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TECHNICAL NOTES

Growth of Sunshine Bass on Dry Feeds

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Abstract.—Sunshine bass, a hybrid of female white bass (*Morone chrysops*) × male striped bass (*Morone saxatilis*), were raised in tanks to mean weights of 1,333 g on two experimental feeds and 894 g on a commercial feed, 19 months after hatching. During 6–19 months posthatch, average weight gain and feed conversion (weight of feed fed/fish weight gained) were 2.8–3.0 g/d and 1.05-3.16 with experimental feeds versus 1.6–2.0 g/d and 1.34–4.87 with the commercial feed. After 19 months, growth on the experimental feed decreased sharply, and at 30 months mean weight was 1,710 g.

Hybrid striped bass such as palmetto bass, a cross of female striped bass (*Morone saxatilis*) and male white bass (*Morone chrysops*), and sunshine bass, the reciprocal cross of female white bass and male striped bass, have high aquaculture potential and are being raised commercially in ponds and tanks (Kerby et al. 1983; Harrell et al. 1990; Van Olst and Carlberg 1990). Some 1,600 tonnes were produced in the USA during 1991 and at least 3,200 tonnes in 1992 (Hodson 1991; T. Smith and W. Jenkins, unpublished). Hybrid striped bass are widely known and accepted by anglers and consumers; have high market value; tolerate temperature changes, salinity fluctuations, crowding, and handling; grow moderately fast; and have high yield (up to 40% of body weight as skinless, boneless fillet).

Optimal feed formulas for hybrid striped bass have not yet been determined. Many farmers have used grower feeds designed for catfish or salmonids. This note describes results of 29 months (June 1988–October 1990) of comparative growth trials with sunshine bass raised in tanks on commercial and experimental feeds.

Fish were reared in two 10-tonne (10-m^3) rectangular concrete tanks (3.3 m long × 2.6 m wide × 1.2 m deep) and four 3.5-tonne circular fiberglass tanks (2.4 m in diameter). The tanks were supplied with unrecirculated fresh artesian well water (hardness, 705 mg/L as calcium carbonate) at 24–26°C with three to five water exchanges per day. Because water was highly aerated and stocking density was low, no water quality problems occurred. Occasional measurements indicated total ammonia nitrogen was less than 0.1 mg/L and dissolved oxygen was 5 mg/L or higher. Fish in concrete tanks were provided with artificial light from fluorescent bulbs (12 h/d) plus up to 2 h of faint, indirect sunlight in summer. During trial 2, fish in concrete tanks received only artificial light for 12 h/d. Trial-2 fish in fiberglass tanks received diffuse natural light (about 80% shade) for 10.5–11.5 h/d.

Two commercial feeds (Zeigler Bros., Inc., Gardners, Pennsylvania) often used for farming hybrid striped bass and two experimental diets were used (Table 1). The corn gluten meal and wheat flour were not cooked, so their digestibility probably was not high (Tucker 1992).

The study consisted of five trials in which fish were followed for increasing lengths of time. Feeding was to satiation, once or twice a day. In trial 1, 200 1-month-old sunshine bass (mean weight, 0.85 g; total length range, 38–56 mm) from a commercial hatchery were stocked in a concrete tank and fed salmon starter twice a day for 156 d. In trial 2, small and large fish were culled; of the remaining medium-sized fish, 15 were placed in each of two concrete tanks and 10 were placed in each of four fiberglass tanks. For the next 50 d, diet HB8825 was fed once a day to fish in one concrete tank and two fiberglass tanks, and trout-grower diet was given to fish in the other concrete tank and two fiberglass tanks. For trial 3, fish in the two concrete tanks were raised for an additional 182 d on diet HB8825 in one tank and trout-grower diet in the other. In trial 4, fish in the two concrete tanks were raised for an additional 156 d on diet HB9020 in one tank and trout grower in the other. In trial 5, eight of the remaining fish reared on experimental diets were kept in one concrete tank for an additional 327 d and were fed diet HB9020. At the end of the study, the sunshine bass were 30 months old. Survival, growth (total length and wet weight), specific

TABLE 1.—Composition of two commercial feeds and two experimental feeds (dry pellets). All values except protein : energy ratio are in percent. Except for moisture, proximate analysis values are moisture free.

