Channel Catfish, Ictalurus punctatus, Size and Feed Conversion Ratio

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Abstract. – Channel catfish, Ictalurus punctatus, of five size-classes were stocked into 20, 0.04-ha earthen ponds at a rate of 14,826 fish/ha. Mean initial weights for each size-class were 0.232, 0.458, 0.678, 0.911, and 1.10 kg/fish. Four ponds were randomly allotted to each treatment. A commercial 28% protein diet was fed daily to apparent satiation. When fish reached a predetermined weight in each size-class, all fish were harvested, counted, weighed. Mean final weights for each size-class were 0.435, 0.683, 0.904, 1.16, and 1.36 kg/fish. The data show that smaller fish consumed more feed (as a percentage of body weight) and grew faster than larger fish. The data clearly demonstrate that feed conversion ratio and fish size are highly correlated and that feed conversion ratio increases as fish size increases. These data hold to the basic principle of animal husbandry that smaller animals are fast gainers and fast gain is generally the most efficient gain.

Because the efficiency of feed utilization of channel catfish (or any farmed animal) is of economic importance, there are many studies that have been conducted with various sizes of channel catfish over the years in which FCR was reported as part of the study, but few that we are aware of which specifically evaluated the relationship between FCR and fish size. Lovell (1989) demonstrated that feed efficiency decreased as the size of channel catfish increased. He fed channel catfish with initial weights of 0.045, 0.15, and 0.55 kg for 90 d and reported an FCR of 1.43, 1.67, and 2.16, respectively. Busch (1986) reported FCR values for channel catfish of about 0.45 or 1.4 kg reared in similar ponds, but as two separate studies to be 1.6 and 2.2, respectively. Busch (1986) reported FCR values for channel catfish of about 0.45 or 1.4 kg reared in similar ponds, but as two separate studies to be 1.6 and 2.2, respectively. In another study in which channel catfish were grown to a final size of 0.46 or 1.6 kg, FCR values were reported to be 1.33 and 1.73, respectively (Lovell and Li 1992). Omolo (2002) conducted a study with various size-classes of channel catfish from 0.25 to 2 kg showed that as fish size increased FCR values increased from 1.47 to 3.54. In several pond studies with channel catfish that we have conducted in which FCR was reported that the trend has been that smaller fish converted feed more efficiently (Robinson and Li 2005, 2007). In contrast, another report indicated that channel catfish grown from 0.26 kg to 0.60, 0.72, 0.91, and 1.17 kg, respectively, had similar FCR values (Green and Engle 2004). Also, contrary to the accepted view, there has been at least one anecdotal report that refutes the idea that feed efficiency in channel catfish decreases with size or age. This study was designed to define the relationship between

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channel catfish size and FCR more precisely by using specific size-classes of fish and growing the fish to a predetermined harvest size.

Materials and Methods

In early April, channel catfish of five size-classes from different ponds from a single farm (Table 1) were stocked into 20, 0.04-ha earthen ponds at a rate of 14,826 fish/ha at the Delta Western Research Center, Indianola, MS, USA. Mean initial weights were 0.232, 0.458, 0.678, 0.911, and 1.10 kg/fish, respectively. Four ponds were randomly allotted to each treatment. A commercial 28% protein diet was used. Fish were allowed to feed as much as they would consume in 20 min once daily to achieve apparent satiation. Amounts of feed consumed by the fish in each pond were recorded daily.

During the study, water temperature and dissolved oxygen were measured in early morning, mid-afternoon, and throughout the night using an YSI model 58 polarographic oxygen meter (Yellow Springs Instrument Company, Yellow Springs, OH, USA). Routine aeration was provided by a 0.5-horsepower, electrical aerator (Model AF-55, Air-O-Lator Corporation, Kansas City, MO, USA) and used in each pond when dissolved oxygen levels decreased to less than 4 mg/L (Tucker and Robinson 1990). Aerators were turned off at about 0700 h when dissolved oxygen levels began to increase. Total ammonia-nitrogen (TAN), nitrite-nitrogen (NO₂⁻N), and pH were measured weekly during the growing season at approximately 1300 to 1600 h using a field kit (Hach Chemical Co., Loveland, CO, USA). Water quality was maintained in ranges considered adequate for optimum fish performance (Tucker and Robinson 1990). Chloride concentration was maintained at ≥50 mg/L to alleviate possible nitrite toxicity. Dead fish were removed from ponds, weighed, and recorded for correction of FCR at the end of the study.

