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Effects of Fish Size and Feeding Frequency on Channel Catfish Production

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INTRODUCTION

Channel catfish (*Ictalurus punctatus*) raised in ponds are typically fed daily to apparent satiation to obtain maximum growth. However, under certain economic circumstances, catfish producers may feed less than daily to reduce feed cost and minimize economic losses. Robinson and Rushing (1994) compared different feeding strategies (once daily, every other day [EOD], once every third day [ETD] to satiation, and once daily to half satiation) for pond-raised channel catfish. They reported that maximum production was achieved by feeding to apparent satiation on a daily basis, but feed efficiency was improved by restricting feed. Further, they observed a 50% and 65% increase in feed consumption (on days fed) of fish fed EOD or ETD, respectively, compared with those fed daily. These data are partly supported by those of Li et al. (2004, 2006) in that production tends to be highest when channel catfish are fed daily to apparent satiation, and feed conversion ratio (FCR) is improved when fish are fed less than daily. The increase in feed consumption reported by Robinson and Rushing (1994) was greater than the 29% and 36% increases reported for channel catfish fed EOD (Li et al. 2004, 2006). The importance of the consumption data is that the more the fish can consume on days fed, the more compensatory growth they can exhibit and the better chance they have to "catch up" to the growth of fish fed daily. Several factors could have influenced the responses from these studies, but the primary difference in the three studies was the size of fish used. Robinson and Rushing (1994) used larger fish (270–320 grams), whereas Li et al. (2004) used fish of about 93 grams, and Li et al. (2006) used 64-gram fish. To attempt to clarify these issues (particularly feed consumption), we conducted this study to evaluate the effect of fish size on feed consumption and growth of pond-raised channel catfish fed daily or EOD to apparent satiation.

METHODS

A 2x3 factorial experiment was conducted to evaluate effects of fish size (small, medium, and large) and feeding regimen (feeding daily or EOD to satiation) on feed consumption, growth, production, and feed conversion of channel catfish. Three sizes of channel catfish — averaging 36, 169, and 354 grams per fish — were stocked into 30, 0.4-hectare ponds at a density of 14,400 fish per hectare on August 18, 2003. Five ponds were used for each fish size x feeding regimen combination. Fish were fed to apparent satiation with a commercial, 28%-protein feed until September 30, 2003. From October 1, 2003, to April 18, 2004, the fish were fed according to winter feeding schedules based on water temperatures (Robinson et al. 2001). Satiation feeding was resumed on April 19 and continued until September 19, 2004. Feed was distributed into each pond by a mechanical feed blower (S and N Spray Co., Greenwood, Mississippi). Fish were allowed to eat as much as they would consume in 15 minutes to achieve apparent satiation. Amounts of feed consumed by the fish in each pond were recorded daily.

During the growing season, water temperature and dissolved oxygen were measured in early morning, mid-afternoon, and throughout the night using a polarographic oxygen meter (Yellow Springs Instrument Company, Yellow Springs, Ohio). Emergency aeration, provided by a 3-horsepower paddle-wheel aerator was used in each pond when dissolved oxygen levels decreased to 4 parts per million (ppm) (Tucker and Robinson 1990). Aerators were turned off at about 7 a.m. when dissolved oxygen levels began to increase. Total ammonia-nitrogen (TAN), nitrite-nitrogen (NO_2-N), and pH were measured weekly during the growing season at approximately 1–4 p.m. using a field kit and the color wheel method (Hach Chemical Co., Loveland, Colorado).

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Chloride concentration was maintained at 50 ppm or more to alleviate possible nitrite toxicity. Water quality was maintained in ranges considered adequate for optimum fish performance (Tucker and Robinson 1990). Dead fish were removed from ponds, weighed, and recorded for correction of feed conversion ratio.

At the end of the study, 30 fish ranging from approximately 680 to 1,140 grams per fish from each pond were selected and stunned by a 40-volt electric pulse (Sylvesters, Inc., Louisville, Mississippi). Fish from each pond were weighed collectively and headed mechanically (Baader, Lübeck, Germany). The carcasses were then eviscerated, and the visceral fat was removed manually. Finally, the dressed carcasses were filleted and skinned by a fillet machine (Baader) and trimmed manually. Weight data were recorded for whole weight, visceral fat, head-gutted carcass, shank fillet, and nugget. Yield was determined as a percentage of whole weight. Fillets (one fillet per fish, 10 fish per pond) were stored at about -20°C for subsequent proximate analyses.

