Centrarchids: Hybrid Bluegill (*Lepomis cyanellus* × *Lepomis macrochirus*)

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Introduction

The pay-lake industry (fee-fishing ponds) is an important sector of the aquaculture industry in many states in the USA. Pay lakes provide a source of income for the pond owner, a source of food and recreation for the public and a market for producers of live fish. The hybrid bluegill (female green sunfish, *Lepomis cyanellus* × male bluegill, *Lepomis macrochirus*) is a desirable fish for the pay-lake industry. Growth of hybrid bluegill is higher than that of either parental stock. Hybrid bluegill reach an acceptable catch size (100 g) quickly, and the fish can be fed a prepared diet due to its aggressive feeding response (Lewis and Heidinger, 1978). This response also increases the vulnerability to hook-and-line capture by anglers. From an angler's viewpoint, an aggressive fish translates into less effort expended to catch the fish. Thus, hybrid bluegill are popular with anglers. However, there have been few reports on the nutrient requirements, practical diet formulations and feeding practices of hybrid bluegill. It is hoped that this brief overview will assist persons interested in culturing this fish.

Nutrient Requirements

Protein and amino acids

Because protein is the most expensive component in a diet, knowledge about the protein requirements of the fish is essential for formulation of nutritious, economical diets. Information on protein, especially the amino acid, requirements of hybrid bluegill is limited. Tidwell *et al.* (1992) formulated three experimental practical diets to contain either 26, 31 or 37% protein, each diet being isocaloric at 4.0 kcal gross energy g^{-1} of diet. Juvenile hybrid bluegill (average weight of 5 g) were stocked into aquaria and fed one of the practical diets

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twice daily to apparent satiation for 10 weeks. At the conclusion of the study, fish fed a diet containing 37% protein had a significantly ($P < 0.05$) higher percentage weight gain (300%) than fish fed a diet containing 26% protein (226%), while the feed conversion ratio was significantly lower (1.9 compared with 2.6). The growth curves are shown in Fig. 27.1. Webster *et al.* (1997) fed juvenile hybrid bluegill (20 g), which had been stocked in cages, diets containing either 35%, 40%, 44% or 48% protein and reported no differences ($P > 0.05$) in final individual weight, specific growth rate (SGR), feed conversion ratio (FCR) or condition factor among treatments. Whole-body amino acid composition of hybrid bluegill indicated no differences ($P > 0.05$) among treatments for any amino acid analysed. When hybrid bluegill (14 g) were fed diets containing various percentages of protein (28, 32, 36 or 38%) in aquaria, final individual weight and percentage weight gain of hybrid bluegill fed a diet containing 38% protein were significantly ($P < 0.05$) higher (53 g and 265%, respectively) than fish fed diets containing 28% and 32% protein (45 g and 211%, respectively), but were not different from fish fed a diet containing 36% protein (51 g and 251%, respectively) (Webster *et al.*, 1997). Thus, it appears that feeding hybrid bluegill a diet containing between 35 and 36% protein is sufficient for good growth, FCR and survival percentages.

It may be that protein requirements are lower if fish are grown in ponds, where natural food organisms may play a role in supplying supplemental nutrients, or if grown to a larger size, when protein requirements may possibly be reduced compared with those of smaller fish. When hybrid bluegill were grown in

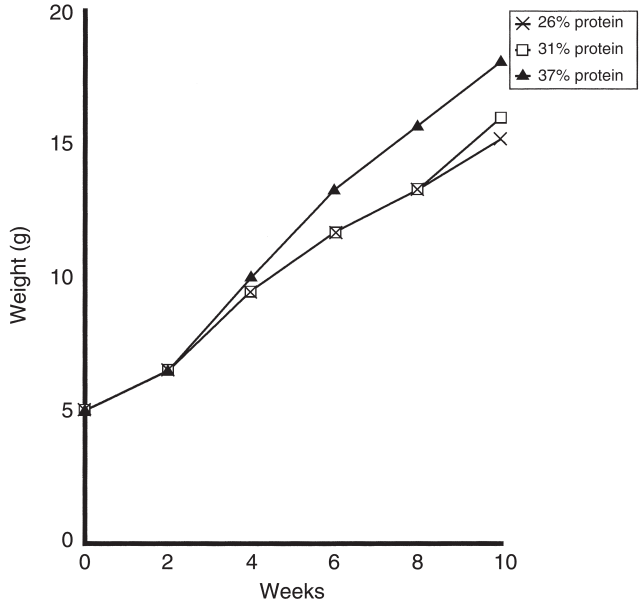

Fig. 27.1. Growth curves of hybrid bluegill grown in aquariums and fed diets containing various percentages of protein (26%, 31% or 37%) for 10 weeks.

ponds and fed diets containing either 32% or 38% protein, no difference in final individual weight, percentage weight gain, FCR or percentage survival was reported (Webster *et al.*, 1992). This is in agreement with Tidwell and Webster (1993), who reported that, when hybrid bluegill were fed during the winter in ponds, there were no differences in percentage weight gain, SGR and FCR.

