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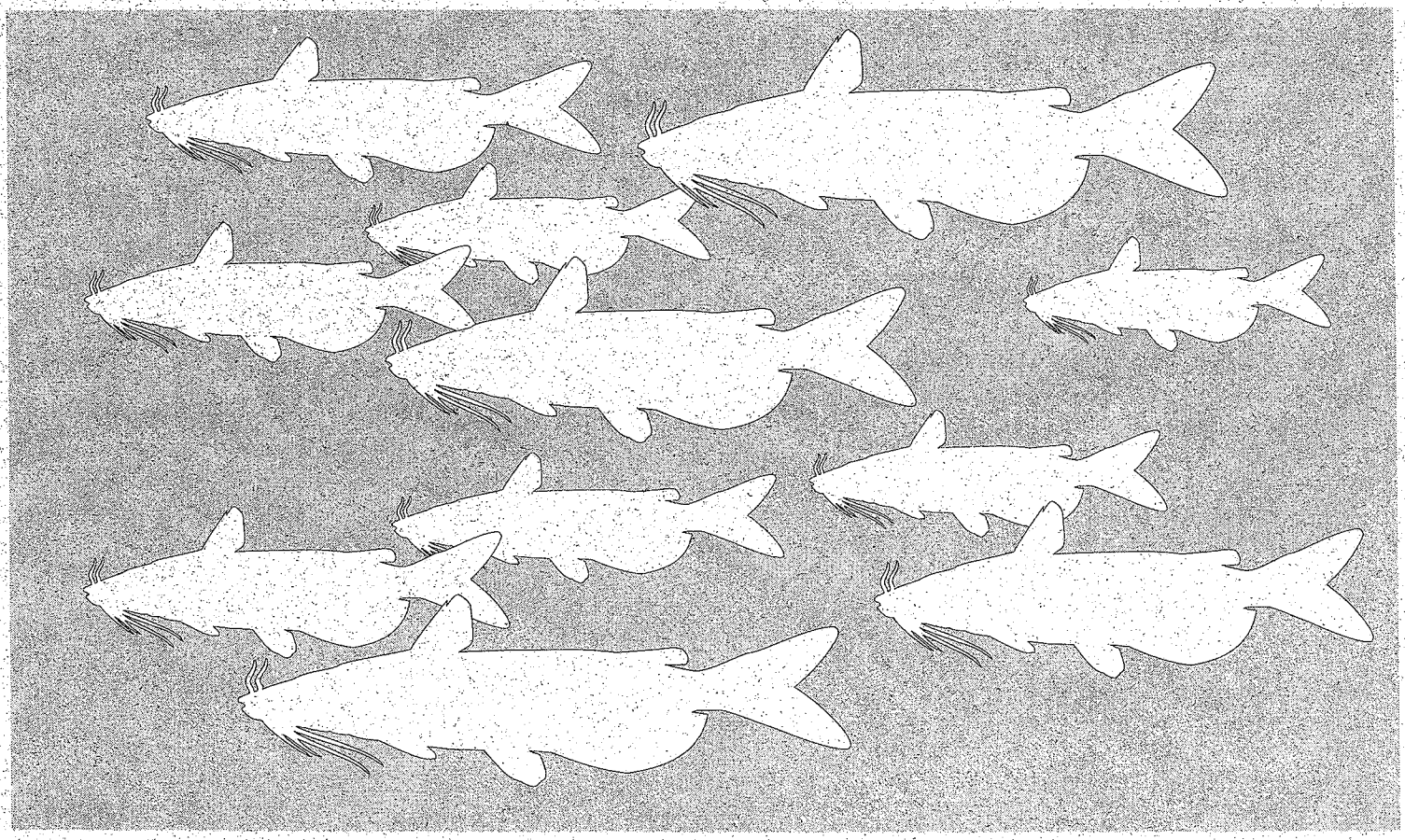
FEEDING CATFISH



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Feeding Catfish

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Preface

Although considerable research has been conducted on feeding catfish, feeding is far from an exact science. It is a highly subjective process that differs greatly among catfish producers. Basically, there does not appear to be one "best" method for feeding catfish, particularly considering that numerous factors (most of which cannot be controlled) affect feeding. The information presented herein was taken from various research and extension publications, from personal observations, and from information provided by commercial catfish producers. Since feeding catfish is as much an "art" as a science, the information presented herein is intended only as a guide.

Acknowledgments

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Introduction

Over the last several years, catfish culture has become more intensive with emphasis on high yields. Stocking densities for commercial catfish ponds have increased from about 2,000 fish per acre to densities of 10,000 or more fish per acre, and feeding rates have increased from 30 to 100 or more pounds per acre per day. As a result, feed quality and feeding practices have become even more critical. Prepared feeds that meet the nutrient needs of the fish must be used, and they must be fed prudently to avoid waste.

