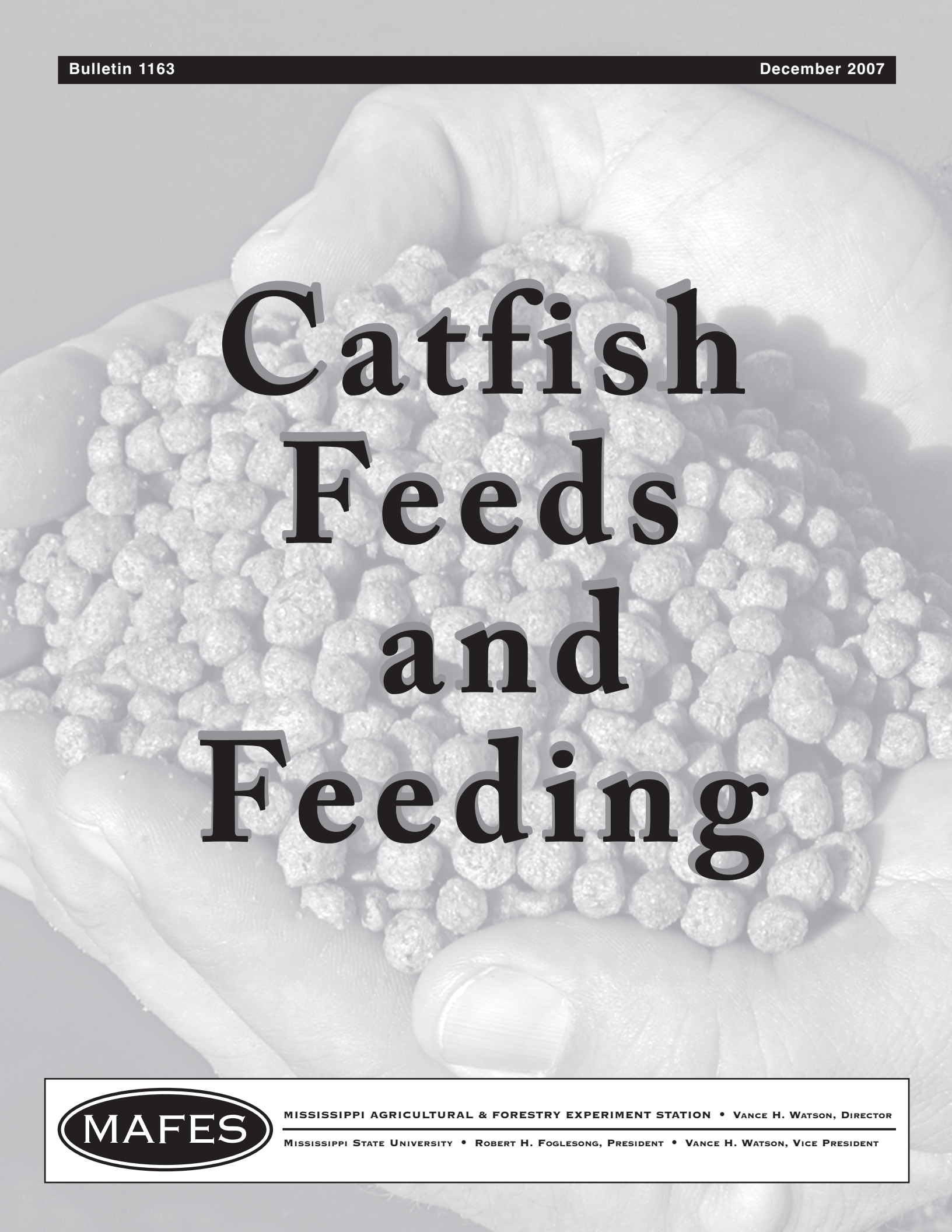
Bulletin 1163 December 2007



Catfish Feeds and Feeding

MAFES

MISSISSIPPI AGRICULTURAL & FORESTRY EXPERIMENT STATION • VANCE H. WATSON, DIRECTOR

MISSISSIPPI STATE UNIVERSITY • ROBERT H. FOGLESONG, PRESIDENT • VANCE H. WATSON, VICE PRESIDENT

Catfish Feeds and Feeding

Edwin H. Robinson
Research Professor
Delta Research and Extension Center

Menghe H. Li
Research Professor
Delta Research and Extension Center

The authors appreciate the support of Mississippi Agricultural and Forestry Experiment Station, Delta Branch Experiment Station, and Thad Cochran National Warmwater Aquaculture Center for funding for this bulletin. Bulletin 1163 was published by the Office of Agricultural Communications, a unit of the Division of Agriculture, Forestry, and Veterinary Medicine at Mississippi State University. Copyright 2007 by Mississippi State University. All rights reserved. This publication may be copied and distributed without alteration for nonprofit educational purposes provided that credit is given to the Mississippi Agricultural and Forestry Experiment Station.

CONTENTS

Catfish Feeds and Feeding

Preface

This bulletin summarizes the feed and feeding aspects of catfish production. It is based on updated research findings at the National Warmwater Aquaculture Center (NWAC) and reports from other sources. Certain sections are presented in more detail than others because of importance of the subject and information available. We hope the information presented is practical and is presented in a usable manner. The information and recommendations given should be considered as guidelines because no single feed or feeding method is suitable for all circumstances.

Introduction

Extensive research has been conducted on the nutrition and feeding of catfish, thus their nutrient requirements and feeding characteristics are well documented. Research data have served as a basis for the formulation of efficient, economical feeds and for the development of feeding strategies. Both accomplishments have been instrumental in the success of the catfish industry. Today's catfish producer feeds a nutritionally complete diet that provides all known nutrients at required levels and the energy necessary for their use in a water-stable, readily digestible form. It is essential to supply all nutrients via the diet because the contribution of microbially synthesized nutrients in the intestine of catfish is minimal. Also, the quantity of nutrients supplied from natural food organisms found in pond waters is relatively small in comparison with total nutrient requirements, except perhaps for early life stages such as fry or small fingerlings. Summaries of catfish feeds and feeding are presented in the following sections.