Quantitative amino acid requirements have not been established for hybrid bluegill; however, the essential amino acid requirements of fish have been shown to correlate with the essential amino acid pattern of whole-body or muscle tissue of the fish. Whole-body amino acid compositions of hybrid bluegill from two feeding trials are presented in Table 27.1. If minimum requirements for lysine and the sulphur amino acids (methionine and cystine) are met, the requirements for the other essential amino acids should also be met. Practical diets containing lysine at 1.72% of the diet (4.70% of the protein) and methionine at 0.59% of the diet (1.68% of the protein) appear sufficient to meet requirements for these two amino acids for hybrid bluegill (Webster *et al.*, 1997).

Fish-meal is an important ingredient in fish diets because of its high protein quality and palatability; however, of all diet ingredients, fish-meal is one of the most expensive. There is a need to reduce the amount of fish-meal in diets to lower the cost of the diet and to decrease reliance. The long-term availability of fish-meal is unclear and it is important for the aquaculture industry to reduce the

Table 27.1. Whole-body amino acid composition (g 100 g^{-1} amino acids) of hybrid bluegill fed a diet with 37% protein (adapted from Tidwell *et al.*, 1992 – Study 1) and from hybrid bluegill fed a diet containing 48% protein (adapted from Webster *et al.*, 1997 – Study 2).

Amino acid	Study 1	Study 2
Alanine	6.7	7.3
Arginine	5.9	6.5
Aspartic acid	11.6	10.3
Cystine	0.9	0.9
Glutamic acid	14.9	14.1
Glycine	8.0	8.3
Histidine	2.1	3.1
Isoleucine	4.3	3.9
Leucine	7.3	7.4
Lysine	8.3	8.3
Methionine	3.1	3.0
Phenylalanine	4.1	4.2
Proline	5.1	5.5
Serine	4.1	4.8
Threonine	4.6	4.9
Tryptophan	1.4	n/a
Tyrosine	2.9	3.1
Valine	4.8	4.5

n/a, not available.

amount of fish-meal added to fish diets without adversely affecting the growth and health of the fish.

Vitamins and minerals

There are no published reports on vitamin or mineral requirements for hybrid bluegill, but there has been success in growing these fish with prepared diets. Levels reported in Webster *et al.* (1997) can be used until definitive requirements are elucidated (mg or IU kg^{-1} of diet): vitamin A, 6000 IU; vitamin D, 2200 IU; vitamin E, 150 IU; vitamin K, 10 mg; niacin, 200 mg; pantothenic acid, 60 mg; thiamine, 30 mg; riboflavin, 20 mg; pyridoxine, 20 mg; folic acid, 5 mg; B_{12}, 0.01 mg; biotin, 2 mg; manganese, 180 mg; copper, 8 mg; cobalt, 1.5 mg; iron, 66 mg; zinc, 150 mg; iodine, 6 mg; selenium, 0.3 mg.

Practical Diets

No data have focused on reducing fish-meal levels in a practical diet for hybrid bluegill, mainly due to the desire to formulate a practical diet that would be palatable to the fish and to ensure that diets would have high digestible-protein and lipid sources. Webster *et al.* (1992) fed commercial catfish diets with between 4 and 8% fish-meal to hybrid bluegill in ponds. Tidwell *et al.* (1992) fed practical diets with different percentages of protein and 10% fish-meal to hybrid bluegill in aquariums, while Tidwell and Webster (1993) fed diets containing between 6.5% and 10% fish-meal to hybrid bluegill grown in ponds during the winter. Webster *et al.* (1997) fed practical diets containing 15–21% fish-meal (29% of the protein) to hybrid bluegill grown in cages and diets with between 18% and 35% fish-meal (40–50% of the protein) to fish in aquariums (Table 27.2).

Practical diets fed to hybrid bluegill in most of the feeding trials have been shown to have some effect on body composition. Webster *et al.* (1992) reported that hybrid bluegill fed a diet containing 38% protein and 3.4% lipid had a significantly ($P < 0.05$) lower percentage of whole-body lipid (12.6% lipid on a dry-matter basis) compared with fish fed a diet containing 32% protein and 4.4% lipid (18.7% lipid on a dry-matter basis), but no differences ($P > 0.05$) in whole-body moisture or protein levels. Webster *et al.* (1997) stated that hybrid bluegill fed diets containing 40%, 44% and 48% protein had higher ($P < 0.05$) percentages of whole-body protein and lower percentages of whole-body lipid compared with fish fed a diet with 35% protein.