Early catfish producers depended primarily on natural pond organisms to provide nutrients essential for fish growth. Fish production was often enhanced by the addition of fertilizers to pond water to stimulate the growth of natural food organisms. Prepared feeds (mixtures of feedstuffs processed into various forms) were first used to supplement natural productivity. Supplemental feeds were largely steam-pelleted (sinking) feeds that provided protein and energy but were generally deficient in micronutrients, such as vitamins, minerals, and essential fatty acids. Requirements for some micronutrients were met from those present in feed ingredients and/or natural foods. Supplemental feeds provided sufficient nutrition as long as fish stocking rates did not exceed 2,000 to 3,000 fish per acre.

As stocking rates increased and the contribution of natural food decreased, there was an apparent need for more nutritionally complete feeds. Prepared feeds that provided all known nutrients required by catfish, as well as sufficient energy needed for their metabolism, were developed and manufactured either by steam pelleting into sinking pellets or by extrusion to make pellets that would float on the water surface. Floating pellets had the advantages of good water stability and allowed the catfish producer to observe feeding activity.

Even though catfish have been cultured for many years, there is still considerable variation in feeding practices on commercial catfish farms. There may be no one "best" method to feed cultured catfish. Computer programs, which generally determine feeding rate based on a percentage of fish body weight, are available and are used by some catfish producers. Feeding a prescribed amount of feed based on fish biomass in a particular pond works best when the biomass in each pond is known and a fairly accurate estimate of feed conversion can be made.

However, because most catfish producers do not clean harvest but remove harvestable fish and then understock with fingerlings, after a year or so it is difficult to accurately determine inventory. In fact, many catfish producers judge their inventory by the amount of feed they feed.

As a result, catfish are generally fed once daily to what is commonly called satiation, i.e. feeding the fish all they will ingest in a reasonable period of time. However, feeding to satiation is highly subjective and satiation is often difficult to achieve, particularly in ponds containing a high standing crop of fish.

There are numerous factors to consider prior to feeding. Typical feeding practices have to be modified for feeding diseased fish or feeding fish during winter. In some instances, it may be desirable to restrict feed or to completely withhold feed. Feeding practices that promote rapid weight gain and high feed efficiency, which generally optimize profits, should be used.

This bulletin is intended to provide information on catfish feeding practices as well as nutrient sources for catfish. Natural foods and prepared feeds will be discussed, in addition to fish size and feeding response, feeding methods, winter feeding, feeding diseased fish, effect of feeds on sensory quality of processed fish, and compensatory growth.

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, and invertebrates such as insects and crustaceans. Many of these organisms are high in protein and other essential nutrients and may contribute to the diet of pond-raised catfish.

The degree that natural food organisms contribute to the nutrition of intensively-grown channel catfish is still relatively unclear. While some commercially cultured fish that feed low on the food chain (such as tilapia and silver carp) make excellent gains on natural foods, channel catfish require prepared feeds for maximum yields. Although natural food organisms are abundant in most catfish ponds, their contribution to growth of stocker-size fish has been generally thought to be minimal. For example, studies conducted at Auburn University estimated that only 2.5% of the protein requirement and 0.8% of the energy needed for catfish grown in intensively-fed ponds was obtained from natural food. However, natural food organisms apparently contribute

significantly to the nutrition of newly-stocked catfish fry.

The major contribution of natural food organisms to the nutrition of commercially cultured catfish may be from nutrients that are required in trace amounts such as vitamins, minerals, and essential fatty acids. Recent studies with catfish have shown that while vitamin deficiencies could be produced by feeding catfish purified diets devoid of various vitamins in aquaria under controlled laboratory conditions, the same deficiencies could not be produced in catfish raised in ponds fed practical feeds lacking a specific vitamin. Thus, the vitamin requirement was met either from naturally occurring vitamins in feedstuffs, natural food organisms, or from a combination of the two.

Studies have also been conducted with minerals and essential fatty acids with similar results. These data indicate that catfish are receiving nutritional value from purposefully or inadvertently consuming natural food organisms. To investigate this topic further, researchers at the Delta Branch Experiment Station (DBES) are in the process of evaluating nutrient profiles of phytoplankton and zooplankton commonly present in commercial catfish ponds.

Feeding

A typical catfish production scheme includes feeding fish in various stages of their life cycle in an aquatic environment that varies widely in temperature and in quality. In addition, diseases and environmental stressors often impact feeding activity. Thus, to maximize production and profits, catfish should be fed a feed that meets their nutritional requirements using a feeding strategy that is adapted to the specific culture conditions at any given time. That is, under normal conditions, catfish should typically be fed daily as much feed as they will consume without adversely affecting water quality. However, depending on water temperature and other water quality parameters and on the health of the fish, it may be prudent to restrict the daily feed allowance or to feed less frequently. How much to feed and the frequency of feeding are decisions that must be made daily by catfish producers based on each pond of fish. No two ponds are exactly alike and as a result fish feeding behavior in individual ponds may differ greatly or feeding activity in a particular pond may vary greatly from day to day (Figure 1).

