culture. Also, it may be beneficial to supplement commercial diets with zooplankton while fry are being held in the hatchery.

INSECT CONTROL

Although catfish fry are large relative to many other species of fish fry, predation by aquatic insects can still be a serious problem until the fry become large enough to outswim the predacious insects or to turn the tables and become predators of the insects.

One group of predacious insects possesses gills and does not need to surface in order to breathe. This group of insects includes an immature stage of dragonflies (order Odonata) (Figure 7). Fortunately, gill-breathing insects take a fair amount of time to become colonized in newly filled ponds. Therefore, problems with predation by gill-breathing insects can be reduced by draining ponds completely and then filling them shortly before stocking fry.

The other group of predacious insects must breathe air, thus comes to the surface of the water to breathe. This group of insects includes the back swimmers (order Hemiptera) (Figure 8). Air-breathing insects tend to be more problematic because they can migrate rapidly from pond to pond and quickly colonize newly filled ponds. Certain chemical pesticides will kill aquatic insects, but none have been approved for use in fishponds containing fish reared for food. Because air-breathing insects must surface to breathe, providing a film barrier between the water and the air will suffocate them. Application of various oils to the pond surface will achieve an effective barrier. A common practice is to mix 3–5 gallons of diesel fuel and 1 quart of motor oil per acre. This mixture is applied to the pond on a calm day 2 days before stocking fry.

Figure 7. Gill-breathing insects, such as the immature stage of the dragonfly, can cause problems in catfish nursery ponds.

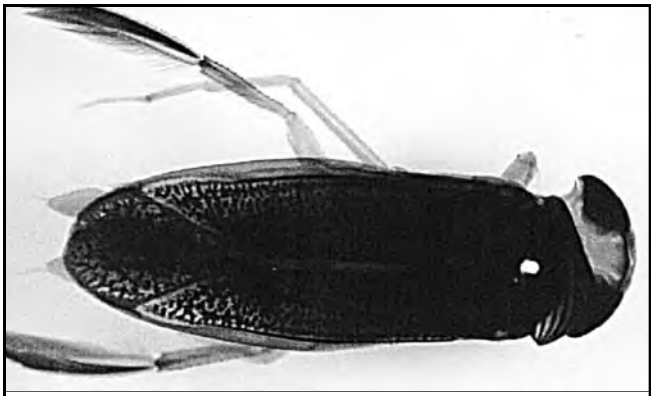


Figure 8. Air-breathing insects from the order Hemiptera can migrate rapidly and kill large numbers of catfish fry.

pH CONSIDERATIONS WHEN STOCKING

Unaccounted mortalities during the early stages of pond culture seriously compromise production efficiency. The extent of these early mortalities is not known until harvest, and if mortalities are high, the result is wasted pond space over an entire growing season.

Although I have been improving pond fertilization practices to enhance natural food productivity in nursery ponds, fry survival remains variable. Because fry survival cannot be completely attributable to fertilization practices, zooplankton abundance, and predation, there may be issues with handling and stocking methods currently used.

Most Mississippi farmers routinely check temperatures when stocking fry and follow the recommendation to temper fish at less than 1°F per minute if water temperatures between the hatchery and pond differ by more than 5°F. However, the effects of abrupt pH changes on fry were not previously known.

The pH range of 6.5–9.0 is commonly cited as the optimum for growth and health of most freshwater aquatic animals. Most waters used for aquaculture have pH values within this range, so direct toxic effects from extremes of pH are seldom encountered. It is assumed that pH problems *per se* are uncommon in channel catfish ponds in the Mississippi Delta because the pH usually does not exceed 9.0, and the most important practical aspect of pH in catfish farming is its effect on the ionization of ammonia.

During stocking, however, fish are transferred relatively quickly from one water to another. Hatchery water pH may be 7.5, and pond water may be 9.0. Even though both pH values are within the optimal range for catfish culture, it was not known if fry could handle an immediate change of 1.5 pH units. Such abrupt changes may cause death. I conducted studies to determine the tolerance of catfish to the abrupt increases in pH that may occur when stocking ponds.

In the first study, catfish fry (8 days after hatch) showed a high tolerance for decreasing pH values but a relatively low tolerance for increasing pH values (Fig. 9). With a beginning pH of 8.2, fry tolerated an abrupt decrease of 4 pH units before mortalities were observed. However, a relatively small increase of less than 1 pH unit caused significant mortalities. This finding shows that increasing pH should be more of a concern than decreasing pH, at least for the short term. Unfortunately, pond waters can be higher in pH than hatchery waters because of photosynthetic activity. Increased ammonia levels exacerbate this problem. I attribute the mortality in this study directly to pH, but with significant ammonia levels in ponds, ammonia toxicity would lower the tolerable pH shift for the fry.

Because it appeared that increasing pH levels were of most concern, I conducted additional studies to concentrate on the effects of increasing pH on survival of different stages of both catfish and hybrid catfish.