Feeds

Catfish feeds are formulated to meet all nutritional requirements of the fish and are manufactured from high-quality ingredients using up-to-date extrusion technology. The feeds are designed to provide for rapid weight gain, high feed efficiency, and a desirable composition of gain (i.e., a product low in fat and high in protein). Since feed ingredient type and quality affect the quality of catfish feeds, careful consideration is given to feed ingredient selection and use. The cost of each feed ingredient is also considered during feed formulation to produce high-quality feeds at affordable costs.

Nutrient Requirements

Forty nutrients have been identified as necessary for the normal metabolic function of catfish. Nutritional requirements for catfish have generally been based on weight gain and feed efficiency of small fish raised under laboratory conditions presumed to be near optimum. However, over the past several years, we have collected data on the nutrient requirements of catfish raised under practical conditions. A summary of nutrient levels recommended for catfish feeds is provided (Table 1).

Table 1. Nutrients recommended for catfish feeds.

Nutrient	Recommended level[1]	Comments
Protein (%)	Grow out: 26–32 Small fingerings: 32–35 Fry: 40–50	Varies depending on fish size, water temperature, dietary energy level, and daily feed allowance.
Essential amino acids (% of protein):		
Arginine	4.3	Generally, if lysine and sulfur-containing amino acid requirements are met, other amino acids will be adequate with feedstuffs commonly used in catfish feeds. Cystine can replace about 60% of methionine requirement. Tyrosine can replace about 50% of phenylalanine requirement. Synthetic amino acids can be used to supplement deficient proteins.
Histidine	1.5	
Isoleucine	2.6	
Leucine	3.5	
Lysine	5.1	
Methionine	2.3	
Phenylalanine	5.0	
Threonine	2.0	
Tryptophan	0.5	
Valine	3.0	
Digestible energy (kcal/g protein)	8.5–9.5	Use carbohydrates and lipid (fats or oils) as energy to spare protein for growth. Fats are more highly digestible to catfish than are carbohydrates.
Lipid (%)	4–6	Mixture of animal, vegetable, and fish oils may be used. High levels of marine fish oil may impart a "fishy" flavor to the fish. Supplemental fat or oil should be sprayed on pellet surface.
Carbohydrate (%)	25–35	Floating feeds require at least 25% grain. Use grain by-products for good expansion and bonding. Crude fiber should be maintained below 7%.
Vitamins		
A	1,000 IU/lb	Acetate ester is used to improve stability during feed processing.
D_3	500 IU/lb	D-activated animal sterol used as source of D_3.
E	30 ppm	DL-α-tocopheryl acetate is used for improved stability.
K	4.4 ppm	Required, but level for catfish not known. Menadione sodium bisulfite is used to ensure adequacy.
Thiamin	2.5 ppm	Thiamin mononitrate is generally used.
Riboflavin	6 ppm	
Pyridoxine	5 ppm	Pyridoxine HCl is generally used.
Pantothenic acid	15 ppm	Calcium d-pantothenate generally used.
Nicotinic acid	None	Required, but feed contains adequate nicotinic acid without adding a supplement
Biotin	None	Required, but feed contains adequate biotin without adding a supplement.
Folic acid	2.2 ppm	
B-12	0.01 ppm	Required, but amount not known. It is synthesized in intestine of catfish.
Choline	None	Required in low-methionine diets. It is abundant in most feedstuffs; therefore, choline supplements do not appear to be necessary.
Inositol	None	No requirement demonstrated.
Ascorbic acid	50[2] ppm	Phosphorylated form is stable during feed processing and storage. Metabolized forms will lose 40–60% of activity during processing.

[1]Recommendations are for advanced fingerlings to marketable size (1–2 pounds).
[2]Amount in finished feed.
[3]A supplement may not be needed when the diet contains 4% or more animal protein.

Table 1 (continued). Nutrients recommended for catfish feeds.

Nutrient	Recommended level[1]	Comments
Minerals		
Calcium	None	Catfish usually absorb sufficient calcium from water to meet their needs. Requirement of 0.45% for fish reared in calcium-free water.
Phosphorus, available	0.3%–0.35%	About 33% of plant phosphorus and about 50–70% of animal phosphorus is available to catfish. Dicalcium or defluorinated phosphates are generally used as a phosphate source in catfish feeds. Phytase enzymes may be used to replace supplemental phosphorus sources.
Magnesium	None	No supplement needed; abundant in feedstuffs.
Sodium, potassium, and chloride	None	No supplement necessary; abundant in feedstuffs.
Sulfur	None	No supplement needed.
Cobalt[3]	0.05 ppm	Cobalt carbonate used to ensure adequacy.
Iodine[3]	2.4 ppm	Calcium iodate used to ensure adequacy.
Zinc	200 ppm	Phytic acid in feed reduces availability. Zinc oxide is generally used.
Selenium	0.1 ppm	Maximum allowable by FDA is 0.1 ppm. Sodium selenite used.
Manganese[3]	25 ppm	Phytic acid in feed reduces availability. Manganese oxide used.
Iron[3]	30 ppm	Ferrous sulfate and ferrous carbonate used.
Copper[3]	5 ppm	Copper sulfate used.

[1]Recommendations are for advanced fingerlings to marketable size (1–2 pounds).
[2]Amount in finished feed.
[3]A supplement may not be needed when the diet contains 4% or more animal protein.

Feed Ingredients

No single feed ingredient can supply all of the nutrients and energy required for optimum catfish growth. Thus, commercial catfish feeds contain a mixture of feedstuffs and vitamin and mineral premixes that provide adequate amounts of essential nutrients and the energy necessary for their use. The amount of each feed ingredient used depends on several factors, including nutrient requirements, ingredient cost, availability of each ingredient, and processing characteristics.

Protein Supplements

Feedstuffs containing 20% or more crude protein are considered protein supplements. Protein supplements may be classified as animal or plant proteins. Animal proteins used in animal feeds come from inedible tissues from meatpacking or rendering plants, milk products, and marine sources. Those that have been used in catfish feeds include fish meal, meat and bone meal, blood meal, poultry by-product meal, and catfish offal meal. Animal proteins are generally considered to be of higher quality than plant proteins, primarily because of their superior complement of indispensable amino acids. Animal protein is essential in the diet of fry and small fingerling catfish. Fish meal prepared from whole fish appears to be a better protein supplement than other animal proteins. Fish meal does not appear to be essential in the diet of catfish after they reach a size of about 6 inches. Fish meal can be completely replaced by meat and bone meal or meat and bone/blood meal in diets for food-fish grow out. There is also evidence that animal proteins can be completely replaced by plant proteins in food-fish grow-out feeds without affecting growth and feed efficiency.