A general description of feeding practices and feeds for fry, fingerling, growout, and brood catfish are presented in the following sections. The recommendations given should be considered as guidelines because no single feed or feeding method is suitable for all circumstances.

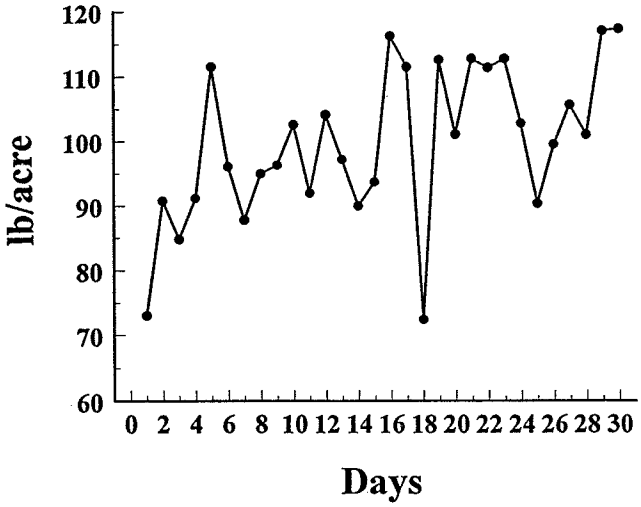

Figure 1. Example of daily feed consumption in one experimental pond for period July 16 to August 14 when fish were fed to satiation.

Warm Weather Feeding

Fry. Newly-hatched catfish fry, which are only about 1/4-inch in total length, are usually held in indoor troughs and tanks for about 10 days before releasing into outdoor nursery ponds. Initially, catfish fry use their yolk sac as an energy and nutrient source. Once the yolk sac is absorbed (approximately 3 to 5 days after hatching), fry begin to seek food and should be fed frequently. In the hatchery, fry should be fed finely-ground meal or flour-type feeds (Table 1) containing 45 to 50% protein supplied primarily from

Table 1. Examples of typical catfish fry and fingerling feeds.

	Feed[a]	
Ingredients (%)	Fry (50% protein)	Fingerling (35% protein
Soybean meal (48%)b	–	38.8
Cottonseed meal (41%)	–	10.0
Menhaden meal (61%)	60.2	6.0
Meat/bone/blood (65%)	15.3	6.0
Corn grain	–	16.1
Wheat middlings	19.0	20.0
Dicalcium phosphate	–	1.0
Catfish vitamin mix[c]	0.3	0.1
Catfish mineral mix[c]	0.1	0.025
Catfish oil[d]	5.0	2.0

[a]For fingerlings less than 4 inches in length. After they reach 4-5 inches, 32 or 28% protein good quality feed may be fed.
[b]Percentage protein.
[c]Commercial mix that meets or exceeds requirements for catfish.
[d]Sprayed on after extrusion to reduce feed dust.

fishmeal at a daily rate equal to about 25% body weight divided into 8 to 10 equal feedings.

It is difficult to effectively feed catfish fry recently stocked into large nursery ponds. The tiny fish spread out over the pond and are relatively weak swimmers so they are not able to move rapidly to areas where manufactured feeds are offered. 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 fry nursery pond when the fish are stocked. Natural foods for channel catfish fry include insects, insect larvae, and zooplankton (microscopic crustaceans). Insects and zooplankton eat plant material in the pond, so to produce them in abundance you must either increase natural plant production within the pond by fertilization or apply the plant material directly to the pond.

Regardless of how you manage the pond for increased production of natural foods, it is important to plan ahead because time is needed for the population of insects and zooplankton to become established in the pond.

The simplest way to prepare the pond for stocking fry is to use a chemical fertilizer to stimulate a bloom of phytoplankton (the microscopic plants that give water the green color). The phytoplankton bloom then serves as food for insects and zooplankton. Start fertilizing the pond about 3 weeks before stocking the fry so that ample time is available for development of a bloom. High-phosphorus liquid fertilizers are the most effective fertilizer material for catfish ponds. Typical analyses for these fertilizers are 10-34-0 and 13-18-0.

Apply about a half gallon of liquid fertilizer per acre every other day for 10-14 days or until a noticeable bloom develops. After the bloom develops, continue fertilizing the pond once or twice a week for 3-4 weeks after the fry have been stocked. By that time, the fry (now small fingerlings) should be feeding on manufactured feed and fertilization is no longer necessary.