When fish reached the predetermined size in each size-class (estimated based on the amount of diet fed and FCR from previous studies with similar fish size), all fish in that size-class were harvested, counted, and weighed. FCR for each size-class was determined as follows: 

\[
FCR = \frac{(\text{total diet fed})}{(\text{total weight of fish harvested} + \text{weight of dead fish} - \text{weight of fish stocked})}
\]

Cumulative FCR provides an estimate of what the FCR would have been if the fish were stocked at a similar size and grown to the desired final weight. It was calculated assuming that all fish were started at an initial weight of 0.232 kg/fish. For example, cumulative FCR for fish grown from 0.232 to 0.683 kg = (IFCR for fish grown from 0.232 to 0.435 kg] + [FCR for fish grown from 0.458 to 0.683 kg])/2.

FCR, feed consumption as percentage of fish body weight, and survival were analyzed by one-way ANOVA and the Fisher’s protected least-significant-difference procedure (Steel et al. 1997) using Statistical Analysis System version 9.0 software (SAS Institute, Cary, NC, USA). Data on survival were square-root transformed before statistical analysis. Ponds were the experimental units, and variation among ponds within a treatment was used as the experimental error in tests of significance. Regression analyses were also performed on FCR and cumulative FCR against fish size. A significance level of \( P \leq 0.05 \) was used.

Results and Discussion

The primary focus of this study was to evaluate the relationship of fish size and FCR, but two other points can be made – smaller fish consume more feed (as a percentage of body weight) and grow faster than larger fish. The number of days required for the fish to gain approximately 0.20–0.25 kg increased as fish size increased except for the two larger groups, which took about the same number of days to reach the desired size (Table 1). Feed consumption as a percentage of fish body weight decreased significantly as fish size increased for the three smaller groups of fish, and then leveled off at about 1% of body weight. This type of response is generally observed for many farmed animals (Ensminger et al. 1990) and we have observed this in other studies with channel catfish (Robinson and Li 2005). The percentage survival of fish decreased in the larger two groups of fish.
Table 1. Mean initial and final weights of channel catfish, number of days to reach final weight, feed consumption, feed conversion ratio, and survival.

<table>
<thead>
<tr>
<th>Initial fish weight (kg/fish)</th>
<th>Final fish weight (g/fish)</th>
<th>Number of days</th>
<th>Feed consumption1 (% BW2/d)</th>
<th>Feed conversion ratio1 (feed/gain)</th>
<th>Cumulative feed conversion ratio1,3 (feed/gain)</th>
<th>Survival1 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.232</td>
<td>0.435</td>
<td>48</td>
<td>2.29 a</td>
<td>1.79 d</td>
<td>1.79</td>
<td>99.0 a</td>
</tr>
<tr>
<td>0.458</td>
<td>0.683</td>
<td>55</td>
<td>1.41 b</td>
<td>1.96 d</td>
<td>1.88</td>
<td>98.4 a</td>
</tr>
<tr>
<td>0.678</td>
<td>0.904</td>
<td>60</td>
<td>1.13 c</td>
<td>2.39 c</td>
<td>2.05</td>
<td>97.5 a</td>
</tr>
<tr>
<td>0.911</td>
<td>1.161</td>
<td>68</td>
<td>1.02 c</td>
<td>2.86 b</td>
<td>2.25</td>
<td>90.6 b</td>
</tr>
<tr>
<td>1.104</td>
<td>1.366</td>
<td>69</td>
<td>1.09 c</td>
<td>3.56 a</td>
<td>2.51</td>
<td>90.6 b</td>
</tr>
<tr>
<td>Pooled SE</td>
<td></td>
<td></td>
<td></td>
<td>0.09</td>
<td>0.14</td>
<td>2.5</td>
</tr>
</tbody>
</table>

SE = standard error.

1Means in a column followed by different letter were significantly different at \( P = 0.05 \) by the Fisher’s protected least-significant-difference (LSD) procedure.

2Body weight was based on the mean of initial and final fish weight.

3Cumulative feed conversion ratio (FCR) was calculated assuming all fish were started at an initial weight of 0.232 kg/fish. For example, cumulative FCR for fish grown from 0.232 to 0.683 kg = ([FCR for fish grown from 0.232 to 0.435 kg] + [FCR for fish grown from 0.458 to 0.683 kg])/2 = 1.88. No statistical analysis was conducted because values were calculated based on original FCR.

