Winter Feeding of Channel Catfish in Mississippi, Arkansas and Texas[1]

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Abstract: Fingerling channel catfish (*Ictalurus punctatus*) fed a 25% crude protein practical feed grew as well as or better than fingerlings fed a 35% crude protein practical feed in both Mississippi and Arkansas ponds during 2 consecutive winters. Fingerlings in Texas grew better on the 35% protein feed, although poor survival may have affected the results. The 35% protein feed provided no growth advantage to adult fish in Mississippi. Both feeds had equivalent energy to essential amino acid ratios and both contained 12% fish meal. There were minimal differences in feed conversion ratios and survival of fish fed the 2 feeds in Mississippi and Arkansas.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 36:162–171

Channel catfish were seldom fed during the winter in the early years of the catfish industry. It was noted, however, that brood stock were in better condition in the spring if forage fish were present in broodstock overwintering ponds. Recently, winter feeding programs have been initiated by nearly

[1] Mississippi Agricultural and Forestry Experiment Station Publication N. 5232.

50% of the Mississippi catfish producers (Tom Wellborn 1982, Extension Wildlife and Fisheries, Mississippi State University, pers. commun.).

Research on winter feeds and feeding practices has been limited. Lovell and Sirikul (1974) overwintered 0.45 kg (1.0 lb) catfish and found that non-fed fish lost 9.1% of their weight, while fish fed at a rate of 1% of body weight when water temperatures were 12 C or above, gained 18.6% of their initial weight. Felts (1977) reported a weight loss of 6.3% for non-fed overwintering catfish compared to a gain of 7.9% for fish fed on days when water temperature exceeded 12 C. Reagan and Robinette (1978) reported that fingerling catfish fed 6 days a week gained 45% of their initial body weight compared to a 21% gain for fish fed 3 times per week during a mild winter; but during a severe winter it was advantageous to feed only 3 days per week.

Robinson (1976, unpublished report, Alabama Agricultural Experiment Station, Auburn University) fed 25% and 35% protein feeds to sub-adult catfish in ponds and evaluated high and low percentages of fish meal at each protein level. The high fish meal diets (14% and 19%) produced an average 14.7% weight gain compared to an 8.9% weight gain for the low fish meal diets (4% and 5.5% fish meal). Weight gains were not significantly different ($P > 0.05$), but results suggested that fairly high levels of fish meal in winter catfish feeds increased growth rates.

From the standpoint of weight gain, it seems obvious that winter feeding should be practiced. However, little information exists concerning the most economical, yet nutritionally satisfactory feed for winter feeding programs. As part of the USDA S-83 Regional Project, *Freshwater Food Animals,* Mississippi State University, the University of Arkansas at Pine Bluff and Texas A&M University entered into a cooperative winter feeding study. The objectives of the study were to evaluate growth, feed conversion, survival, and body composition of adult and fingerling channel catfish fed a 25% or a 35% crude protein feed.

We thank John E. Waldrop, Department of Agricultural Economics, for computer assistance in developing the experimental feeds; Martin W. Brunson, Department of Wildlife and Fisheries, for statistical analyses; and Craig Tucker, Delta Branch Experiment Station, for field assistance, all of Mississippi State University. We thank Producer's Feed Company, Isola, MS for milling the experimental feeds.

Methods

A 25% crude protein experimental sinking feed was formulated at Mississippi State University to be compared to a commercial 35% crude protein sinking feed currently used in Mississippi for winter feeding of channel catfish. The 25% protein feed was formulated to maintain energy to lysine and methionine + cystine ratios equivalent to the commercial feed (Tables 1 and 2). Availabilities of amino acids were based on digestibility values of Wilson et al. (1981) and energy values were primarily based upon Cruz (1975). Both feeds contained 12% fish meal. Control fish were not fed during the study periods. Each treatment (25% and 35% protein) and the controls

Table 1. Composition (%) of Feeds Fed to Channel Catfish During the Winters of 1980–81 and 1981–82