Fertilizing ponds with chemical fertilizers does not always produce a good bloom, and a more dependable way to produce abundant natural food is to apply organic material directly to the pond. The organic material serves as a direct food source for insects and zooplankton and also slowly decomposes to release plant nutrients that stimulate development of a phytoplankton bloom. Good organic fertilizers include alfalfa pellets, cottonseed meal, or any high-quality hay. Start applying the organic material about 2 weeks before stocking fry. Apply the material twice a week at 100 to 200 pounds per acre. After stocking the fry, reduce the rate to 25 pounds per acre once or twice a week. Adding liquid chemical fertilizer at a half gallon per acre once or twice a week in addition to the organic fertilizer will produce even more rapid and dependable results. Stop fertilizing the pond when the fingerlings begin vigorously accepting manufactured feed.

Even though fry presumably meet their nutrient needs from natural food organisms, they should be fed once or twice daily using finely-ground feed at a rate equal to 25 to 50% of fry biomass. Since the feed serves primarily to fertilize the pond, it is not necessary to feed a high protein feed like that used in the hatchery. Fines from regular 28% or 32% growout feeds are suitable for catfish fry during this phase. Some catfish producers do not feed the flour-type feeds, but feed 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 or 2 inches in length and will come to the pond surface seeking food.

Flour- or meal-type feeds (Table 1) are usually prepared by either reducing the particle size of a steam-pelleted or extruded feed by grinding and screening to the appropriate size or by finely grinding feed ingredients to a particle size of less than 0.5 mm and mixing the ground ingredients. Meal-type feeds prepared from an extruded feed are generally better fry feed than those produced by grinding a steam-pelleted feed. Fry feeds should be overfortified with vitamins because water soluble vitamins are lost by leaching into the water. Fry feeds should also be sprayed ('top dressed') with oil (fat) to improve water stability and reduce nutrient loss. Oil also serves as an energy source.

Fingerlings. Initially, small fingerlings (1-2 inches) should be fed once or twice daily to satiation using a crumbled feed or small pellets (1/8-inch diameter) containing 35% protein (Table 1), a part of which should be supplied by fishmeal, meat and bone/blood meal, or a mixture of the two protein sources. Some catfish producers feed fingerlings the same feed they feed to fish for growout. 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.

Growout (food fish). Catfish grown for food are usually stocked as advanced fingerlings of about 5-6 inches in length (about 50-60 lb/1,000 fish). They are generally fed a floating feed of approximately 5/32- to 3/16-inch diameter containing 28 to 32% protein (Table 2). It has generally been recommended to start with a 32% protein feed in early spring when temperature is relatively low and fish are feeding with less vigor, and as the temperature increases and the fish are feeding vigorously change to a 28% protein feed and feed to satiation. Starting with the 32% pro-

Table 2. Examples of typical catfish growout feeds.

Ingredient	% of feed					
	(32%)[a]	(32%)	(32%)	(28%)	(28%)	(26%)[b]
Soybean meal (48%)[a]	36.5	34.5	22.5	26.3	25.5	21.3
Cottonseed meal (41%)	10.0	12.0	27.5	10.0	10.0	12.0
Menhaden meal (61%)	4.0	–	4.0	4.0	–	4.0
Meat/bone/blood (65%)	4.0	8.0	4.0	4.0	4.0	4.0
Corn grain	22.9	22.4	21.1	30.6	31.4	51.4
Wheat middlings	20.0	20.0	18.0	22.5	22.5	4.0
Dicalcium phosphate	1.0	1.0	1.0	1.0	1.0	1.0
Lysine-HCl	–	–	0.275	–	–	–
Catfish vitamin mix	include	include	include	include	include	include
Catfish mineral mix	include	include	include	include	include	include
Catfish oil[c]	1.5	2.0	1.5	1.5	1.5	1.5

[a]Percentage protein.
[b]Can be used for growout catfish. Catfish fed a 26% protein feed generally contain a higher level of body fat than those fed 28 or 32% protein feeds. Also, may decrease dressed yield.
[c]Sprayed on finished feed pellet to reduce feed dust ('fines').

tein feed may be unnecessary because there is evidence that the 28% protein feed can be used throughout the growout phase without detrimental effects. Protein levels as low as 25% may provide similar growth as feeds containing higher levels of protein if the fish are fed to satiation. Because management practices vary greatly throughout the catfish industry, the choice of which feed to use is up to the individual catfish producer.

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. Feeds should be scattered over a large area to provide equal feeding opportunities for as many fish as possible. It is desirable to feed on all sides of the pond, but this is generally not practical on large farms where several ponds of fish must be fed in a limited period of time. Also, prevailing winds dictate that feed must be distributed along the upwind levee to prevent it from washing ashore.