Feeding Practices

Results from feeding trials where hybrid bluegill are grown in aquariums or cages appear to indicate that, when feeding small (4–10 g) fish, a diet with 35–36% protein and where fish-meal comprises between 15% and 30% of the protein is

Table 27.2. Formulation and proximate composition of practical diets fed to hybrid bluegill.

	Diet no.		
	1	2	3
Ingredient			
Menhaden fish-meal	15.00	17.00	28.00
Soybean meal	41.00	49.00	14.85
Maize meal	36.95	27.45	20.00
Wheat	0.00	0.00	29.00
Hydrolysed feather meal	0.00	0.00	3.50
Monocalcium phosphate	1.00	1.00	0.75
Vitamin and mineral mix	2.00	2.00	0.85
Ascorbic acid	0.05	0.05	0.05
Menhaden (or cod-liver) oil	4.00	3.50	3.00
Proximate analysis (dry-matter basis)			
Protein (%)	35.2	40.2	36.6
Lipid (%)	7.8	7.2	11.7
Ash (%)	1.9	2.0	1.6
Protein-to-energy ratio	87	101	89

sufficient (Tidwell *et al.*, 1992; Webster *et al.*, 1997); however when hybrid bluegill (3.5 g) are stocked in ponds at low densities (12,350 fish ha^{-1}), it may be possible to feed a diet with a lower percentage of protein (32%) and lower levels of fish-meal (4–8% of diet) (Webster *et al.*, 1992). Hybrid bluegill do not appear to consume zooplankton, but can utilize benthic organisms from the taxa Oligochaeta, Chironomidae and Planorbiidae when grown in ponds (Brunson and Robinette, 1982, 1986).

Wang *et al.* (1998) reported that feeding small (4–7 g) hybrid bluegill to satiation three times per day increased growth and food consumption compared with fish fed once or twice daily, but was not different ($P > 0.05$) from fish fed four times per day. Feeding this often may be practical for fish grown indoors or in tanks, cages or outdoor raceways, but may not be practical or necessary if fish are grown in ponds. If fish are stocked in ponds at a low density (12,000 fish ha^{-1}), it may be possible to feed fish only once daily due to the fish consuming natural foods present in the pond. The FCR for fish stocked at 12,350 fish ha^{-1} was 1.3 when fish were fed a sinking diet during the winter in Kentucky, but fish stocked at 24,700 fish ha^{-1} had an FCR of 5.8 (Tidwell and Webster, 1993). A producer with a large number of ponds may be able to feed only once a day since it may take all day to feed the fish in all the ponds. Also, Webster *et al.* (1997) reported that, during the hot summer months, hybrid bluegill consumed less diet during the day so that feeding once a day was more desirable than feeding twice daily. Thus, it may be best to feed hybrid bluegill to apparent satiation and not to use a feeding chart when fish are fed only once during the day.

Feeding hybrid bluegill twice daily to satiation appears to be a viable method of feeding where practical. Feeding hybrid bluegill stocked in cages a floating diet twice daily (0800 and 1900 h) produced good growth rates, but high FCR values 3.5–4.4 (Webster *et al.*, 1997). This may have been due to some fish not being able to consume the diet because of the territorial nature of hybrid bluegill. Some fish (smaller, less aggressive fish) may have been prevented from getting to the surface to feed by larger, more aggressive fish. Likewise, Tidwell and Webster (1993) also reported a high (3.4–3.8) FCR when hybrid bluegill were fed in ponds during the winter when a sinking diet was fed according to a feeding chart used in feeding channel catfish, *Ictalurus punctatus*. Webster *et al.* (1992) reported FCR values of approximately 3.8 when hybrid bluegill grown in ponds were fed a floating diet.

For each size of fish desired for pay lakes (> 100 g) and for seafood markets (> 250 g), hybrid bluegill must be overwintered before a second-year grow-out in most regions of the USA. However, during the colder winter months, where water temperatures decline below those for optimal growth and fish feed aggressively, it does appear that feeding fish, at reduced levels, is advantageous. Brunson and Robinette (1982) reported that hybrid bluegill that were not fed a prepared diet during the winter had weight gains of 183% while fish fed a prepared diet had a significantly ($P < 0.05$) higher percentage weight gain (261%). In areas that have lower winter temperatures, hybrid bluegill fed a prepared diet during the winter had weight gains of 12% for fish stocked at 24,700 fish ha^{-1} and 26% of fish stocked at 12,350 fish ha^{-1} (Tidwell and Webster, 1993).

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