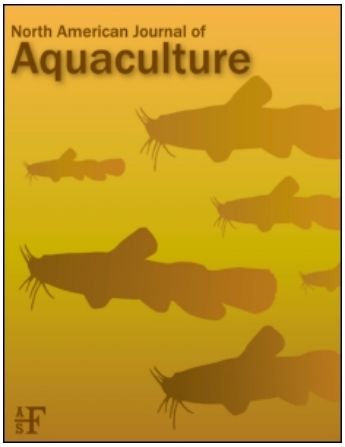

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[Communication]

Comparison of Soybean-Based Practical Diets Containing 32, 36, or 40% Crude Protein Fed to Hybrid Striped Bass in Earthen Culture Ponds

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Abstract.—Three practical diets were formulated for hybrid striped bass (striped bass *Morone saxatilis* × white bass *M. chrysops*) grow out. The diets were formulated to contain 32, 36, or 40% crude protein and high levels of soybean meal and met the established or predicted essential amino acid requirements for this hybrid. All diets were extruded by a commercial feed mill. Diets were fed to fish in triplicate ponds for two growing seasons. Mean final weight, consumption, feed conversion ratio, and final standing crop were not significantly affected by the dietary crude protein concentration. Feed consumption appeared to be related to water temperature, maximum values occurring between 17°C and 27°C. Expenditures related to feed, labor, fingerlings, and electricity for agitation were the largest contributors to the cost of production. Based on these data, optimal dietary crude protein concentrations for hybrid striped bass grow out in earthen culture ponds do not appear to be greater than 32% when fish are fed practical diets containing high levels of soybean meal.

Production diets for the culture of hybrid striped bass (striped bass *Morone saxatilis* × white bass *M. chrysops*) are not well developed despite considerable research effort quantifying the nutritional requirements for juvenile fish. Dietary crude protein is typically one of the early considerations in diets for fish because they grow maximally when fed relatively high levels. Additionally, protein is often the most expensive component of a diet. Initial estimates of optimal dietary crude protein for juvenile hybrid striped bass were approximately 40% of the dry diet (Brown et al. 1992; Nematipour et al. 1992). Diets for hybrid striped bass currently contain relatively high levels of crude protein and fish meal as the main source of crude protein and essential amino acids, despite indications that these levels can be reduced (Brown et al. 1997; Bharadwaj et al. 2002; Gummadi and Reigh 2003).

Most of the research conducted with hybrids has been with juvenile fish whose optimal dietary protein concentration may be higher than that of larger fish (Winfree and Stickney 1981; Siddiqui et al. 1988). D'Abramo et al. (2000) reported reduced growth and a higher feed conversion ratio (FCR) in phase III hybrid striped bass fed 36% dietary crude protein compared with those fed 40% crude protein. However, there appear to be no other comparisons of grow-out fish fed varying dietary crude protein concentrations.

The objective of this study was to evaluate the grow out of hybrid striped bass over a 2-year production cycle when the fish were fed soybean-based practical diets containing dietary crude protein concentrations of 32, 36, or 40%.

Methods

Three diets were formulated to contain 32, 36, or 40% crude protein (Table 1) and to meet the established or predicted essential amino acid requirements for this hybrid (Twibell et al. 2003), expressed as a percentage of the dietary crude protein. Solvent-extracted, dehulled soybean meal was the primary source of dietary crude protein and essential amino acids; whole wheat was the carbohydrate source; fish meal was added to all diets at a concentration of 16–19% (Brown et al. 1993); and fish oil was the lipid source. Availability of essential amino acids was assumed to be 80% from all protein-containing ingredients. All diets contained 10–12% lipid. All diets were extruded by a commercial feed mill (Nelson and Sons, Murray, Utah). Feeds were ordered on five separate occasions during the 2-year grow-out cycle and shipped in 18.2-kg bags. All feeds were stored in a secured building at ambient temperatures before feeding.