Typically, catfish producers feed once a day, 7 days a week. Feeding twice a day appears to improve growth and feed efficiency. However, the logistics of multiple feedings on large catfish farms generally make it impractical. Under certain circumstances less frequent feedings may be desirable. For example, during certain disease episodes, or during extremely hot weather, it may be beneficial to feed every other day or every third day.

Feed allowance is affected by several factors, including fish standing crop, fish size, water temperature, and water quality. Water temperature has profound effect on feeding rate (Table 3). As fish size increases, feed consumption as percentage of body weight decreases and feed conversion increases (Table 4). Because catfish are generally cultured using a

Table 3. Example of feeding rate for growout catfish fed once daily to satiation from May to October in ponds stocked at a rate of 10,000 fish/acre in a single-batch system in the Mississippi Delta.

Date	Water Temperature (°F)		Fish size (lb/1,000 fish)	Feeding rate (% body weight)
	7:00 a.m.	4:00 p.m.		
May 1	68	73	110	2.1
May 15	72	79	136	3.4
June 1	70	77	180	2.9
June 15	81	86	244	3.2
July 1	81	88	316	2.7
July 15	82	88	388	2.4
August 1	82	90	513	1.8
August 15	81	86	628	2.0
September 1	77	86	739	1.5
September 15	77	86	841	1.3
October 1	68	72	1,019	1.1

Table 4. Estimated feed consumption and feed conversion ratio for different sizes of catfish at optimum temperature.

Fish body weight (lb/1,000 fish)	Feed consumption (% body weight)	Feed conversion ratio
60	4.0 - 4.5	1.1 - 1.2
100	3.5 - 4.0	1.3 - 1.4
300	2.5 - 3.0	1.4 - 1.6
600	2.0 - 2.5	1.6 - 1.8
750	1.5 - 2.0	1.8 - 1.9
1,000	1.3 - 1.5	1.9 - 2.0
2,000	1.1 - 1.2	2.0 - 2.2
3,000	1.0 - 1.1	2.2 - 2.4

multiple-batch production system in which several sizes of fish are present in the pond, it is recommended that they be fed to satiation. Offering as much feed as possible (without wasting feed) provides a better opportunity for the smaller less aggressive fish to receive feed. Satiation feeding appears to be particularly important when catfish are fed less frequently than on a daily basis.

Although it is recommended that catfish typically be fed as much feed as they will consume, at high standing corps of fish it may be impossible to satiate the fish and maintain water quality at an acceptable standard. As a rule of thumb, feeding rates should not exceed what can be assimilated by organisms in the pond. This is difficult to judge, but generally long-term average feed allowance should not exceed 100 to 120 lb/acre/day. However, exceeding this rate for a few days should be acceptable. Overfeeding should be avoided since wasted feed increases production cost by increasing feed conversion (Table 5). Also, uneaten feed contributes to deterioration of water quality.

The best time of day to feed is still debated, but the point is more or less academic. On large catfish farms, the time fish are fed is largely dictated by the logistics required to feed large numbers of ponds in a limited time period. As a result, many catfish producers start feeding early in the morning as soon as dissolved oxygen levels begin to increase.

Some catfish producers and scientists argue that it is best to begin feeding mid-morning or early afternoon. A study conducted in ponds at this station showed no significant differences in weight gain, feed consumption, feed conversion, and survival among catfish fed to satiation at 8:30 a.m., 4:00 p.m., and 8:00 p.m. There were also no differences in emergency aeration time among treatments. However, feeding late afternoon or at night in large commercial catfish ponds is not recommended because it may not be possible to aerate a commercial catfish pond as can be done in a small experimental pond. Peak oxygen demand generally occurs about 6 hours after feeding. If dissolved oxygen levels are particularly low at this time and aeration is insufficient, fish may be stressed or die. Generally, it appears most practical to begin

Table 5. Feed cost in cents per pound of catfish produced at different feed conversion ratios and feed prices.

	Feed cost (cents/lb fish produced)					
	Feed price (cents/lb, dollars/ton in parentheses)					
Feed conversion ratio	10.0 (200)	11.25 (225)	12.5 (250)	13.75 (275)	15.0 (300)	16.26 (325)
1.3:1	13	15	16	18	20	21
1.4:1	14	16	18	19	21	23
1.5:1	15	17	19	21	23	24
1.6:1	16	18	20	22	24	26
1.7:1	17	19	21	23	26	28
1.8:1	18	20	23	25	27	29
1.9:1	19	21	24	26	29	31
2.0:1	20	23	25	28	30	33
2.1:1	21	24	26	29	32	34
2.2:1	22	25	28	30	33	36
2.3:1	23	26	29	32	35	37
2.4:1	24	27	30	33	36	39
2.5:1	25	28	31	34	38	41
2.6:1	26	29	33	36	39	42
2.7:1	27	30	34	37	41	44
2.8:1	28	32	35	39	42	46
2.9:1	29	33	36	40	44	47
3.0:1	30	34	38	41	45	49
3.5:1	35	39	44	48	53	57
4.0:1	40	45	50	55	60	65

feeding in the morning as the dissolved oxygen begins to increase.