After these fish were sampled for processing, all remaining fish from each pond were harvested and weighed. Due to the relatively large number of fish used in the study, not all of them were counted. Instead, a 500-fish sample was randomly collected and group-weighed to estimate weight gain of individual fish.

Individual fillet samples were separately ground into a paste using a food processor. A 25-gram ground fillet sample from each of 10 fish per pond was pooled, reground, and mixed as a composite sample. Part of the composite sample was lyophilized for 16 to 18 hours for protein and fat analyses. Proximate analyses were conducted in triplicate on the composite samples with methods described by AOAC (2000). Crude protein was analyzed by the combustion method, crude fat by ether extraction, and moisture by oven drying.

Data on production characteristics, processing yield, and fillet composition were subjected to ANOVA and the Fisher's protected LSD procedure (Steel et al. 1997) using Statistical Analysis System version 8.0 software (SAS Institute, Inc., Cary, North Carolina). Pond was used as the experimental unit, and variation among ponds within a treatment was used as the experimental error in tests of significance. A significance level of $P \leq 0.05$ was used.

Results

Some general observations can be made based on patterns of individual treatment means (Table 1). Daily feeding resulted in more feed being fed and an increase in production. When the fish were fed EOD as compared with daily feeding, percentage feed consumption on days fed increased 61% for small fish (initial weight = 36 grams), 46% for medium fish (169 grams), and 68% for large fish (354 grams). Fish fed daily converted feed less efficiently compared with those fed EOD. Viewing the main effects (Table 1), larger fish ate more feed, and production was higher for the medium and large fish. Feed efficiency decreased as fish size increased. Pooling the data without regard to fish size showed that fish fed daily consumed more feed and production was increased compared with fish fed EOD.

Body composition data (Table 2) was similar for all treatments. Carcass, fillet, and nugget yield were higher in fish fed daily based on data pooled over all treatments without regard to fish size.

Table 1. Means of production characteristics of channel catfish of different stocking sizes fed once daily or once every other day (EOD) to apparent satiation in production ponds.

Stocking size	Feeding frequency	Amount of feed fed	Net production	Weight gain[1]	Feed conversion
g/fish		*kg/ha*	*kg/ha*	*g/fish*	*feed/gain*
Individual Treatment Means[2]					
36	EOD	14,728	7,658	740	1.91
36	Daily	18,324	8,175	798	2.22
169	EOD	18,325	8,581	860	2.13
169	Daily	25,197	10,867	1,028	2.34
354	EOD	25,462	8,758	973	2.79
354	Daily	30,298	9,927	976	3.04
Pooled SE		1,067	729	71	0.12
Main Effect Means[3]					
36		16,526 c	7,917 b	769 b	2.07 b
169		21,761 b	9,724 a	944 a	2.24 b
354		27,880 a	9,342 a	974 a	2.92 a
	EOD	19,505 y	8,332 y	857	2.28 y
	Daily	24,607 x	9,656 x	934	2.54 x
ANOVA (P values)					
Stocking size (SS)		< 0.001	0.050	0.019	< 0.001
Feeding frequency (FF)		< 0.001	0.036	0.20	0.012
SS x FF		0.30	0.46	0.49	0.91

[1]Estimated based on a 500-fish random sample per pond.
[2]Means represent average values of four ponds per treatment.
[3]Main effect means followed by different letters were different ($P \leq 0.05$) by Fisher's protected LSD procedure.

Table 2. Mean weight for processed fish, visceral fat, processing yield, and fillet composition of channel catfish of different stocking sizes fed once daily or once every other day (EOD) to apparent satiation in production ponds.