Juvenile hybrid striped bass were acquired from a commercial producer (Keo Fish Farms, Keo, Arkansas) and delivered to the Purdue University Aquaculture Research Laboratory in September 2001. Fish were immediately and randomly stocked into nine 0.1-ha

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TABLE 1.—Composition of diets containing 32, 36, and 40% crude protein fed to hybrid striped bass (%, as-fed basis) in earthen culture ponds at the Purdue University Aquaculture Research Laboratory, Indiana, for two growing seasons in 2001 and 2002.

Ingredient	Dietary protein (%)		
	32	36	40
Soybean meal	31.0	42.5	50.0
Wheat, mill run	24.4	11.4	3.8
Wheat, whole	17.5	17.5	17.5
Fish meal	16.5	17.5	19.0
Fish oil	5.5	6.0	5.5
Dicalcium–phosphate	2.1	2.1	1.2
Lecithin	2.0	2.0	2.0
Choline-Cl	0.45	0.45	0.45
Vitamin premix, federal number 30	0.27	0.27	0.27
STAY-C	0.13	0.13	0.13
Mineral premix number 3	0.1	0.1	0.1

earthen culture ponds and fed a trout diet (Nelson and Sons, Murray, Utah) until April 2002. A subsample of 500 fish was collected to establish average initial weight. Each pond was stocked with approximately 1,500 fish (initial average weight, 41 g). Dietary treatments were randomly assigned to triplicate ponds. Fish in each replicate were fed their respective diets for two growing seasons. All replicates were fed to satiation once daily when weather permitted, and daily consumption was monitored throughout the study. Total daily consumption was restricted to 18.2 kg per replicate pond.

Surface temperature and dissolved oxygen (DO) were monitored each morning with a DO meter (Yellow Springs Instruments, Inc., Yellow Springs, Ohio). Total ammonia nitrogen and nitrite-nitrogen were measured daily in the spring and then weekly throughout the remainder of the growing season for both years with a water quality test kit (Hach Chemical Co., Loveland, Colorado). All ponds were aerated with surface agitators (Kasco Marine, Inc., Prescott, Wisconsin). Temperatures varied throughout the season, and DO levels were not below 2.5 mg/L . The total ammonia nitrogen and nitrite-nitrogen concentrations did not exceed 1.5 mg/L in either year. Copper sulfate and endothall were applied as needed to control filamentous algae and aquatic macrophytes, respectively. All ponds contained six to eight grass carp *Ctenopharyngodon idella*.

At the end of the first growing season, survival was assumed to be 80% for all ponds, and 250 fish were randomly removed to reduce the standing crop, resulting in 950 fish per pond for the second year. Harvested fish from the first year were weighed to establish growth. At the end of the second growing season, all fish were harvested by seine, counted, and weighed. All ponds were completely drained to remove all fish. Separate tanks (2,400 L) containing water and ice (an approximately 50:50 mixture) were placed near each pond, and fish from each replicate were placed into receiving tanks. All fish were killed by hypothermia before they were packed on ice in transport containers.

TABLE 2.—Mean final weight (g/fish), feed consumption (g/fish), feed conversion ratio (FCR), and final standing crop (kg/ha) of hybrid striped bass fed practical diets containing 32, 36, or 40% crude protein for two growing seasons in earthen culture ponds in 2001 and 2002. Values in each column were not significantly different as determined by ANOVA ($n = 3$).

Dietary crude protein (%)	Final weight	Feed consumption	FCR	Standing crop
32	837	1,229	1.47	6,513
36	850	1,365	1.60	6,240
40	846	1,267	1.50	5,717
PSEM[a]	34.9	132.2	0.146	1,742.7

[a] Pooled standard error of the mean.

The final weights of fish, feed consumption, FCR, survival, and standing crop were statistically analyzed by one-way analysis of variance (ANOVA), each replicate pond being used as the experimental unit (Zar 1984). All data analyses were conducted with the Statistical Analysis System (SAS Institute, Cary, North Carolina); the accepted level of significance was 0.05.