The data demonstrate that FCR increases as fish size increases (Table 1) and that FCR and fish size are highly correlated (Fig. 1). The same relationship exists for cumulative FCR (Table 1, Fig. 2). Our data are supported by other studies with channel catfish. Lovell (1989) fed channel catfish with initial weights of 0.045, 0.15, and 0.55 kg and measured FCR monthly for 3 mo and showed that as the fish increased in size the FCR increased. The FCR for the different size groups at the end of the study was 1.43, 1.67, and 2.16 for small, medium, and large size fish, respectively. In another study with channel catfish raised in similar ponds but as two separate studies, FCR values of 1.6 and 2.2 were reported for fish weighing about 0.45 or 1.4 kg, respectively (Busch 1986). Lovell and Li (1992) reported FCR values of 1.33 and 1.73 for channel catfish grown from advanced fingerlings to a final size of 0.46 or 1.46 kg, respectively. Omolo (2002) conducted a study with various size-classes of channel catfish from 0.25 to 2 kg that showed that as fish size increased FCR values increased from 1.47 to 3.54, and Robinson and Tiersch (1995) reported FCR values greater than 4 for channel catfish weighing from about 2.0 to 2.5 kg.

In contrast to our data and other studies, Green and Engle (2004) reported similar FCR values for channel catfish regardless of size.
They observed FCR values of 2.0, 1.9, 2.0, and 1.8 for channel catfish grown to 0.60, 0.72, 0.91, and 1.17 kg, respectively. We cannot explain the response they obtained and, as they point out, the FCR values they report are generally similar in magnitude to those reported for channel catfish by other researchers. In fact, the FCR of 2.0 reported in their study for 0.60 kg fish was similar to what we found in this study. However, they did not put forth an argument that FCR did not change with fish size, but rather just reported the data they obtained. In this study, the weight of dead fish was accounted for in the calculation of FCR. It is not clear whether the weight of dead fish was considered by Green and Engle (2004). It is unlikely that the discrepancy between this study and that of Green and Engle (2004) was caused by the difference in FCR calculation methods. If they did not include the weight of dead fish, their actual FCR would be lower especially for the larger fish because of high mortality.

Researchers often compare FCR values among studies, but it is difficult to make direct comparisons of specific FCR values among studies because so many factors affect its value. Apart from size or age, genetics, environmental factors, and fish husbandry practices are among other factors that affect FCR, but, in our experience, the single most critical factor affecting FCR is feeding rate. In particular, overfeeding leads to increased FCR primarily because uneaten feed cannot contribute to weight gain (Tucker et al. 1979; Cole and Boyd 1986).

Although the same stocking density (14,826 fish/ha) was used for various size-classes in this study, the total biomass of ponds stocked with larger fish was greater than that of ponds with smaller fish. The stocking density is considered moderate in commercial catfish production. It is not clear whether differences in total biomass have any effect on feed consumption, growth, and FCR of the fish. In ponds stocked with larger fish with higher biomass, there would be higher oxygen demand which may affect feed consumption of the fish. However, dissolved oxygen levels in the water were maintained at ≥4 mg/L by using routine aeration; therefore, it is unlikely that dissolved oxygen levels have affected the results of this study.

In summary, the data presented herein clearly demonstrate that smaller channel catfish consume more feed as a percentage of body weight, grow faster, and convert feed more efficiently than larger fish. This holds with the basic principle of animal nutrition that fast gains are generally more efficient gains and young smaller animals typically grow faster and utilize feed more efficiently than older larger animals. Substantiating this principle is in itself of value because it refutes anecdotal reports among catfish producers that larger fish convert diet more efficiently. Further, these data more precisely define the efficiency of various sizes of channel catfish because of the manner in which the study was conducted, starting with a specific size fish and growing them to a predetermined weight. Typically, feed efficiency is reported from studies in which fish are stocked at the beginning of the growing season and harvested at the end of the study, providing little insight into efficiency of fish at a given size during the study. Nevertheless, results from this study suggest that it is more cost effective to grow relatively smaller market-size fish than larger fish especially when feed prices are high. Generally

![Figure 2. Cumulative feed conversion ratio as a function of final fish weight (assuming all fish grew from 0.232 kg).](image)
fish should be harvested at a size of about 680 to 900 g for better feed conversion.

Acknowledgments

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