Stocking size	Feeding frequency	Weight of processed fish	Visceral fat	Carcass yield[1]	Fillet yield	Nugget yield	Fillet protein	Fillet fat	Fillet moisture
g/fish		*g/fish*	%	%	%	%	%	%	%
Individual Treatment Means[2]									
36	EOD	859	4.48	65.7	35.8	9.33	17.3	8.32	73.3
36	Daily	860	4.63	67.0	36.8	9.57	16.8	9.27	72.9
169	EOD	934	4.26	65.1	35.6	9.13	17.3	7.46	74.0
169	Daily	988	4.42	66.1	36.4	9.34	17.4	8.06	73.5
354	EOD	952	3.86	65.0	35.6	9.35	17.0	7.82	74.2
354	Daily	1,054	3.62	65.4	36.1	9.55	17.2	8.29	73.4
Pooled SE		36	0.23	0.39	0.28	0.09	0.17	0.59	0.58
Main Effect Means[3]									
36		859 b	4.56 a	66.4 a	36.3	9.45 a	17.0	8.79	73.1
169		961 b	4.34 a	65.6 ab	36.0	9.24 b	17.3	7.76	73.8
354		1,003 a	3.74 b	65.2 b	35.8	9.45 a	17.1	8.05	73.8
	EOD	915	4.20	65.3 y	35.7 y	9.27 y	17.2	7.87	73.8
	Daily	967	4.22	66.2 x	36.4 x	9.49 x	17.1	8.54	73.3
ANOVA (P values)									
Stocking size (SS)		0.003	0.005	0.023	0.32	0.034	0.16	0.22	0.39
Feeding frequency (FF)		0.086	0.90	0.013	0.003	0.008	0.61	0.18	0.27
SS x FF		0.40	0.60	0.45	0.62	0.97	0.10	0.92	0.95

[1]Carcass yield is a percentage of the carcass (without head and viscera) weight relative to whole fish weight.
[2]Individual treatment means represent average values of four ponds per treatment.
[3]Main effect means within a column followed by different letters were different ($P \leq 0.05$) by Fisher's protected LSD procedure.

Discussion

The data from this study agree in general with that of similar studies (Robinson and Rushing 1994; Li et al. 2004, 2006). Channel catfish fed EOD eat more feed on days fed and convert feed more efficiently, but they gain less weight than fish fed daily. Even though channel catfish have been shown to demonstrate compensatory growth (Kim and Lovell 1995; Gaylord and Gatlin 2000, 2001; Chatakondi and Yant 2001), and feed consumption dramatically increases after feed restriction, they apparently are unable to consume enough feed to catch up to the weight gain of fish fed daily. In our study, using total-feed-fed data pooled over all size groups, fish fed EOD consumed about 60% more feed on days fed and had about a 11% decrease in FCR, but net production was reduced by about 16% compared with fish fed daily. Though the magnitude of the changes differed somewhat, the same trend was observed in earlier studies (Li at el. 2004, 2006).

We know that channel catfish consume more feed on days fed when fed less than daily, but the percentage increase in feed consumption reported in the literature differed among studies (Robinson and Rushing 1994; Li et al. 2004, 2006). We attributed these differences among studies to differences in fish size because various sizes of fish were used in the studies. However, data from the present study do not support our hypothesis. The percentage increase in feed consumption of fish fed EOD was similar regardless of fish size. The increase in consumption was lower for medium-sized fish (46%) compared with small- (61%) and large-sized fish (68%). However, this finding was likely not a function of fish size but rather related to some other unknown factor. These data compare favorably to those reported for channel catfish by Rushing and Robinson (1994), but they are somewhat higher than those observed by Li et al. (2004, 2006). We are unable to explain the differences, but based on data from the present study, fish size does not appear to be a major factor influencing the percentage increase in feed consumption observed when channel catfish are fed EOD instead of daily.

Catfish fed to satiety on a daily basis tend to contain more body fat than fish fed EOD (Rushing and Robinson 1994; Li et al. 2004, 2006). In the present study, fillet fat was somewhat higher in fish fed daily compared with those fed EOD, but the results were not statistically significant. Li et al. (2004, 2006) reported that dressed yield was reduced in fish fed EOD as compared with those fed daily. Yield data from our study also demonstrated that feeding channel catfish EOD reduces carcass, fillet, and nugget yields. The reason for this response in fish fed EOD is not clear, but it is likely related to the reduction in nutrient intake that may negatively influence body composition or configuration and thus dressing characteristics.

Summary

In the present study, channel catfish ate substantially more feed (46–68%) on days fed when fed EOD to satiety compared with fish fed daily, regardless of fish size. Fish fed EOD converted feed more efficiently (11%) than those fed daily, but they did not grow as fast as fish fed daily. Net production was reduced by 16% when the fish were fed EOD. Carcass, fillet, and nugget yields were reduced in fish fed EOD compared with fish fed daily. Feeding catfish less than daily may be acceptable as a short-term strategy when economic conditions justify it, but it does not appear to be a sound practice in the long term.

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