The primary plant protein sources used in catfish feeds are oilseed meals, such as soybean meal, and cottonseed meal. Certain other oilseed meals could be used but are not generally available on a timely basis and at an economical cost per unit of protein. Compared with animal proteins, most plant proteins are deficient in lysine and methionine, the two limiting amino acids in catfish feeds. In addition, certain plant proteins contain toxins and antinutritional factors that may or may not be inactivated during processing of the meal. A brief description of various animal and plant protein sources that can be used in catfish feeds is presented in Table 2.

Table 2. Feed ingredients used in commercial catfish feeds.

Ingredient	Selected characteristics (%)						Comments
	Dry matter	Crude protein	Crude fat	Crude fiber	Lys	Met + Cys	
Protein Supplements							
Soybean meal (dehulled, solvent-extracted)	89.3	48	1	3	3.2	1.5	Major protein source used. A high-quality ingredient. Contains antinutritional factors that are destroyed by heating. Palatable to catfish.
Cottonseed meal (direct solvent-extracted)	90.4	41	2.1	11.3	1.76	1.1	About 10–15% is generally used. Higher levels (20–30%) can be used if supplemented with lysine. Highly palatable to catfish. Contains free gossypol, which can be toxic to catfish at high levels. Deficient in lysine; lysine availability reduced by binding to free gossypol.
Peanut meal (mechanically-extracted)	91.8	45	5	12	1.55	1.1	Deficient in lysine. Levels restricted to about 15–20% without lysine supplementation.
Fish meal[1] (Menhaden)	92	62	10.2	1	4.7	2.4	Good source of indispensable amino acids, phosphorus, and digestible energy. May also provide essential fatty acids. Highly palatable to catfish. Grow-out feeds for catfish generally contain 2–4% fish meal.
Meat and bone meal[2]	92.6	50	8.5	2.8	2.6	1.0	Good source of calcium and phosphorus. High in ash, which limits its use somewhat because of possibility of mineral imbalances. Maximum level recommended for catfish feeds is 15%.
Blood meal[2]	91	85	1	1	6.9	1.6	Flash or spray-dried blood meal have been used. Excellent source of lysine but is deficient in methionine. Up to 5% can be used as lysine supplement. Generally used in combination with meat meals.
Catfish offal meal	90	58	11	–	4.19	1.9	Prepared from catfish processing waste. Good source of calcium, phosphorus, and energy. Its use depends on availability.
Poultry by-product meal	94	58	14	2.5	2.57	2.04	Prepared from ground, rendered, or clean parts of the carcass of slaughtered poultry. It is marginal in lysine. Its use depends on availability and cost.
Hydrolyzed feather meal	93	85	2.5	1.5	1.05	3.55	Prepared by the high-pressure treatment of clean, undecomposed feathers from slaughtered poultry. It is high in methionine and cystine but severely deficient in lysine; therefore, it is rarely used in catfish feeds.
Canola meal	91	38	3.8	11.1	2.3	1.2	Prepared from a special rapeseed that is low in glucosinolates and erucic acid, toxic compounds to animals. Slightly deficient in lysine. It is palatable to catfish and can be used at levels up to about 35% in catfish feeds without detrimental effects.
Distillers' grains	91	29	8.4	7.8	0.81	0.98	Prepared from residuals after removal of the alcohol by distillation from the yeast fermentation of cereal grains. Deficient in lysine. It is palatable to catfish and can be used at levels up to about 35% in catfish feeds without lysine supplementation.

[1]Other fish meals may be used.
[2]Meat and bone meal and blood meal from ruminant animals are not recommended because of the perception of "mad cow" disease.
[3]Corn screenings and corn gain are often used interchangeably.
[4]If processed milo is used as a binder, it has nutritive value of milo grain.

Table 2 (continued). Feed ingredients used in commercial catfish feeds.

Ingredient	Selected characteristics (%)						Comments
	Dry matter	Crude protein	Crude fat	Crude fiber	Lys	Met + Cys	
Full-fat soybeans	90	38	18	5	2.4	1.1	Rarely used in catfish feeds, primarily because of high fat content. A limited amount can be used as long as total fat level in feed does not exceed about 6%.
Energy supplements							
Corn grain (yellow)[3]	88	8.9	3.5	2.9	0.22	0.3	Abundant and relatively inexpensive source of energy. Cooking improves energy digestibility. Aids in pelleting and improves floatability of feed.
Wheat gain	88	13.5	1.9	3	0.4	0.6	Generally used sparingly in catfish feeds because corn is less expensive. It may be used at rate of 3–4% to improve binding of feed pellet.
Wheat middlings	89	17.7	3.6	7	0.6	0.3	Can be used at levels up to 30% or so. Improves pellet binding. Nutritional value to catfish as good as or better than corn and wheat grain.
Rice bran	91	13.5	12.5	13	0.5	0.3	Used at low levels (3–5%) because of high fat and fiber levels.
Corn gluten feed	88	21	2.0	10	0.6	1.0	It is the part of corn remaining after the extraction of most of the starch, germ, and gluten by the process of wet milling to produce starch and syrup. Up to 50% can be used in catfish feeds without detrimental effects.
Catfish oil	–	–	100	–	–	–	Fat extracted from processing waste. About 1–2% is sprayed on top of finished feed. Good energy source and used to reduce feed dust.
Fish oil	–	–	100	–	–	–	Good source of essential fatty acids and energy. Also used to reduce feed dust by spraying on finished feed pellet. Used at a rate of < 2%. Higher levels may reduce survival of fish exposed to ESC.
Fat	99.5	–	99.4	–	–	–	Generally highly digestible. May not supply essential fatty acids. Spray on top of finished feed at rate of 1– 2% to reduce feed dust.
Vitamin Supplements							
Vitamin premix	–	–	–	–	–	–	Meet recommendations given in Table 1.
Mineral Supplements							
Mineral premix	–	–	–	–	–	–	Meet recommendations given in Table 1.
Dicalcium or defluorinated phosphates	–	–	–	–	–	–	Used as a phosphorus source at a rate of 1–1.5%. Phosphorus from these sources is about 80% available to catfish.
Pellet binders[4]	–	–	–	–	–	–	Generally, natural binders in grains are sufficient for extruded feeds. Some feed manufacturers add about 2–2.5% processed milo as a binder in extruded feeds. Various binders have been used in pelleted (sinking) feeds, including lignosulfonates, bentonites, and processed milo.