Table 8. Toxicity (24-hour) of abrupt pH increases to channel catfish and catfish hybrid yolk sac fry, swim-up fry, and fingerlings.[1]

Fish	LC$_{50}$ (95% CI)
Catfish yolk sac	0.36 (0.248-0.469)^{a}
Catfish swim-up	1.28 (1.177-1.362)^{b}
Catfish fingerlings	1.33 (1.232-1.413)^{b}
Hybrid yolk sac	0.48 (0.421-0.542)^{c}
Hybrid swim-up	0.83 (0.690-0.920)^{d}
Hybrid fingerlings	1.54 (1.466-1.608)^{e}

[1] Numbers represent the estimated pH unit increase from 9.0 (ambient pH) that will kill 50% of the fish and 95% confidence interval (CI). Different letters within a lethal concentration column denote significant differences among the age and species of fish tested.

Results showed that yolk sac fry, swim-up fry, and fingerlings of both channel catfish and catfish hybrids are sensitive to abrupt pH increases. With both species, fish became more tolerant with age (Table 8). Hybrid yolk sac fry were more tolerant than channel catfish yolk sac fry as evidenced by their higher LC50 values. Channel catfish swim-up fry were more tolerant of pH increases than the hybrids, but hybrid fingerlings were more tolerant than catfish fingerlings.

It was expected that yolk sac fry might be more tolerant of pH increases than swim-up fry because of the physiological differences in the two life stages. In other toxicity studies, yolk sac fry were shown to be 1.3–8.6 times more tolerant of copper than swim-up fry. This finding was attributed to a weakened system of the swim-up fry after yolk sac absorption. Also, increased metabolic rate, increased vascularization of the gill surface, and increased intestinal absorption in the swim-up fry were cited as contributing to the differences in toxicity. With pH, however, tolerance increased with age. High pH inhibits sodium uptake and ammonia excretion in fish. At high pH, there is a reduced availability of H^+ ions to trap NH_3 as NH_4^+, causing a disruption of the partial pressure gradient across the gills. The inhibition of ammonia excretion leads to an increase in plasma ammonia, which may be the cause of mortalities. Catfish fry apparently become better equipped physiologically to deal with the partial pressure gradient disruption as they mature from sac fry to swim-up fry to fingerlings.

Differences in temperature, starting pH, and ammonia-nitrogen concentrations, as well as the relative health of the fry all affect the tolerance to pH increases. In this study, the total ammonia-nitrogen concentration was relatively high (1 mg/L), and the initial hatchery pH was high (9.0).

Regardless of other water quality variables, it is clear that abrupt increases in pH will cause mortalities in sac fry, swim-up fry, and fingerlings of both catfish and hybrids. Differences in pH between the hatchery and pond — or between ponds when moving fingerlings from pond to pond — should play a major role in management decisions. In attempts to reduce hatchery costs, there is some interest and success in stocking fry within 2 days after hatching. Because sac fry are the most sensitive to increases in pH, extra monitoring of pH would be necessary, and fry should only be moved to equal or lower pH when implementing this strategy. Sometimes fingerlings are moved to a new pond to limit losses from proliferative gill disease. Because fingerlings also show sensitivity to abrupt pH increases, this strategy should only be used when fingerlings can be transferred to a pond of equal or lower pH.

Gradual water exchanges are commonly used to acclimate fish to temperature differences, but water exchanges are less effective in changing the pH of hauling water. The time it would take to safely change the hauling water pH through water exchanges would not

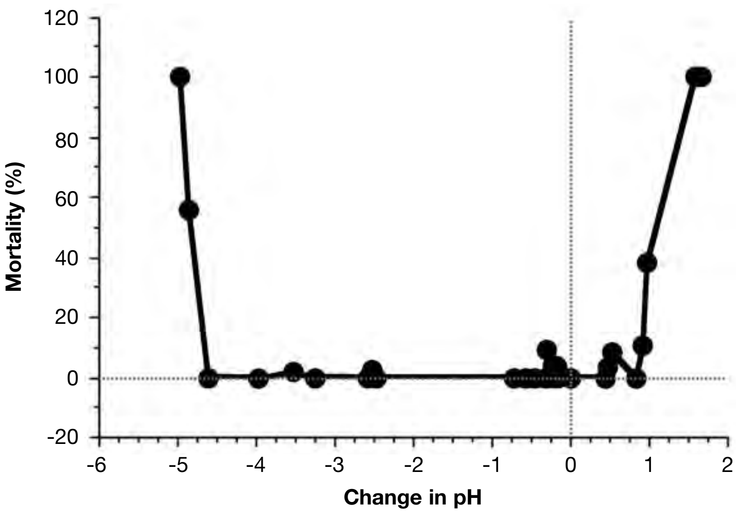


Figure 9. Effects of pH change on fry survival. Graph represents survival after 24 hours with a starting hatchery pH of 8.82.

be practical for tempering catfish. Excessive residence time in hauling tanks would lead to several water quality problems in the tanks. Therefore, the most practical solution to pH management is probably to monitor pH and only stock into waters that have a lower pH than the current resident water. Although most water used for catfish culture is well buffered, pond pH still fluctuates significantly in these fertilized ponds. Attention to pH is important, and fry should not be stocked if the pond pH is more than 0.5 units higher than the hatchery water pH. Stocking in the morning may be helpful with ponds that have large fluctuations in pH. By monitoring pond pH at stocking, some of the variability in fry survival may be eliminated.

MISSISSIPPI STATE
UNIVERSITY™

Printed on Recycled Paper

MSUcares.com