Broodfish. Catfish broodstock is usually fed the same feed used for growout. Some catfish producers prefer feeding sinking feeds because broodfish are often hesitant to feed at the surface. However, because brooders generally feed slowly, sinking pellets may disintegrate before they can be consumed. Some catfish producers supplement commercial feeds for brood fish with live or frozen forage fish, such as golden shiners. It is recommended that catfish brooders be fed a typical 28 to 32% protein feed once daily. The feeding rate should be about 1% fish bodyweight.

Winter Feeding

Although catfish feed inconsistently at water temperatures below 70°F, a winter feeding program appears to be beneficial to prevent weight loss and maintain fish health. Research has shown that significant increases in weight gain can be obtained in fish fed during the winter months as compared to fish that were not fed. This appears to be particularly true with fingerlings. The health aspect of winter feeding is less well defined, but logically one would expect fish fed during the winter to be in better condition and perhaps more resistant to disease-causing organisms than fish that were not fed. Even so, many catfish producers do not feed during the winter months. Often fish are not fed in the winter because inclement weather may prevent access to pond levees. However, some catfish producers simply do not see any benefit to winter feeding. It has been shown that weight gain of catfish not fed during the coldest winter months catches up with that of fish fed during the winter months when satiate feeding is resumed in the spring and summer.

Even though some catfish producers choose not to feed for various reasons, considering potential weight gains and health benefits, we feel that it is prudent to follow a winter feeding program on commercial catfish farms. The following sections provide guidelines to consider in winter feeding of catfish.

Fingerlings and growout. Several schedules for winter feeding of fingerlings and food fish have been suggested. Generally, all schedules are such that water temperature dictates feeding frequency. A typical winter feeding schedule is shown in Table 6. Since most production ponds contain mixed sizes of fish at any given time, the feeding schedule chosen should be based, in addition to water temperature, on the number of small fish in the pond that require higher feeding rates and more frequent feedings.

The type of feed that should be fed during the winter has not been precisely defined. A typical growout floating feed containing 28 or 32% protein is sufficient. A 25% protein slow-sink feed (Table 7) is also available and is preferred by some producers. Either of these feeds will provide sufficient nutrition for overwintering catfish.

Broodfish. While it is important throughout the year to ensure that broodfish receive adequate nutrition, it is especially important during the winter months. It is at this time of the year that eggs which were produced by females the previous summer after spawning are developing yolks and maturing. This process requires that broodfish receive adequate nutrition on a regular basis, which makes winter feeding of broodfish important.

Feeding rates and frequencies used in winter feeding of broodfish, as with fingerlings and growout fish, are based on water temperature. A suggested

Table 7. Typical catfish winter feed and Romet-medicated feed.

Ingredient	Percent of feed	
	Winter feed (25% protein slow-sink)	Medicated feed[a] (32% protein with Romet)
Soybean meal (48%)b	18.3	26.8
Cottonseed meal (41%)	10.0	10.0
Menhaden meal (61%)	4.0	16.0
Meat/bone/blood (65%)	4.0	–
Corn grain	35.1	23.0
Wheat middlings	25.0	20.0
Dicalcium phosphate	1.0	1.0
Catfish vitamin mix	0.1	0.1
Catfish mineral mix	0.025	0.025
Catfish oil[c]	2.5	1.5
Romet	–	1.65

[a]Protein levels not critical. Could be lowered, but fishmeal needs to remain at 16%.
[b]Percentage protein.
[c]Sprayed on after extrusion to reduce feed dust.

Table 6. Winter feeding schedule for fingerling, growout, and brood catfish.

Temperature (°F)	Fingerlings		Growout		Brooder	
	% Body weight	Frequency	% Body weight	Frequency	% Body weight	Frequency
< 55	0.5 - 1.0	1 - 2 days/week	0.5 - 1.0	Weekly	0.5 - 1.0	Weekly
55 - 70	1.0 - 2.5	Daily or every other day	1.0 - 2.0	Every other day	1.0 - 2.0	2 or 3 times a week

schedule is shown in Table 6. Regardless of the specific schedule chosen, the feeding rate should not be restricted too much since the more aggressive male broodfish may outcompete females for feed which can restrict egg maturation.

The most common broodfish ration used in the winter is the same feed used to feed fingerlings and growout fish – a 28 or 32% protein floating pellet. If broodfish appear to be reluctant to feed at the surface, the 25% slow-sink feed can be used. Some catfish producers also stock forage fish (e.g. fathead minnows) into ponds to ensure that adequate food is available during the winter.