Results

The mean weight of sampled fish at the end of the first year of growth averaged 318 g across all treatments (data not shown). The estimated FCR values were 1.12 in fish fed diets containing 36% crude protein, 1.25 in fish fed 32% crude protein, and 1.47 in fish fed 40% crude protein. At the end of the second year of growth, no significant differences were seen in mean final weight, feed consumption, FCR, or final standing crop of fish fed 32, 36, or 40% dietary crude protein (Table 2). The mean final weights of fish varied from 837 g in fish fed 32% crude protein to 850 g in fish fed 36% crude protein. Mean FCR values ranged from 1.47 to 1.60, and mean final standing crops ranged from 5,717 kg/ha in fish fed 40% crude protein to 6,513 kg/ha in fish fed 32% crude protein. The mean number of harvested fish from each replicate pond was not significantly different for the three treatment groups (data not shown). Mean numbers were 847, 882, and 771 for fish fed 32, 36, or 40% dietary crude protein, respectively.

In each study year, feed consumption tended to increase from April through May. The maximum consumption of feed began in mid-June and continued through mid-September. This coincides with increasing water temperatures, specifically as water temperatures

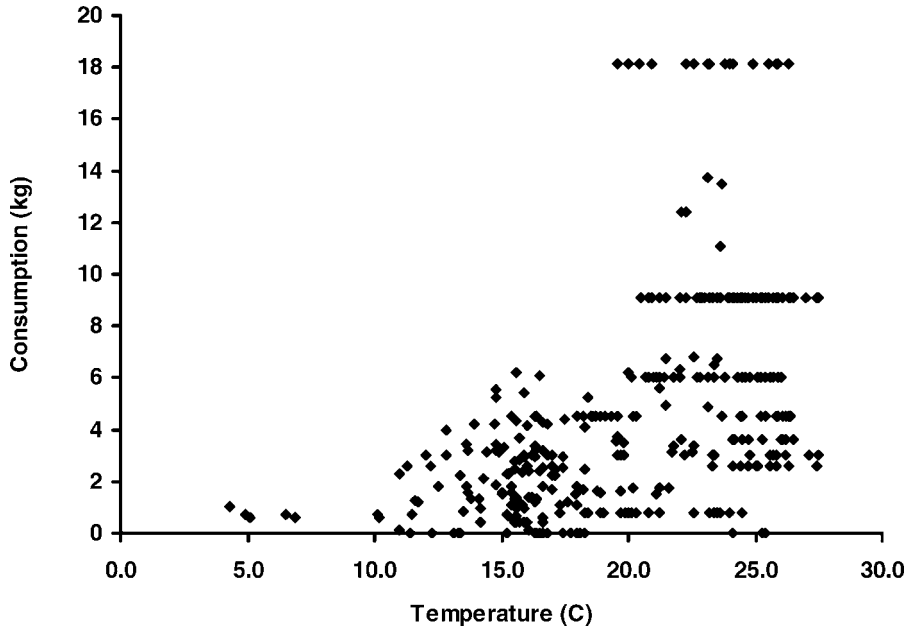

FIGURE 1.—Consumption (kg/pond) at various temperatures by hybrid striped bass fed the diet containing 36% crude protein in all replicate earthen culture ponds at the Purdue University Aquaculture Research Laboratory for two growing seasons in 2001 and 2002.

reached and exceeded 20°C. As water temperatures declined in the fall, consumption followed an inverse pattern. When daily consumption values for all three replicate ponds fed 36% dietary crude protein were combined, a clearer pattern emerged. Daily consumption expressed as a function of water temperature indicates maximum daily consumption beginning at approximately 17°C and continuing through approximately 26°C (Figure 1).

