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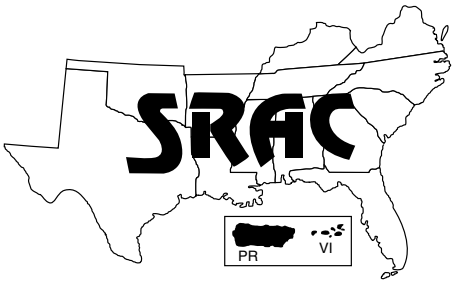

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Revision

Feeding Catfish in Commercial Ponds

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Since feeding is the most important task in the intensive pond production of catfish, the person responsible for feeding should be an experienced fish culturist who can tell whether or not the fish are feeding normally by observing them as they come to the surface to feed. This is generally the only time the fish can be seen during grow out. Feeding behavior can be an important clue to the general health of the fish and the pond environment. If the fish are not feeding normally, the person who is feeding must inform the farm manager that there may be a problem. Feed cost is the largest operating expense in catfish production, so fish should be fed a nutritious feed in a manner that results in fast growth and efficient feed conversion without degrading water quality. Because feeding is influenced by a number of uncontrollable factors and because the environment in each pond is different, there are no standard feeding practices in the catfish industry. The following recommendations are guidelines.

Feed formulations

Feeds used in commercial catfish production must contain adequate amounts of all essential nutrients to meet the fishes' total nutritional requirements for normal growth and development. All catfish feeds are manufactured commercially; none are prepared on the farm.

Manufacturers usually produce "least-cost" formulations rather than "fixed-formula" feeds. In least-cost feed formulation, the formulas vary as ingredient prices change. However, there are several limitations in the manufacture of catfish feed using least-cost formulations.

- There is a relatively small number of suitable feedstuffs.
- There is a general lack of knowledge about the nutrient levels that result in maximum profit as opposed to maximum weight gain.
- Feed mills lack the storage capacity to house a large number of different ingredients.

Examples of feed formulations used to grow catfish at various life stages are given in Table 1.

Form and size

Feeds must not only contain all essential nutrients, but must also be palatable and of a size that can be readily ingested. If fish don't eat it, or cannot eat it, maximum growth is not achieved and the producer loses money. The feed must be offered in a way that promotes total consumption to avoid waste and higher production cost. Catfish feeds are available as meal (powder), crumbles, and floating or slow-sinking pellets. Sinking feeds (prepared in a pellet mill) are seldom used in catfish production. Some producers use sinking medicated feed containing oxytetracycline because the antibiotic is sensitive to the high heat used in the manufacture of floating feeds. However, there are now floating oxytetracycline-medicated feeds made with "cold-extrusion" technology.

The size and form of feed to use depend on fish size, water temperature and the type of management used. Meal feeds are used in hatcheries and nursery ponds during the first 3 to 4 weeks of fry culture. When fry grow to about 1 to 2 inches and come to the surface seeking food, they are fed small floating pellets (1/8 inch in diameter) or crumbles. Floating feed is generally preferred because it makes feeding behavior much easier to monitor.

In commercial food fish production, floating feed pellets 5/32 to 3/16 inch in diameter are usually used. In multiple-batch cropping systems, where various sizes of fish are present in a pond, it would be desirable to use multiple feed sizes, but this is not practical in large-scale operations. Slow-

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Table 1. Examples of feed formulations used to culture catfish.

Ingredient	% of feed						
	Fry feed	Fingerling feed	Food fish feed				
	(50%)[a]	(35%)	(32%)	(32%)	(28%)	(28%)	(26%)
Soybean meal (48%)[a]	–	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[b] (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[c]	–	0.5	0.6	1.0	0.6	1.0	0.7
Catfish vitamin mix[d]	include	include	include	include	include	include	include
Catfish mineral mix[d]	include	include	include	include	include	include	include
Fat/oil[e]	5.0	2.0	1.5	1.5	1.5	1.5	1.5

[a] Values in parentheses represent the percentage protein.
[b] Other animal proteins can be used to replace menhaden meal.
[c] Phytase enzymes can be used to replace dicalcium phosphate.
[d] Commercial mixes meet or exceed all requirements for channel catfish.
[e] This is sprayed on finished feed pellets to reduce feed dust (“fines”).

sinking feeds are often used during the winter when low temperatures make catfish reluctant to come to the surface. Using a slow-sinking feed at this time gives fish a better opportunity to feed. Antibiotic-medicated feeds are available as small and large floating pellets to treat bacterial infections.

Factors affecting feeding practices

Feeding is a highly variable process among catfish producers. Some producers use computer programs that determine feeding rate based on a percentage of fish body weight. 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, since most catfish producers remove only market-size fish and replace harvested fish with fingerlings, it is difficult to know the biomass after several harvests and restockings. In fact, many catfish producers estimate their inventory by the amount of feed fed. As a result, catfish are generally fed once daily to what is commonly called satiation (that is, feeding the fish all they will eat in about 20 to 30 minutes).