Feeding Diseased Fish

Feeding diseased fish may be difficult because fish that are sick feed poorly, if at all. However, offering medication through the feed is generally the only method available to treat bacterial infections. As with most any subject concerning catfish, there is considerable debate over the efficacy of medicated feeds (feeds containing antibiotics) and the best method to treat diseased fish. There are catfish producers who do not feed during outbreaks of certain diseases or those who limit feed to every other day. However, the efficacy of such practices is still in question.

Medicated feeds. Antibiotics can be administered to large populations of fish through the feed. Medicated feeds have been used to treat diseased fish for a number of years in other aquaculture industries (i.e. salmon and trout) and are currently accepted as the only viable alternative to treat systemic bacterial infections of catfish. Two antibiotics, Romet® (sulfadimethoxine-ormetroprim, Hoffmann-La Roche, Nutley, NJ) and Terramycin® (oxytetracycline, Pfizer, Inc., New York) are registered by the Food and Drug Administration (FDA) to treat bacterial infections of catfish through their incorporation into feeds. Another antibiotic, Sarafin® (sarafloxacin-hydrochloride, Abbott Laboratories, Chicago, IL) is currently awaiting FDA approval.

Romet is registered for control of enteric septicemia of catfish (ESC) and has also been shown to be effective in treating motile aeromonad septicemia (MAS) caused by *Aeromonas hydrophila* and systemic columnaris infections. Romet-medicated feed (Table 7) is fed at a feeding rate (dependent on the formulation of Romet used) sufficient to deliver 2.3 grams of antibiotic/100 pounds of fish/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 bodyweight daily. However, because of palatability problems, the amount added was reduced to 33.3 pounds per ton of feed and the feeding rate increased to 1% fish body weight daily.

Data from a recent study conducted at the DBES, indicated that the effectiveness of treating ESC with Romet could be increased by feeding a reduced concentration of antibiotic formulation at a greater rate – both adjusted to deliver the required legal level of antibiotic. The reason for the increased effectiveness of this feeding strategy was speculated to be due to 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 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. Research at the Delta Branch Experiment Station indicated that the level of fishmeal should be increased to 16% to improve the palatability of feeds containing Romet to catfish.

Romet is registered by the FDA 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 1/8-in diameter pellets) is usually suggested. This recommendation is based on results obtained in the aforementioned study, which showed that ESC-infected fingerlings fed medicated feed of reduced pellet sizes had better survival than those fed regular size 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, which is registered by the FDA to treat MAS infections. Terramycin has also been shown to be effective in treating other aeromonad infections, ESC, and systemic columnaris infections. The most common feed formulation currently used contains 50 pounds of TM-100® premix per ton of finished feed. The resulting medicated feed contains 2.5 grams of antibiotic/pound of feed and when fed at 1% of body weight/day delivers 2.5 grams antibiotic/100 pounds of fish/day.

Terramycin-medicated feed is usually manufactured only as sinking pellets. The antibiotic is heat-labile and does not withstand the high temperatures required to make 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* that are resistant to Romet (see below). Terramycin is registered to be fed for 7 to 10 consecutive days. A 21-day withdrawal period is required before fish are slaughtered and processed.

Research with Sarafin has shown the drug to be effective in treating ESC infections. In these experiments, fish were administered Sarafin-medicated feed for 5 consecutive days at feeding rates of 1 to 2% of bodyweight/day to deliver 0.4 to 0.5 grams antibiotic/100 pounds of fish/day. Based on the results of these studies, Sarafin, if approved for use by the FDA, appears to be an effective drug to treat ESC infections, and will be invaluable in treating ESC caused by the bacteria that are resistant to currently available antibiotics. The required withdrawal period for fish treated with Sarafin-medicated feed has yet to be determined.

Considerations. Several important considerations should be taken into account when treating fish with medicated feed. 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. For example, fish with a systemic ESC infection may also have a concurrent systemic or external columnaris infection coupled with a parasitic infection. In these situations, the choice of treatment should be made only after careful consideration of the results of an accurate diagnosis.

Another important factor producers must consider is bacterial resistance. Some strains of bacteria causing diseases in catfish 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. In a sensitivity test, the infective bacteria are cultured under laboratory conditions and exposed to available antibiotics. If the bacteria are not affected by the antibiotic, they are resistant and an alternate treatment strategy is recommended. Sensitivity tests are routinely conducted by fish disease diagnostic laboratories.

Resistance of bacteria to antibiotics may result from indiscriminately feeding medicated feed 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 because of the lack of effective legal antibiotics.

When using medicated feed, every effort should be made to ensure that fish consume the feed and receive the proper dose of antibiotic. Several practices can help ensure that fish consume 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 of time, 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 treating fish with medicated feed, losses of fish 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.