	25% Protein		35% Protein	
Ingredient	1980–81	1981–82	1980–81	1981–82
Corn	5.30	5.30	16.00	20.15
Menhaden	12.00	12.00	12.00	12.00
Wheat	2.00	2.00	16.00	15.80
Rice bran	30.45	31.80		
Rice mill feed	18.75	20.00		
Soybean meal (44%)	27.65		55.00	
Soybean meal (48%)		25.00		50.80
L-lysine	0.25	0.25		
Methionine (DL)	0.11	0.11		
Dicalcium phosphate	0.78	0.78	0.80	1.00
Masonex	2.50	2.50		
Vitamin premix[a]	0.10	0.10	0.10	0.10
Trace mineral premix[b]	0.05	0.05	0.05	0.05
Choline chloride	0.05	0.05	0.05	0.05
Ascorbic acid	0.03	0.05	0.03	0.05
Digestible lysine	1.43	1.53	1.79	1.98
Digestible methionine + cystine	0.77	0.76	0.94	0.90
Digestible energy (kcal/kg)	1,967	2,002	2,477	2,561

[a] Provides (as mg/kg) ascorbic acid, 382; ethoxyquin, 5.5; Vitamin E, 33; Vitamin B_{12}, 9; Riboflavin, 7; Niacin, 27; d-Pantothenic acid, 10; Menadione, 2; Folic acid, 0.5; Pyridoxine, 9; Thiamine, 5; (as I.U.) Vitamin A, 2200; Vitamin D_3, 550.

[b] Provides (as mg/kg): Manganese, 100; Zinc, 100; Iron, 7; Copper, 7; Iodine, 2.4.

Table 2. Proximate Analyses (%) of the 25% and 35% Protein Sinking Channel Catfish Feeds Fed During the Winters of 1980–81 and 1981–82

	25% Crude Protein		35% Crude Protein	
	1980–81	1981–82	1980–81	1981–82
Crude Protein	25.6	25.5	35.0	34.2
Crude Fat[a]	6.8	10.5	3.0	6.2
Crude Fiber	8.2	9.5	4.3	3.2
Nitrogen Free Extract	38.0	34.7	39.0	39.2
Ash	10.1	10.9	6.6	7.2
Moisture	11.3	9.0	12.1	10.0

[a] Higher fat values in 1981–82 probably reflect the use of acid hydrolysis to measure fat in 1981–82 feeds compared to ether extraction used on 1980–81 feeds.

were replicated 3 times during 2 winters in Mississippi and Arkansas and during 1 winter in Texas for each fish size utilized.

In Mississippi, 37,050 fingerlings/ha and 9,880 adult fish/ha were each separately stocked into 9, 0.04 ha ponds (18 total ponds) in December 1980. The fingerlings ranged in length from 127–312 mm and the adult fish ranged from 279–412 mm. Fingerlings were stocked at 49,400/ha in December 1981 and were smaller (127–152 mm), but the adults were of similar size to the adult fish of the previous year and were stocked at the same rate. Similar size fingerlings (76–127 mm) were stocked at 49,400/ha into 9, 0.1 ha ponds in both winters in Arkansas and stocked at 44,460/ha into 9, 0.1 ha ponds in Texas during the winter of 1981–82.

Fish were fed daily according to prevailing water temperature recorded at 1-m depth between 1200–1500 hours (Table 3). Daily feed allotments

Table 3. Winter Feeding Schedule for Channel Catfish as a Percent of Fish Body Weight in Relation to Water Temperature[a]

Feeding Rate As a Percent of Body Weight	Water Temperature at 1-m Depth
%	Degree C
No Feed	<7
½	$>7 \leq 10$
1	$>10 \leq 16$
2	$>16 \leq 21$
3	>21

[a] Schedule was modified in 1981–82 so that feed was fed at ½% body weight on each third consecutive day that water temperature was below 10 C.