[1]Other fish meals may be used.
[2]Meat and bone meal and blood meal from ruminant animals are not recommended because of the perception of "mad cow" disease.
[3]Corn screenings and corn gain are often used interchangeably.
[4]If processed milo is used as a binder, it has nutritive value of milo grain.

Energy Supplements

Energy supplements are feedstuffs that contain less than 20% crude protein. These include grain and grain by-products, as well as animal fat or vegetable oil. Energy sources typically used in commercial catfish feeds include corn, corn screenings, wheat grain, wheat middlings, rice bran, milo, animal fat, and fish oil (Table 2).

Premixes

Vitamin and mineral premixes are generally added to catfish feeds. They should be formulated to meet nutrient requirements and manufactured using digestible nutrient sources. Specifics of vitamin and mineral premixes used in catfish feeds are given below.

Vitamins — Commercial catfish feeds are supplemented with a vitamin premix that provides vitamins in quantities necessary to meet dietary requirements, including losses from feed processing. Vitamins commonly added to commercial catfish feeds and the amounts recommended are given in Table 1. Data on vitamin stability during feed processing (Table 3) and bioavailabilities of some vitamins from feed ingredients may allow reduced amounts of certain vitamins added to catfish vitamin premixes.

Minerals — Generally, if 4–5% or more animal protein is included in catfish feeds, supplemental trace minerals are not necessary. Since most feeds for food-sized catfish grow out usually contain low levels of animal protein, a trace mineral premix is commonly added to commercial catfish feeds (Table 1).

Table 3. Retention of vitamins in extrusion processed catfish feeds.

Vitamin	Retention (%)
Vitamin A (vitamin A acetate)	65[1]
Vitamin E (DLalphatocopherol acetate)	100[1]
Thiamine (thiamin mononitrate)	64[1], 67[2]
Riboflavin	100[2]
Vitamin B-6 (pyridoxine hydrochloride)	67[1], 70[2]
Folic acid	91[1]
Niacin	96[2]
Pantothenic acid	100[2]
Ascorbic acid (fatcoated)	57[3]
Ascorbic acid (ethylcellulosecoated)	43[1], 48[3]
Ascorbic acid (Lascorbyl2polyphosphate)	77[1], 83[4]

[1]From Producer's Feed Company, Belzoni, Mississippi; assayed by Hoffman La Roche, Inc., Nutley, New Jersey.
[2]From Li, M.H., J.B. Rushing, and E.H. Robinson, 1996, Stability of B-complex vitamins in extruded catfish feeds, Journal of Applied Aquaculture 6 (2):67-71.
[3]From Robinson, E.H., 1992, Vitamin C studies with catfish: requirements, biological activity and stability, Technical Bulletin 182, Mississippi Agricultural and Forestry Experiment Station, Mississippi State University, Mississippi.
[4]From Robinson, E.H., J.R. Brent, and J.T. Crabtree, 1989, AsPP, an ascorbic acid, resists oxidation in fish feed, Feedstuffs 61(40):64-66.

Supplemental Amino Acids

In a practical feed, amino acid requirements are best met by feeding a mixture of feedstuffs or by using a mixture of feedstuffs supplemented with amino acids. Data indicate that amino acids are effectively used by catfish when supplemented into a practical feed. Although several amino acids are available for use in animal feeds, in practice lysine is currently the only supplemental amino acid used in commercial catfish feeds.

Feed Formulation

Catfish feeds have generally been based on a fixed formula with little use of a least-cost approach as is used in other animal industries. In the past, fixed formulas were used because of the lack of sufficient nutritional information. Presently, nutritional data are available to allow the nutritionist to formulate catfish feeds on a least-cost basis. The primary constraint limiting the use of least-cost programs for formulating catfish feeds is that relatively few feedstuffs are available that can be used in catfish feeds. Many feedstuffs are unsuitable for use in catfish feeds because of their poor nutritional content or because of manufacturing constraints.

To use a least-cost computer program to formulate feeds, the following information is needed: (1) cost of feed ingredients; (2) nutrient concentrations in feedstuffs; (3) nutrient requirements; (4) nutrient availability from feedstuffs; and (5) nutritional and nonnutritional restrictions. In addition to the lack of suitable feedstuffs, several other constraints limit the widespread use of least-cost formulation of catfish feeds. These include the logistics of obtaining a wide assortment of feedstuffs on a timely basis, a lack of capacity to store large numbers of different ingredients at the feed mills, and a lack of knowledge of the nutrient levels that result in maximum profit (as opposed to levels that maximize weight gain). However, a limited application of least-cost feed formulation is used to formulate catfish feeds. Cottonseed meal, milo, and meat and bone/blood meal are often used to replace a part of soybean meal, corn, and fish meal, respectively, depending on cost. Examples of restrictions placed on nutrients and feed ingredients for least-cost formulation of catfish feeds are presented in Table 4.

Table 4. Restrictions for least-cost formulation of a 28% protein feed for catfish.

Item	Restriction	Amount	Unit
Crude protein	Minimum	28.0	%
Crude fiber	Maximum	7.0	%
Lipid	Maximum	6.0	%
Available phosphorus	Minimum	0.30	%
Available phosphorus	Maximum	0.40	%
Digestible energy	Minimum	2.8	kcal/g
Digestible energy	Maximum	3.0	kcal/g
Available lysine	Minimum	1.43	%
Available methionine	Minimum	0.26	%
Available methionine + cystine	Minimum	0.65	%
Grain or grain by-products	Minimum	25.0	%
Cottonseed meal[1]	Maximum	15.0	%
Whole fish meal	Maximum	3.0	%
Non-fish animal protein[2]	Maximum	3.0	%
Xanthophylls	Maximum	11.0	ppm
Vitamin premix[3]	Include		
Trace mineral premix[3]	Include		

[1]Higher levels may be used if supplemental lysine is used.
[2]Beef products are not recommended because of its implication of “mad cow” disease.
[3]Meet dietary allowances for catfish.