A simple economic analysis of variable costs was completed at the end of this study (Table 3). Data were developed for fish fed the diet containing 36% dietary crude protein. When compared with the diet containing 36% crude protein, the cost of the diet containing 32% crude protein was US$0.02 less per kilogram and the cost of the diet containing 40% crude protein was $0.02 more per kilogram. Total variable costs were $19,085/ha. The greatest annual expenditure ($5,603/ha; 29.4%) was for feed, followed by the expenditures for labor and juvenile fish. All fish were sold whole, dead, and packed on ice at the end of the study to a commercial wholesaler, who paid $4.73/kg. All dead fish were picked up at pond side. The return after variable costs was $9,273/ha over the 2-year grow-out cycle.

Discussion

Based on these data, the optimal dietary crude protein concentration for grow out of hybrid striped bass in earthen culture ponds does not appear to be greater than 32% of the dry diet. This is a lower value than that reported for juvenile fish raised in tanks (Brown et al. 1992; Nematipour et al. 1992) and lower than that reported in a previous study with hybrids raised in earthen culture ponds (D'Abramo et al. 2000). We suspect that the higher recommendations for smaller fish are a function of the initial size of the fish used and the study duration. Our fish were relatively large, and the study was conducted for two growing seasons. It is not clear why fish fed 36% crude protein gained significantly less weight than fish fed 40% crude protein in a previous pond production study

TABLE 3.—Variable costs (US$) associated with growing hybrid striped bass in earthen culture ponds at the Purdue University Aquaculture Research Laboratory, Indiana, for two growing seasons in 2001 and 2002. Data were developed for fish fed the diet containing 36% dietary crude protein ($n = 3$).

Variable	Unit cost	Units	Total cost	Cost/ha
Feed	0.55/kg	11,588 kg	6,373.5	5,602.96
Fingerlings	0.26/fish	15,000 fish	3,900	3,432
Agitation	2.07/kWh	1,500 kWh	3,105	2,732.4
Herbicide	6.58/L	249.8 L	114.84	101.07
Ice	0.44/kg	1,136 kg	500	440
Labor	7.00/h	900 h	6,300	5,544
Harvest labor	7.00/h	200 h	1,400	1,232
Total				19,085.06

(D'Abramo et al. 2000), but this difference may be related to differences in diets or environmental conditions.

The diets used by D'Abramo et al. (2000) contained cottonseed meal, and the effect of that ingredient on hybrid striped bass has not been determined. This lower-protein diet also contained less fish meal and a higher concentration of plant protein ingredients, which can affect mineral availability in hybrids (Brown et al. 1997). The composition of the mineral premix used by D'Abramo et al. (2000) was not specified. The mineral premix used in our diets was formulated to meet the requirements for trout, assuming no mineral contribution from other ingredients. Although not reported, water temperatures in the previous study were probably higher than those in our study. However, the available data indicate no significant changes in optimal protein : energy ratios in juvenile hybrids raised at 26°C or 32°C (Keembiyehetty and Wilson 1998).

All three diets were consumed throughout the experimental period, but the amount consumed appeared to be related to water temperature. Fish size probably influenced consumption as well, but there was a clear increase in consumption after water temperatures reached and exceeded 17–18°C, and maximal consumption values occurred between approximately 17°C and 27°C. This range coincides with optimal temperature for growth in hybrids (Cox and Coutant 1981).

Our densities and final standing crop were relatively high compared with those in other studies, yet the only water quality problem encountered was low DO concentrations on an intermittent basis in the warmer months. Those depletions were probably caused by high feed rates. Agitation was used throughout the second year, and DO decreases did not last more than 2 d.

A simple economic analysis of variable costs associated with our study indicates that feed, labor, juvenile fish, and agitation are the most expensive components, as in other budgets developed for pond culture of hybrids (D'Abramo et al. 2004). Our evaluation also indicated considerable economic opportunity for earthen pond culture of hybrid striped bass at this latitude.

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