Table 4. Descriptive Features of the Channel Catfish Winter Feeding Studies in 1980–81 and 1981–82

	Mississippi		Arkansas		Texas
	1980–81	1981–82	1980–81	1981–82	1981–82
Study initiation	12/1	12/14	11/26	12/4	12/7
Termination date	3/29	4/2	3/17	3/23	3/31
Days in study	119	107	112	110	117
Days fed @ 0.5% body weight	12	13	19	18	11
Days fed @ 1.0% body weight	48	29	46	25	53
Days fed @ 2.0% body weight	16	17	5	7	10
Days fed @ 3.0% body weight		4		6	4
Total days fed	76	63	70	56	78
Average water temperature (degree C, range)	9.8(0–20)	10.6(1–24)	9.1(0–23)	9.2(0–18)	11.6(0–23)

were adjusted biweekly based upon a 3:1 estimated feed conversion ratio. Water temperature was recorded daily. Table 4 lists various descriptive features of the study by state and year. Whole body proximate analyses of Mississippi fingerling and adult fish were determined by the Mississippi State Chemical Laboratory. Analyses were performed on a homogenous mixture of 3 fish from each pond. Changes in fish weight, survival, feed conversion, body composition analyses and condition factors were analyzed using a 1-way analysis of variance and Duncan's multiple range test was used to separate significant differences. Unless otherwise stated, statistical significance was established at the 0.05 level of probability.

Results

Mississippi

Average adult weight gain for fish receiving the 25% protein feed was significantly greater than the gain for fish fed the 35% protein feed in 1980–81, but not in 1981–82 (Table 5). During both winters, adult non-fed fish lost weight, while the fed fish gained weight. There was no significant difference in average weight gain for fingerlings fed either the 25% or 35% protein feeds during either winter. Non-fed fingerlings lost weight during both winters. There was no significant difference in average feed conversion or average survival of either adult or fingerling channel catfish fed either the 25% or 35% protein feeds during either of the 2 winters. Percent protein, fat, ash and moisture content were not significantly different for either fingerlings (1980–81, 1981–82) or adult fish (1981–82) whether non-fed, or fed the 25% or 35% protein feeds (Table 6).

Arkansas

Growth of fingerlings fed the 25% and 35% protein feeds was not significantly different during the first winter, but fish fed the 25% protein feed grew significantly better than fish fed the 35% protein feed during the second winter (Table 5). Non-fed fish lost weight during both winters. Fish fed the 35% protein feed had a significantly higher average feed conversion ratio than fish fed the 25% protein feed during the first winter, but average feed conversion ratios were similar during the second winter.

Texas

Severe outbreaks of *Ichthyophthirius multifilis,* which occurred in January, caused extensive mortalities in a number of ponds in each treatment. All ponds were treated with combinations of copper sulfate and formalin. Due to an inability to accurately assess mortalities, no adjustments in feeding rates

Table 5. Average Weight Change, Feed Conversion, and Survival of Channel Catfish for Winter Feeding Studies in Mississippi (MS), Arkansas (AR), and Texas (TX) in 1980–81 and 1981–82

		Weight Change[a] (%)				Feed Conversion (kg feed/kg gain)				Survival (%)			
		Adult Fish	Fingerlings			Adult Fish	Fingerlings			Adult Fish	Fingerlings		
Treatment	Winter	MS	MS	AR	TX[b]	MS	MS	AR	TX	MS	MS	AR[c]	TX
No Feed	1980–81	−6.0A[d]	−8.0A	−2.9A						89.9A	99.4A		
25% Protein	1980–81	17.0C	18.0B	24.0B		9.2A	5.8A	3.2A		94.3A	99.4A		
35% Protein	1980–81	9.0B	14.0B	18.2B		61.5A	7.9A	8.5B		93.3A	98.7A		
No Feed	1981–82	−6.9A	−3.3A	−4.6A	−34.5A					86.4A	94.0A		88.5
25% Protein	1981–82	10.5B	37.7B	24.2C	75.3B	12.3A	3.6A	3.0A	6.0	76.1A	91.7A		36.0
35% Protein	1981–82	9.3B	25.0B	17.6B	105.0C	12.1A	3.8A	4.3A	5.3	85.8A	98.5A		51.3

[a] Based upon average fish weight at harvest in each treatment in Mississippi and Texas, but based upon total standing crop per pond in Arkansas.
[b] Values from 1 pond in the no feed treatment and from 1 pond in the 25% protein feed treatment were deleted from analyses because of poor survival.
[c] Data unavailable from Arkansas.
[d] Means in a column not followed by the same letter are significantly different ($P \leq 0.05$, Duncan's multiple range test) within each winter.