Finished Feeds

Commercial catfish feeds are high-quality feeds that provide all essential nutrients and energy that catfish need for rapid growth. Most catfish feeds are manufactured by extrusion, which results in a water-stable pellet that floats on the water surface. Since no single feedstuff can provide all the nutrients and energy needed by catfish, commercial catfish feeds are composed of mixtures of feedstuffs, vitamins, minerals, fats, enzymes, and possibly supplemental amino acids. Examples of feed formulations that could be used to feed catfish are presented in Table 5.

Table 5. Examples of feed formulations used to culture catfish.

Ingredient	Percent of feed						
	Fry feed	Fingerling feed	Food fish feed				
	(50%)[1]	(35%)	(32%)	(32%)	(28%)	(28%)	(26%)
Soybean meal (48%)[1]	–	44.2	41.6	47.0	30.1	35.4	28.3
Cottonseed meal (41%)	–	10.0	10.0	10.0	10.0	10.0	5.0
Menhaden meal (61%)	74.2	8.0	4.0	–	4.0	–	4.0
Corn grain	–	27.6	32.1	30.3	33.6	31.9	35.3
Wheat middlings	20.4	7.5	10.0	10.0	20.0	20.0	25.0
Dicalcium phosphate[2]	–	0.5	0.6	1.0	0.6	1.0	0.7
Catfish vitamin mix[3]	Include	Include	Include	Include	Include	Include	Include
Catfish mineral mix[3]	Include	Include	Include	Include	Include	Include	Include
Fat/oil[4]	5.0	2.0	1.5	1.5	1.5	1.5	1.5

[1]Values in the parentheses represent percentage protein.
[2]Phytase enzymes can be used to replace dicalcium phosphate.
[3]Commercial mixes that meet or exceed all requirements for channel catfish.
[4]Sprayed on finished feed pellet to reduce feed dust ("fines").

FEEDING

Unlike other farmed animals, fish are not fed *ad libitum*; in other words, feed is not made available to catfish at all times, and they are not allowed to feed at will. Rather, the feeder generally decides how much feed is offered to the fish. Therefore, feeding fish is a highly subjective process. There are no standard feeding practices across the catfish industry because many factors affect feeding and every pond of fish behave differently. Since feed cost is the largest operating expense in catfish production, feeding the fish in a manner that results in efficient feed conversion and fast growth without negatively affecting water quality will increase production and profit. Under normal conditions, catfish are typically fed daily as much feed as they will consume — that is, "fed to apparent satiation." However, depending on water temperature, water quality, and fish health, it may be prudent to restrict the daily feed allowance or to feed less frequently than daily.

General discussions of natural foods, warm-weather feeding, winter feeding, and feeding diseased fish are presented in following sections. The recommendations provided should be considered as guidelines because no single feed or feeding method is suitable for all circumstances.

Natural Foods

Because of the high level of nutrients introduced by feeding, commercial catfish ponds are fertile and normally contain large numbers of organisms, including phytoplankton, zooplankton, other crustaceans, and insects. Many of these organisms are high in protein and other essential nutrients and may contribute to the diet of pond-raised catfish. The contribution of natural food organisms to the nutrition of farm-raised catfish is relatively unclear, but their major contributions are likely to be nutrients that are required in trace amounts. Some indirect evidence suggests that natural foods may contribute vitamins, minerals, or essential fatty acids to catfish nutrition. For example, a deficiency for a specific vitamin can be induced in catfish fed a purified diet devoid of that vitamin when the fish are raised in the laboratory under controlled conditions. However, the same deficiency could not be induced in catfish raised in ponds fed practical diets lacking a supplement of a specific vitamin. Therefore, the vitamin requirement was met either from vitamins naturally occurring in feedstuffs, natural food organisms, or from a combination of the two. In addition, we have been unable to induce signs of mineral or essential fatty acid deficiencies in pond-raised catfish fed diets containing no supplement. Research has shown that large zooplankton found in pond waters may contribute micronutrients (vitamins, minerals, essential fatty acids) to the diet of fry and small fingerling catfish. Because of the variability of natural foods among ponds, one cannot rely on these sources alone to meet catfish dietary requirements.

Warm-Weather Feeding

Fry

Newly hatched catfish fry — only about ¼ inch in total length — are usually held in indoor troughs and tanks for no more than 10 days before being released into outdoor nursery ponds. Initially, catfish fry use their yolk sacs as energy and nutrient sources. Once the yolk sac is absorbed (approximately 3–5 days after hatching), fry begin to seek food, and they should be fed frequently. In the hatchery, fry should be fed finely ground flour-type feeds (Table 5) containing 40–50% protein supplied primarily from fish meal. Most producers feed catfish fry in the hatchery with trout starter feeds because of their high quality and ready availability.

Hatchery-held fry should be fed at a daily rate equal to about 25% body weight divided into 8–10 equal feedings. Automatic feed dispensers can also be used to deliver the amount of feed prescribed daily at relatively short time intervals. Some producers do not feed the fry in the hatchery; instead, they directly stock the fry into nursery ponds when most fry swim freely. Research conducted at Kentucky State University has shown that stocking channel catfish swim-up fry directly into properly prepared nursery ponds is a suitable method for fingerling production.

After being released into nursery ponds, catfish fry are still tiny and are weak swimmers, so they are not able to move rapidly to areas where manufactured feeds are offered, which makes feeding difficult. The best way to ensure good growth and survival of newly stocked fry is to make sure that plenty of natural food

is available in the nursery pond when the fish are stocked. Natural foods for channel catfish fry include large zooplankton (microscopic crustaceans), insect larvae, and insects. Zooplankton and insects eat plant material in the pond, so to produce them in abundance you must increase natural plant production by fertilizing the pond before stocking fry. For details on fertilization guidelines, see *Optimizing Fry Pond Fertilization* published by Charles Mischke and Paul Zimba (NWAC News, vol. 6, no. 1, 2003, www.msstate.edu/dept/tcnwac/Vol06No1Oct2003.pdf).