Effect of Feeds on Sensory Quality of Processed Catfish

Flavor

Commercial feeds composed of oilseed meals, grains, and animal products generally have little influence on flavor quality of farm-raised catfish. A study was conducted at the USDA Agricultural Research Service, Southern Regional Research Center, New Orleans, LA, and the USDI Fish and Wildlife Service, Fish Farming Experiment Laboratory, Stuttgart, AR, to evaluate the effects of feed ingredients on flavor quality of farm-raised catfish. Commonly used feed ingredients were substituted individually into semipurified experimental diets at levels commonly used in commercial feeds. The diets were fed to catfish under laboratory conditions for 2 months and fish were evaluated for flavor quality by a trained panel using quantitative sensory techniques. Results showed no significant differences in flavor among fish fed different experimental diets.

High levels of dietary marine fish oil may give catfish a "fishy" flavor that is undesirable, but catfish fed feeds containing 2% menhaden oil (this level is rarely exceeded in growout feeds for catfish) have no distinct "fishy" flavor. Off-flavor problems of farm-raised catfish are predominantly influenced by phytoplankton, some of which can excrete certain metabolites that are absorbed by fish. Phytoplankton growth is related to feed input, so increased feeding rates may affect fish flavor indirectly by influencing phytoplankton growth.

Appearance

Consumer acceptance of farm-raised fish depends mainly on the color of the flesh. The preferred color of catfish flesh is white. At high dietary levels, the yellow pigment xanthophyll has been shown to concentrate in catfish giving the flesh a yellowish coloration that is undesirable. Corn gluten meal is limited as a feed ingredient because of its high concentration

of xanthophyll. Corn and corn screenings contain the pigment, but it is present at concentrations that are not problematic. Other than this, feeds appear to have little effect on appearance of catfish flesh.

Fattiness

The amount of body fat found in catfish is influenced by several factors, including dietary protein level and energy/protein ratio, feeding rate, and fish size and age. Regardless of fish age and feeding rate, as dietary protein level decreases and the energy/protein ratio increases, body fat increases. Regardless of dietary protein and energy levels, fish fed to satiation generally contain more fat than fish fed at restricted levels. Presently body fat of catfish is higher than it was 20 or 30 years ago because catfish are fed more liberally today.

There is evidence that feeding synthetic compounds, such as Ractopamine® and carnitine may reduce body fat in catfish. Ractopamine is a so-called repartitioning agent that can repartition fat to synthesize protein, while carnitine is a natural compound that acts as a catalyst for fat metabolism. However, these compounds have not been approved for use by FDA.

A major concern about fattiness of catfish is that increasing fat in edible tissue may reduce the shelf-life of frozen fish. However, a cooperative study involved several universities has shown that body fat content has little effect on frozen keeping quality of catfish products.

Compensatory Growth

After a period of feed deprivation or restriction, animals have the potential to compensate or "catch up," resulting in increased growth rate after full feeding is resumed. This phenomenon is called compensatory growth. It is well documented that compensatory growth occurs in mammals and it also appears to occur in fish. A study conducted at Auburn University indicated that catfish had the ability to make up weight gain following a 3-week restricted feeding regimen where fish were fed every third day during the summer. Another study at Auburn University showed that catfish which were not fed during the winter months of December, January, and February could make up for the weight loss if the fish were fed as much as they would consume the following spring and summer.

These studies clearly indicate that catfish exhibit compensatory growth. This is of practical importance, because fish are often either not fed during the winter or fed infrequently due to factors such as inclement weather, holidays, hunting season, etc. However, it should be noted that these studies were conducted at relatively low standing crops with fish of a single size class.

In the typical multiple-batch system used to raise catfish and at high standing crops, it may be difficult to feed enough feed to fully realize potential compensatory growth and avoid the negative effects of increased feed input on water quality. Feeding to satiation is essential for compensatory growth, but at high standing crops the amount of feed necessary may exceed the capacity of the pond to "assimilate" the input and avoid poor water quality conditions.

Although compensatory growth does occur, it should not be taken as a substitute for good feed management. That is, one should not assume that severely restricting feed or not feeding at all will always be compensated for by compensatory growth. It is therefore recommended that catfish be fed daily during the growing season when culture conditions are suitable.

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In conformity with Title IX of the Education Amendments of 1972 and Sections 503 and 504 of The Rehabilitation Act of 1973, as amended, Section 402 of the Vietnam Era Veterans Adjustment Assistance Act of 1974, and The Americans with Disabilities Act of 1990, Dr. Joyce B. Giglioni, Assistant to the President for Affirmative Action, 614 Allen Hall, P. O. Drawer 6199, Mississippi State, Mississippi 39762, office telephone number 325-2493, has been designated as the responsible employee to coordinate efforts to carry out responsibilities and make investigation of complaints relating to discrimination.

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