Since catfish feeding activity varies with fish size and age, water temperature, water quality, and fish health status, producers must decide each day how much and how often to feed. No two ponds of fish are exactly alike; as a result, feeding behavior may differ greatly from pond to pond and from day to day. Under normal conditions, catfish should be fed daily as much feed as they will consume without adversely affecting water quality. However, depending on water temperature, water quality and the health of the fish, sometimes it may be better to restrict the daily feed allowance or to feed less frequently.

Most commercial ponds are relative large (usually 10 acres or larger). It is important that the feed be blown over a large area to make it accessible to as many fish as possible. It is better to feed on all sides of the pond, if wind conditions allow. If the wind is blowing, feed must be distributed along the upwind side of the pond to prevent it from washing ashore.

Factors affecting feed conversion

Feed conversion ratio (pounds of feed fed per pound of weight gain) is a production term used to measure how efficiently fish convert the feed to body mass. The lower the ratio, the better the feed is being used by fish. In commercial catfish production, the feed conversion ratio dramatically affects the profitability of the farm. The higher the feed conversion ratio, the higher production cost will be (Table 2). For example, at a feed price of $250 per ton, it takes 25 cents worth of feed to produce 1 pound of fish if the feed conversion ratio is 2, while it costs 38 cents (a 50 percent increase) at a feed conversion ratio of 3.

The feed conversion ratio of catfish is influenced by feed quality, fish size, feeding rate and frequency, stocking density, water temperature and water quality. Fish size appears to have a marked effect on feed conversion. As fish grow larger, the feed conversion ratio greatly increases. For example, in small experimental ponds, it takes 1.8 pounds of feed to grow 1 pound of

Table 2. Feed cost in cents per pound of catfish produced at different feed conversion ratios and feed prices.

Feed conversion ratio	Feed price, dollars/ton (cents/pound in parenthesis)					
	200 (10.0)	225 (11.25)	250 (12.50)	275 (13.75)	300 (15.0)	325 (16.25)
1.5	15	17	19	21	23	24
1.6	16	18	20	22	24	26
1.7	17	19	21	23	26	28
1.8	18	20	23	25	27	29
1.9	19	21	24	26	29	31
2.0	20	23	25	28	30	33
2.1	21	24	26	29	32	34
2.2	22	25	28	30	33	36
2.3	23	26	29	32	35	37
2.4	24	27	30	33	36	39
2.5	25	28	31	34	38	41
2.6	26	29	33	36	39	42
2.7	27	30	34	37	41	44
2.8	28	32	35	39	42	46
2.9	29	33	36	40	44	47
3.0	30	34	38	41	45	49
3.5	35	39	44	48	53	57
4.0	40	45	50	55	60	65

fish when the fish are raised from ½ pound to 1 pound (Fig. 1). However, if the fish are raised from 2 to 2½ pounds, 2.9 pounds of feed would be needed to grow 1 pound of fish. Larger fish use more energy for sexual maturation and reproduction than for growth, which increases the feed conversion ratio.

Theoretically, the best biological feed conversion ratio occurs when fish are fed to or near satiation. However, in production ponds satiation feeding usually leads to poorer feed conversion than that seen in restricted feeding programs. This is mainly because more feed is wasted when fish are fed to satiation daily. Research with food fish demonstrates that feeding to satiation daily results in greater production and weight gain, but causes the feed conversion ratio to be higher than when fish are fed no more than 80 pounds per acre per day. The 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 120 pounds per acre per day. Generally, the higher the stocking density, the lower the feed efficiency will be, but this may be due partly to poorer fish survival at higher densities. Unfavorable environmental conditions, such as temperature extremes, also can lower feed efficiency.

Warm weather feeding

Fry and fingerlings

When stocked into nursery ponds, catfish fry are tiny and are weak swimmers. They cannot 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 catfish fry include large zooplankton (micro-