Although fry presumably meet their nutrient needs from natural food organisms, they are fed once or twice daily using a finely ground feed at a rate of 10–30 pounds per acre per day. Fry feed may serve as a secondary food source and as a fertilizer to keep the pond fertile, so it is not necessary to feed a high-protein feed as is used in the hatchery. Fines from regular 28% or 32% protein feeds for food fish grow out are suitable for catfish fry during this phase. Some catfish producers do not feed the flour-type feeds, but rather a pelleted or crumbled feed, which is largely uneaten but breaks up in the water and serves to keep the pond fertile. After a few weeks, the fry will have grown into fingerlings of 1–2 inches in length and will come to the pond surface seeking food.

Fingerlings

Once small fingerlings (1–2 inches) come to the pond surface to feed, they should be fed once or twice daily to satiation using small floating pellets (⅛-inch diameter) or crumble feeds containing about 35% protein (Table 5), a part of which should be supplied by fish meal. There is research data that show when fingerlings reach about 4 inches in length, a 28% protein feed is sufficient for maximum growth. Feeding twice daily may improve fingerling weight gain and production. Some catfish producers feed fingerlings the same feed as food fish. Fingerlings consume large feed pellets by nibbling on the feed after the pellets soften and begin to break up in the water. Fingerlings appear to grow well using this feeding strategy, but nutrient losses, especially micronutrients, are likely due to leaching of nutrients because of the extended time the pellet is in contact with the water.

Food Fish

Catfish grown for food are usually stocked as advanced fingerlings of about 5–6 inches in length (about 40–60 pounds per 1,000 fish). They are generally fed a floating feed of approximately 5/32–3/16 inch in diameter containing 28–32% protein (Table 5). On large commercial catfish farms, feed is typically blown onto the surface of the water using mechanical feeders that are either mounted on or pulled by vehicles.

Feeding Rate. Several factors dictate how much to feed catfish in a production pond. These include fish size, water temperature, water quality, weather conditions, and standing crop (number and weight of fish present in the pond). Generally, catfish should be fed daily as much as they will eat (satiation) without wasting feed and without adversely affecting water quality. Feeding to satiation is especially important when catfish are raised in a multiple-batch cropping system in which several sizes of fish are present in the pond because it provides a better opportunity for the smaller, less aggressive fish to feed. However, feeding to satiation is problematic since it is difficult to determine when the fish are satiated. Thus, it is easy to overfeed, which results in wasted feed that may have deleterious effects on water quality. Feeding rates should not exceed what organisms in the pond can assimilate. Long-term average daily feeding rates should not exceed about 120–150 pounds per acre. However, it is okay to feed at higher rates on occasion. Our data demonstrated that feeding to satiation daily resulted in higher production and weigh gain, but feed conversion was increased compared with feeding a restricted rate of up to 80 pounds per acre per day. The lower feed conversion in fish fed the restricted rate is mainly because of less wasted feed compared with that of fish fed to satiation. We also found that total feed input, net production, weight gain, and feed conversion were about the same when fish were fed to apparent satiation or fed at a "cut-off" rate of up to 120 pounds per acre per day under a single-batch cropping system.

Feeding Time. The best time to feed fish during the day on a large farm is mainly dictated by the logistics required to feed large numbers of ponds in a limited time. As a result, during warm weather many catfish producers start feeding early in the morning as soon as dissolved oxygen levels begin to increase. This approach appears to work well. In research, we find no advantages to feeding at a certain time of day. There were no differences in weight gain, feed consumption, and feed conversion among catfish fed to satiation at 8:30 a.m., 4 p.m., or 8 p.m. No differences in emergency aeration time were noted among treatments.

However, we do not recommend feeding near dark or at night in large commercial catfish ponds unless sufficient aeration is available because peak oxygen demand generally occurs about 6–12 hours after feeding. This time corresponds to the time when dissolved oxygen levels are low. Generally, it appears most practical to begin feeding in the morning as the dissolved oxygen begins to increase during warm weather. However, in cool weather (late fall, winter, and early spring), water temperature is usually higher in the afternoon, and fish will eat better.

Feed Distribution and Duration of Feeding. Since most commercial ponds are relatively large (usually 10 acres or larger), it is important that the feed be blown over a large area to make the feed accessible to as many fish as possible. It is better to feed on all sides of the pond, but this is usually not possible to do because of the prevailing wind. Therefore, feed must be distributed along the upwind side to prevent it from washing ashore. On a large commercial farm, the time it takes to feed the fish in each pond is generally influenced by the number of ponds to feed and the number of feeders. Feeding fish, especially feeding fish to satiation, requires experience and patience. An experienced feeder is invaluable to the farm. The longer the feeder spends feeding each pond, the better the chance to optimize feeding. Feeding fish in a hurry will often result in fish being underfed or overfed. Generally, in our small research ponds, if the fish are actively feeding, they typically eat all they want in about 30 minutes.

Feeding Once vs. Twice Daily. Generally, feeding once daily is satisfactory for food fish grow out. Research has shown that feeding food fish twice daily is not necessarily beneficial. Although fish fed twice daily were offered more feed than fish fed once daily, the increased amount of feed fed was not completely converted into weight gain. It is likely that feeding twice daily increases feed conversion because, if the feeder is not careful, overfeeding can easily waste feed.

Feeding Once Daily vs. Once Every Other Day or Third Day. Although we recommend that catfish grown for food be fed once daily, feeding less frequently than daily may be appropriate under certain circumstances. Our data have shown that fish fed every other day or every third day consume up to 50% and 65% more feed on days fed, respectively, compared with fish fed once daily to apparent satiation. The increased feed consumption on days fed in fish fed less frequently than daily is primarily the result of compensatory growth, or at least a partial compensatory growth. Fish are capable of compensating for all or part of the weight loss during a short period of feed deprivation when full feeding is resumed. Although there are some advantages (reduced feed conversion, labor cost, and aeration) to feeding every other day or every third day, we do not recommend this type of feeding regimen for routine feeding since fish fed on these schedules cannot consume enough feed on days fed to compensate for the missed feed on days when they are not fed. In addition, feeding every other day or every third day appears to reduce fish processing yield, and it extends the production cycle, so in the long term it may not be economical.