Table 6. Proximate Analyses (%, dry matter basis except moisture) of Whole Bodies[1] of Non-Fed and Fed Channel Catfish Cultured During 2 Winters in Mississippi[2]

		Winter 1980–81					Winter 1981–82								
		Fingerlings					Fingerlings					Adults			
		Protein	Fat	Ash	Moisture		Protein	Fat	Ash	Moisture		Protein	Fat	Ash	Moisture
Non-Fed		64.2	27.7	12.6	75.2		67.4	18.9	13.6	74.7		65.7	27.5	11.9	76.2
Fish		63.4	24.2	13.5	75.6		60.9	41.2	14.1	75.2		63.8	27.0	11.4	73.3
		61.6	29.7	12.7	74.7		64.0	29.6	8.6	77.9		56.6	25.6	13.5	74.1
	$\bar{x}$	63.1	27.2	12.9	75.2	$\bar{x}$	64.1	29.9	12.1	75.9	$\bar{x}$	62.0	26.7	12.3	74.5
25%		60.9	30.7	15.2	72.7		58.5	28.9	13.4	75.7		53.8	32.6	8.7	73.8
Protein		58.0	34.4	12.2	72.0		59.1	36.3	7.1	74.0		62.2	35.3	9.2	75.3
Feed		59.1	31.0	12.6	72.4		51.6	30.9	6.9	74.0		53.9	34.4	11.2	72.7
	$\bar{x}$	59.3	31.9	13.3	72.4	$\bar{x}$	56.4	32.0	9.1	74.6	$\bar{x}$	56.6	34.1	9.7	73.9
35%		56.7	35.6	10.6	72.2		55.3	28.6	14.1	73.5		55.5	31.6	8.8	72.8
Protein		54.7	35.9	11.1	70.5		62.3	30.9	7.6	77.0		53.6	41.9	6.0	72.2
Feed							60.2	35.9	6.2	75.1		62.7	30.3	11.1	70.1
	$\bar{x}$	55.7	35.8	10.9	71.4	$\bar{x}$	59.3	31.8	9.3	75.2	$\bar{x}$	57.3	34.6	8.6	71.7

[1] A homogenous mixture of 3 fish from each pond was analyzed.
[2] There were no significant ($P \leq 0.05$) differences between treatment means for non-fed and fed fish for any body composition parameter in either winter.

were made to compensate for losses. Calculatable feed conversions varied considerably within and between treatments (2.8 to 9.2). However, fish maintained on the 35% protein feed exhibited an average feed conversion ratio of 5.3 compared to a feed conversion ratio of 6.0 for those fed 25% protein feed (Table 5). Also, because of the ubiquitous nature of the disease situation, no attempt was made to correlate survival rates with treatments. Survival in the individual ponds ranged from 7.2 to 99.5%.

While both feeding treatments differed significantly from the control, there was no significant difference, when considering all ponds, for average weight gain or condition factor for fish receiving either the 25% or 35% protein feeds. However, when 2 ponds with exceptionally low survival (1 from the non-fed treatment and 1 from the 25% treatment) were removed from the analysis, there were significant differences among all 3 treatment groups for weight gain and condition factor. Fish maintained on the 35% protein feed outperformed in both categories those which received 25% protein feed. Fish in non-fed ponds had the poorest performance in both categories.

Discussion

Fingerling channel catfish fed a 25% protein feed grew as well as or better than fingerlings fed a 35% feed in both Mississippi and Arkansas during 2 winters of the study. Fingerlings in Texas grew better on the 35% protein feed. However, Texas' results should be viewed with caution because poor survival caused by disease problems may have biased the results. Because of the varied and sometimes extensive mortalities in the Texas study, the initial statistical analysis was performed using estimated weight gain (rather than standing crop) as the parameter of interest. However, even when using estimated weight gain, some difficulties were encountered in interpretation of the results. Smaller fish, tending to be somewhat more susceptible to "Ich," were effectively eliminated in ponds with severe outbreaks (initial fish weights ranged from 2.5 g to 19.7 g, and averaged 7.6 g). In certain cases this resulted in apparent and often dramatic increases in average weight (with only the relatively larger fish being left to sample).