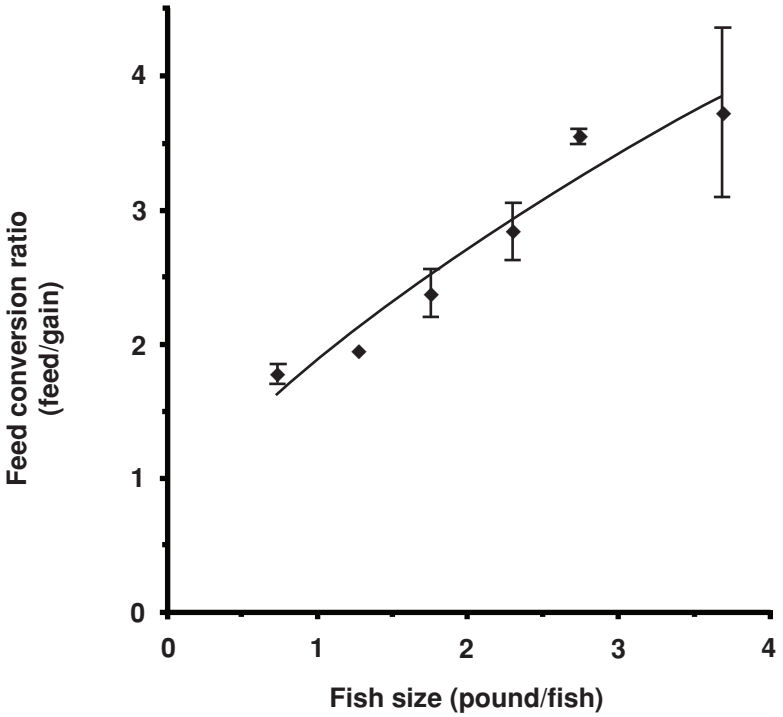

Figure 1. Relationship of fish size and feed conversion ratio for pond-raised channel catfish. Data are from a feeding study conducted with small experimental ponds.

scopic 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 fry are stocked. For pond fertilization guidelines, see "Optimizing Fry Pond Fertilization" by Charles Mischke and Paul Zimba (National Warmwater Aquaculture Center [NWAC] News, Vol. 6, No. 1, 2003, *http://www.msstate.edu/dept/tcnwac/Vol06No1Oct2003.pdf*).

Even though fry presumably meet their nutrient needs from natural food organisms, they are fed once or twice daily with a finely ground feed at a rate of 10 to 30 pounds per acre per day. Fry feed may be a secondary food source, as well 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 are suitable for catfish fry during this phase. Some catfish producers do not feed the flour-type feeds, preferring feed crumbles or floating pellets that, though largely uneaten, break up in the water and help keep the pond fertile. After a few weeks, the fry will have grown into fingerlings 1 to 2 inches long and will come to the pond surface seeking food.

Small fingerlings are typically fed once or twice daily to satiation using small floating pellets (⅛ inch in diameter) or crumble feeds containing 32% or 35% protein. Part of this ration is fish meal. Research shows that 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 producers feed fingerlings the same feed they feed to 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 with this feeding method, but much of the feed's nutrient value (especially micronutrients such as vitamins and minerals) is probably lost because of the extended time the pellet is in contact with the water.

Food fish

Commercial feeds for food fish generally contain 28% or 32% protein. A 26% protein feed is also available from some feed mills. Research has shown that protein levels as low as 24% can support maximum growth if fish are fed as much as they will eat. Low-protein feeds cost less, but usually result in more body fat and lower processed yield. Research has shown that there is a marginal difference in the processed yields of fish fed a 28% or 32% protein feed (about 0.3 to 0.4 percentage unit reduction in fish fed the 28% protein diet), but the difference may be significant to catfish processors. The type of feed to choose depends on whether fish prices are based on live weight or on processed yield. Although fish fed higher protein feeds (35% to 40%) have better processed yield and lower body fat content, these feeds usually are not economical.

Several factors influence how much to feed in a production pond. These include fish size, standing crop (number and weight of fish present in the pond), water temperature, water quality and weather conditions. Food fish are typically fed daily to apparent satiation without adversely affecting water quality. Feeding as much as the fish will eat is especially important in a multiple-batch cropping system because it gives the smaller, less aggressive fish more opportunity to feed. However, feeding to satiation is not an easy task because it is difficult to determine when the fish are satiated. Thus, it is easy to overfeed, which wastes feed and may cause water quality problems. Feeding rates should not exceed what can be assimilated by microorganisms in the pond. Long-term, average daily feeding rates should not exceed 120 to 150 pounds per acre.

On a large farm, the feeding time is mainly dictated by the large number of ponds that must be fed in a limited time. Studies conducted at the NWAC show 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., 4:00 p.m. and 8:00 p.m. No differences in aeration time were noted either. However, feeding near dark or at night is not recommended for large commercial ponds unless sufficient aeration is available. The fishes' peak oxygen demand occurs about 6 to 12 hours after feeding. If fish are fed at night, peak oxygen demand will occur when dissolved oxygen levels are low. In cool weather (late fall, winter and early spring), water temperature is usually higher in the afternoon and fish will eat better then. During warm weather, many catfish producers start feeding early in the morning as soon as dissolved oxygen levels begin to increase. This appears to work well.