Feeding 7 Days vs. 5 or 6 Days per Week. During the growing season, most catfish producers feed their fish 7 days a week, but some producers feed 6 days a week. Our data show that feeding 6 days a week (not feeding on Sundays) reduces net production by 3.3%, and feeding 5 days a week (not feeding on Saturdays and Sundays) reduces net production by 6.9%, compared with feeding 7 days per week for a growing season. Feed conversion was reduced by 4.8% and 7.9%, respectively, for fish fed 6 days and 5 days a week, compared with fish fed 7 days per week. Considering the slight decrease in net production, slight improvement in feed conversion, and possible reduction in other costs associated with feeding, feeding 6 days per week may reduce production costs for food-sized channel catfish. However, it should be noted that in our study, we used a single-batch cropping system, and the fish were fed to satiation on days fed. If feed were restricted, one would expect a further reduction in net production by feeding 6 days per week, compared with feeding 7 days. Also, if this strategy is used in a multicrop system, skipping feed days may have a more negative impact than in single-crop systems because the smaller fish may lose more weight than was demonstrated in our study.

Maintenance Feeding. Maintenance feeding means that all feed eaten by the fish is used to maintain the animal with no gain or loss of weight. This feeding regimen may be achieved either by feeding fish a maintenance ration daily or by feeding them to apparent satiation one or two times per week. Since fish of various sizes are typically present in a given pond at the same time, it is better to feed all they will eat on days fed than feeding a little every day. Feeding to satiation on the

days fed will allow the smaller, less aggressive fish to feed. The maintenance feeding regimen may be used to feed food-sized fish that cannot be harvested because of off-flavor or other issues. Based on our research results, it appears that feeding once a week to satiation can maintain the body weight of food-sized catfish under a single-batch cropping system. However, the condition factor — a nutritional status indicator that measures the relationship between fish body weight and length — is lower for fish fed once a week than fish fed more frequently per week.

Broodfish

Catfish broodstock are usually fed the same feed used for food fish grow out. Some catfish producers prefer using sinking feeds because broodfish are often hesitant to feed at the surface. However, because brooders generally feed slowly, sinking pellets made through a pellet mill may disintegrate before they can be consumed. If a sinking feed is used, make sure that it is an extruded feed (slow sink). Some producers also stock forage fish, such as fathead minnows and golden shiners, in broodfish ponds or supplement commercial feeds with live or frozen forage fish to ensure adequate nutrition for gonad development. It is recommended that catfish brooders be fed a typical 28% or 32% protein feed once daily. It is not necessary to feed once the spawning begins because of diminished feeding activities during that time. Male brooders are generally more aggressive feeders than females, so sufficient feed should be provided to allow females opportunity to feed. The feeding rate should be about 0.5–1% fish body weight.

Winter Feeding

Unlike warm-blooded animals, catfish do not feed consistently when water temperature drops below 70°F. When water temperature falls to 50°F and below, catfish more or less stop eating. Many catfish producers choose not to feed during winter for a variety of reasons, one of which is that it is difficult to see a positive response from a winter feeding program. However, based on research results, winter feeding is beneficial, especially for fingerlings, though the magnitude of benefit from a winter feeding program depends on the severity of the winter. Fish will gain (if fed) or lose (if not fed) more weight during a mild winter than a cold one. Research conducted at Auburn University has shown that food-sized catfish held over winter without food can lose up to 9% of their body weight, while catfish fed 1% of their body weight when water temperature exceeded 55°F gain 18% weight over the winter. We conducted a study during the winter of 2005-2006 that showed food fish (average weight about 1 pound) gained up to 21% when fed a high-protein diet (41%), and feed conversion improved as dietary protein increased. It should be noted that the winter was mild, and we were able to feed often. Different results would be expected depending on the severity of the winter temperatures. Although there have been some published winter feeding charts giving feeding rates and corresponding temperatures, there is really no precise temperature at which to feed during the winter. Generally, if it is warm and fish will eat, it is beneficial to feed.

Since feeding activity of the fish is much lower in the winter than in the summer, it is thought that catfish may respond to a sinking feed better than a floating feed during the winter. An extruded, slow-sink feed may work better than a sinking feed made through a pellet mill because extruded feeds are more water-stable and will remain intact longer than a steam-pelleted feed.

Feeding Diseased Fish

Feeding diseased fish may be difficult because sick fish feed poorly, if at all. Early and accurate diagnosis of disease(s) is essential in the success of managing and feeding diseased fish. Systemic bacterial infections in catfish can be successfully treated with medicated feeds containing antibiotics if the diseased fish are treated at the early stage of the disease outbreak. However, feeding medicated feeds should not be substituted for proper management practices because medicated feeds are expensive, and their efficacy varies depending on the state and severity of the disease. Efforts should be made to identify and eliminate possible stress factors that weaken the fish's immune system and induce infections. There are no medicated feeds available for catfish diseases other than bacterial infections.

Medicated Feeds

Antibiotics can be administered to large populations of fish through the feed to treat systemic bacterial infections in catfish. Only three antibiotics — Romet® (sulfadimethoxine-ormetoprim), Terramycin® (oxytetracycline), and Aquaflor® (florfenicol) — have been registered by the FDA to control bacterial infections through incorporation into catfish feeds.

Romet is registered for control of enteric septicemia of catfish (ESC) and has been proven effective in treating motile aeromonad septicemia caused by *Aeromonas hydrophila* and systemic columnaris infections. Romet-medicated feed is fed at a rate (depending on the Romet formulation) sufficient to deliver 2.3 grams of antibiotic per 100 pounds of fish per day. Romet was originally formulated to contain 66.6 pounds of Romet-30® premix per ton of finished feed and delivered the required dosage of antibiotic when fed at a rate of 0.5% of fish body weight daily. However, because of palatability problems, the amount added was reduced to 33.3 pounds per ton of feed, and the daily feeding rate was increased to 1% of fish body weight. Research at the NWAC indicated that the concentration of fish meal should be increased to 16% to improve the palatability of feeds containing Romet.