Alternately, other factors may have contributed to location differences in feed performance: 1) variability in initial fish sizes may have contributed to altered food consumption, 2) availability of natural food items may have been different among study sites, 3) fish were fed on more days in Texas (66%) than in Mississippi (59%) or Arkansas (51%), indicating the relatively warmer winter in Texas during 1981–82, 4) warmer water temperatures may have enabled the Texas fish to make greater use of the available protein (Asadi 1967). DeLong et al. (1958) demonstrated that optimum protein levels based upon growth of chinook salmon (*Oncorhynchus tshawyt-*

scha) were directly correlated with water temperature. Optimum protein level was 40% at 8 C and 55% at 14 C. Hastings (1974) reported that low protein feeds gave equal performance to high protein feeds when fed to channel catfish during the early part of a growing season (water temperature below 24 C). Growth data from this study indicate that low protein (25%) can be utilized as effectively by channel catfish as high protein (35%) at low water temperatures (e.g., winter water temperatures in Mississippi and Arkansas during the 2 years of this study).

Data from these studies indicate that both fingerlings and adult fish grew as well on 25% protein as on 35% protein feed, although growth of adult fish was typically much less than growth of fingerlings. Feed conversion of the adult fish was higher than feed conversion of the fingerlings. Reagan and Robinette (1978) had winter feed conversions with fingerlings of 1.98 and 2.50 when fish were fed at a rate of 1% of body weight either 3 or 6 days a week without regard to water temperature during a relatively severe winter ($\bar{x}$ water temperature = 7.7 C). Feed conversions in this study were generally higher which indicates that the feeding schedule used requires additional refinement. Fingerling feed conversion in Mississippi improved when the schedule was modified so that fish were fed only every third day that water temperature was below 7 C.

One might expect that body composition of non-fed fish would be different from that of fed fish. Lovell and Sirikul (1974) reported that although non-fed fish lost weight during a winter study, they had more body fat than fed fish, indicating that protein was degraded for energy needs. However, during the 1980–81 winter, non-fed fingerlings in Mississippi had less ($P \leqslant 0.1$) body fat than either fish fed the 25% or 35% protein feeds which were significantly different from each other in percentage of fat. Non-fed adult fish in the 1981–82 winter had less ($P \leqslant 0.1$) fat than either adult group of fed fish. Differences in fat content of fish between the former and latter studies may be a result of differences in energy metabolism between different sizes of fish, or may be a statistical artifact of variance coupled with few replications. There were no other significant differences between body composition parameters.

In order to formulate a 25% crude protein feed with a proportionately lower energy level, soybean meal was reduced approximately 50%, corn 66%, and wheat 88% of the levels that occurred in the 35% crude protein commercial feed. Rice bran and rice mill feed were used primarily to fill out the formulation. The reduced level of soybean meal left the formulation deficient in lysine and methionine so synthetic lysine and methionine were added in sufficient amounts to meet proportionate levels in the 35% protein feeds. The excellent performance of fish fed the 25% protein feed strongly suggests that the synthetic or free amino acids, lysine and methionine, were available to and used by the fish. Dupree (1967) suggested that animal protein may be more readily digested under winter feeding conditions than plant proteins. All feeds contained 12% menhaden fish meal.

Specific levels of protein in practical fish feeds have not been recommended because of the effect of many variables on optimum protein usage in feeds, but recommended protein ranges are given as 25% to 36% for fingerlings to subadults and 28% to 32% for adults and brood fish by the National Research Council (1977). Commercial catfish feeds generally range from 32% to 36% crude protein. The data from Mississippi and Arkansas indicate that adequate crude protein levels (along with appropriate energy and amino acid levels) for winter feeds could be as low as 25%. Obviously, the key to adequate nutrition is related to protein quality, i.e. maintaining adequate levels of digestibility. Reduction of protein in winter feeds for channel catfish may provide an economic advantage to fish culturists, particularly if it is demonstrated that supplementation with feed grade amino acids is unneccessary.

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