Feeding once daily is usually satisfactory for food fish grow out. Research has shown that feeding twice daily is not necessarily beneficial because the increased amount of feed was not completely converted into weight gain. It is likely that feeding twice daily increases the feed conversion ratio because over-feeding can waste feed if the feeder is not careful.

During the growing season, most food fish producers feed seven days a week, although some feed six days a week. Research conducted at the NWAC, using a single-batch cropping system, showed that feeding fish to satiation six days a week (not feeding on Sundays) reduced net production by 3.3 percent, compared with fish fed seven days a week. Feeding five days a week (not

feeding on both Saturdays and Sundays) further reduced net production (by 6.9 percent). The feed conversion ratio was reduced by 4.8 percent for fish fed six days and by 7.9 percent for fish fed five days a week. When you consider all factors (a slight decrease in net production, slight improvement in feed conversion, and possible reduction in other costs associated with feeding), feeding six days per week may reduce production cost. However, feeding only six days per week is not recommended if feed is restricted rather than offered to satiation because the restriction will further reduce fish production. This is also true for a multiple-batch cropping system, since the smaller fish may have less chance to feed.

Feeding less frequently than daily may be called for under certain circumstances. Research at the NWAC has shown that fish fed to satiation every other day eat up to 50 percent more feed on days fed, and fish fed every third day eat up to 65 percent more feed, compared with fish fed once daily. Catfish are capable of regaining all or part of the weight they lose during a short period of feed restriction once full feeding is resumed. Although there are some advantages (lower feed conversion ratio and lower costs for labor and aeration) to feeding every other day or every third day, this practice is not recommended for routine feeding because the fish fed can not eat enough feed on the days they are fed to make up for all the feed missed. Also, feeding every other day or every third day extends the production cycle and may reduce processing yield, so in the long run it may not be economical.

Sometimes when fish reach market size but cannot be harvested because of off-flavor or other issues that delay harvest, they may be fed a minimum amount just to maintain body weight with no gain or loss of weight. This maintenance feeding is done by feeding a maintenance ration daily or by feeding to apparent satiation once or twice a week. Since fish of various sizes are usually present in a pond at the same time, it is better to feed all they will eat on days fed than to feed a little every day. Feeding the fish all they will eat on the days fed will allow the smaller, less aggressive fish to feed. Based on research at the NWAC, it appears that feeding once a week to satiation can maintain the body weight of food-size catfish in a single-batch cropping system. However, feeding more frequently will improve the body conditions of the fish.

Winter feeding

Unlike warm-blooded animals, catfish do not feed consistently when water temperatures are below 70 °F (21 °C). At water temperatures of 50 °F (10 °C) and below, catfish more or less stop eating. Many producers do not feed during the winter for various reasons, one of which is that it is difficult to see a positive response from a winter feeding program. Research shows that winter feeding is beneficial, though the benefit 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. A recent study showed that food-size catfish fed from mid-November to mid-March gained about 15 percent more body weight, while fish that were not fed did not gain or lose weight. There is no precise temperature at which to feed during the winter, but as a general rule, from November to March when afternoon water temperatures are 55 to 65 °F (13 to 18 °C), feeding about 20 to 30 pounds per acre once or twice a week appears to be sufficient. When temperatures are above 65 °F (18 °C), feed two or three times a week.

Since fish feed less in winter than in summer, it is thought that catfish may respond better to a sinking feed than to a floating feed during the winter. Sinking feed should be an extruded feed (slow-sinking) and not a feed made through a pellet mill. Extruded feeds are more stable in water and will remain intact longer than a feed prepared in a pellet mill.

Summary

Feeding catfish is more an art than a science. There is no best feeding method for the whole catfish industry because each farm, and even each pond on the same farm, is different. To maximize profits, producers must decide what type of feed and feeding method are best for their particular operations. The bottom line is economics. Factors to consider are fish price, feed price, and whether the product price is based on live weight or processed yield. Here are general guidelines for feeding healthy fingerlings and food fish:

- Feed small fingerlings (less than 25 pounds per 1,000) a 32% or 35% protein feed twice daily to satiation.
- Feed stockers and food fish a 28% protein feed once a day to satiation, but do not distribute more feed than the pond can safely "metabolize" to prevent water quality problems.
- If fish are fed every other day, feed a 32% protein feed to satiation.
- Harvest food fish at 1½ pounds for efficient feed conversion if that size is acceptable to the processing plant.
- Feed 20 to 30 pounds per acre of a slow-sinking feed once or twice a week during the winter when afternoon water temperatures are 55 to 65 °F (13 to 18 °C). Feed two or three times a week when temperatures are above 65 °F (18 °C).

SRAC fact sheets are reviewed annually by the Publications, Videos and Computer Software Steering Committee. Fact sheets are revised as new knowledge becomes available. Fact sheets that have not been revised are considered to reflect the current state of knowledge.

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