Data from an NWAC study indicate that the effectiveness of treating ESC in fingerlings with Romet can be increased by feeding a reduced concentration of antibiotic formulation at a greater rate adjusted to deliver the required legal level of antibiotic. The reason for the increased effectiveness of this feeding strategy was speculated to be from the increased availability of medicated feed to larger numbers of sick fish. Thus, catfish feed mills in the Mississippi Delta currently manufacture Romet-medicated feed (for fingerlings) using 11.1 pounds of Romet-30 per ton of feed. This feed is then fed at a rate of 3% body weight daily or fed to satiation. Romet is heat-stable, so it can be used in a floating feed.

Romet is registered to be fed at the prescribed rate for 5 consecutive days. If the majority of fish affected by the disease in the pond are fingerlings, feeding smaller feed size (crumbles or ⅛-inch-diameter pellets) is usually suggested. Research at the NWAC showed that ESC-infected fingerlings fed medicated feed of reduced pellet sizes have better survival than those fed regular-sized medicated feed. If mortality does not decrease after treatment, additional sick fish should be diagnosed. An additional 5-day period of medicated feed may be prescribed. A 3-day mandatory withdrawal period is required before fish can be slaughtered.

Terramycin is a broad-spectrum antibiotic registered by the FDA to treat Aeromonas infections. Terramycin also has proven effective in treating other aeromonad infections, ESC, and systemic columnaris infections. The most commonly used feed formulation contains 50 pounds of Terramycin TM-100® premix per ton of finished feed. The resulting medicated feed contains 2.5 grams of antibiotic per pound of feed, and when fed at 1% of body weight per day, it delivers 2.5 grams of antibiotic per 100 pounds of fish per day.

Terramycin-medicated feeds usually have been manufactured as sinking pellets because the antibiotic is heat-labile and does not withstand the high temperatures required to make floating pellets. However, a new "cold" extrusion process has been developed to make floating Terramycin feeds that allow the feeder to observe the fish feeding during a bacterial disease episode. Floating Terramycin feeds are commercially available and should replace sinking Terramycin feeds because of the advantage of floating pellets.

Based on field observations, Terramycin-medicated feed is primarily recommended to treat systemic columnaris infections or ESC infections caused by strains of *E. ictaluri* resistant to Romet. Terramycin is registered to be fed for 7–10 consecutive days, and a 21-day withdrawal period is required before fish can be slaughtered.

Aquaflor, or florfenicol, is another broad-spectrum antibiotic registered by the FDA in 2005 to control ESC in channel catfish. This antibiotic can only be used

under the professional supervision of a licensed veterinarian through a veterinary feed directive order.

Aquaflor-medicated feed is fed at a rate sufficient to deliver 10 milligrams of active florfenicol per kilogram of fish per day for 10 days. Commercial Aquaflor-medicated feed for channel catfish typically contains 500 milligrams of active florfenicol per kilogram and is fed at 2% of body weight per day. Because Aquaflor is heat-stable, it is typically incorporated into a floating feed. A 12-day withdrawal period for channel catfish is required before fish can be slaughtered and processed.

Considerations

Several important considerations should be taken into account when treating fish with medicated feeds. An accurate diagnosis of the specific disease(s) affecting the fish population must first be obtained if effective treatment is expected. In many cases, fish are infected with multiple disease agents. There may be more than one infection associated with a group of sick fish. For example, catfish that have ESC may also be infected with another bacterial organism or have external parasites. Consideration should be given as to which of these infections should be primarily treated. Consultation with a veterinarian or a fish pathologist who is familiar with catfish diseases is important to ensure that fish receive timely and proper treatment.

Another important factor producers must consider is bacterial resistance. Some strains of bacteria are resistant to currently available antibiotics (i.e., the bacteria causing the disease will not be killed by application of the antibiotic). To avoid problems associated with bacterial resistance, a sensitivity test of the bacteria in question should always be obtained. Fish disease diagnostic laboratories routinely conduct sensitivity tests. Bacterial resistance to antibiotics may result from indiscriminate feeding of medicated feeds or from using feeding schedules not prescribed by the FDA. It is important to remember that once a bacterial strain becomes resistant to an antibiotic, it may be impossible to treat future disease outbreaks due to the lack of effective legal antibiotics. The antibiotic not resisted by the bacterium should be used, or an alternate treatment strategy is recommended.

When producers use medicated feed, they should make every effort to ensure that fish consume the feed and receive the proper dose of antibiotic. Several practices can help ensure that fish consume the feed. Fish should be submitted for diagnosis as soon as any potential problems are observed. If disease outbreaks are allowed to progress for a long period, fish may be too weak to feed, and treatment with medicated feed will prove useless. Fish should be fed when dissolved oxygen concentrations are relatively high. Feeding fish more than once a day and feeding over a large portion of the pond rather than in one area may also help increase consumption of medicated feed.

When fish are treated with medicated feed, losses may not immediately subside. Even if detected early, bacterial diseases may affect a portion of the fish in a pond to an extent that they will not consume feed. These fish normally will continue to die during and after the treatment period, but the remaining fish in the pond that consume medicated feed have a good chance for recovery.

Restrictive feeding regimens — in which nonmedicated feed is totally or partially withdrawn during an ESC episode — have been used as an alternative method for managing outbreaks of the disease. Effective implementation of the restrictive feeding regimens depends on several factors, including stage and severity of the infection and fish size (whether fish are in fingerling or food-fish production). Readers are referred to *Considerations for Determining Treatment Strategies to Control Bacterial Infections in Channel Catfish* published by David Wise of NWAC (NWAC News vol. 1, no. 1, 1998, www.msstate.edu/dept/tcnwac/Vol01No1Dec1998.pdf) for details for treatment strategies for bacterial infections.

Mississippi State University

Printed on Recycled Paper

Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the Mississippi Agricultural and Forestry Experiment Station and does not imply its approval to the exclusion of other products that also may be suitable.

Discrimination based upon race, color, religion, sex, national origin, age, disability, or veteran's status is a violation of federal and state law and MSU policy and will not be tolerated. Discrimination based upon sexual orientation or group affiliation is a violation of MSU policy and will not be tolerated.

msucares.com