Component	Salmon starter[a]	Trout grower[a]	Feed HB8825[b]	Feed HB9020[c]
Formulation (%)				
Anchovy meal			30.0	
Low-temperature herring meal				45.0
Poultry and meat meal			30.0	
Blood meal				3.5
Feather meal				10.0
Textured vegetable protein			25.0	13.0
Corn gluten meal				5.0
High-gluten wheat flour			8.0	13.9
Brewer's yeast				1.0
Bonemeal				2.0
Menhaden oil			2.9	3.5
Soybean oil			2.9	
Lecithin				1.0
Proximate analysis (%, vacuum dry)				
Crude protein (Kjeldahl)	57	42	53.9	59.7
Crude fat (ether extract)	17.6	8.8	15.5	10.3
Carbohydrate (difference)			16.9	17.2
Fiber (acid detergent)			1.1	0.9
Ash (600°C for 4 h)			12.6	11.9
Total fish oil			5.3	8.0
EPA[d]			0.8	0.7
DHA[d]			0.5	0.7
Protein (P) : digestible energy (DE)[e]				
mg P/kcal DE	152	135	138	160
mg P/kJ DE	36.3	32.3	33.0	38.3
Proximate analysis (% of air-dry weight)				
Moisture	9.0	9.0	6.2	7.6

[a] Manufacturer's guaranteed analysis values for protein and fat, adjusted for moisture content.

[b] Feed HB8825 contained, in mg/kg diet: iodine (potassium iodide) 4, zinc (oxide) 60, manganese (oxide) 5, chromium (chromium potassium sulfate) 1, thiamin (mononitrate) 40, riboflavin 60, pyridoxine 40, pantothenic acid (*d*-calcium pantothenate) 200, niacin 300, biotin 2, folacin 20, cyanocobalamin 0.2, choline 4,000, inositol 900, ascorbic acid 700, ethoxyquin 200; in IU/kg diet: retinol 20,000, cholecalciferol 3,000, tocopherol 500, menadione 50.

[c] Feed HB9020 contained the same mineral and vitamin concentrations as HB8825, except we (1) added iron (ferrous sulfate) 50 mg/kg, (2) increased choline to 4,800 mg/kg, (3) substituted for ascorbic acid (L-ascorbyl-2-polyphosphate) 300 mg/kg equivalent, (4) decreased ethoxyquin to 150 mg/kg.

[d] Contents of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) were calculated using average values for anchovy, herring, and menhaden oils from Lovell (1989) and Sargent et al. (1989).

[e] Digestible energy (DE) was estimated using the values 4 kcal/g protein, 8 kcal/g fat, 3 kcal/g carbohydrate.

growth rate (SGR: %/d = $100[\log_e W_t - \log_e W_0]/T$; W_t is the weight of fish at time t, W_0 is the weight of fish at time 0, and T is the culture period in days), feed consumption (vacuum dry weight), and feed conversion (FC = [dry weight of feed fed]/[wet fish weight gained]) were determined at the end of each trial.

Early growth was good but not exceptional (Table 2) and might have improved with the use of higher water temperature and a starter feed formulated for hybrid bass. These trials were conducted at temperatures slightly lower (24–26°C) than optimal for growth of palmetto bass (26–28°C; Woiwode and Adelman 1991). Minimum dietary protein requirements for most fish are in the range 25–55% (Millikin 1982; Lovell 1989); most carnivorous fish need at least 40% (Tucker 1992). Young striped bass might need 55% or more at the starter-feed level (Millikin 1982). From aquarium experiments with semipurified diets, M. Brown, G. Nematipour, and D. Gatlin (unpublished) concluded that 40% dietary protein was sufficient for sunshine bass of 2.68 g initial mean weight at 0 and 7‰ salinity.

In the present study, growth and feed conversion of sunshine bass were better with the experimental grower diets than with the commercial trout grower (Table 2). Results with the experimental diets were as good as or better than those previously reported for hybrid striped bass (Har-

TABLE 2.—Growth data for sunshine bass fed commercial salmon starter and trout grower feeds and two experimental feeds in fresh artesian well water at 24–26°C. Total length ranges and wet weight means are given. Daily growth is specific growth rate. Daily ration and feed conversion are on a dry-weight basis. Growth and feed data are given as mean (SD) for fiberglass tanks (two replicates per treatment).

Trial	Feed	Time (d)	Fish per tank	Final length (mm)	Initial weight (g)	Final weight (g)	Final density (kg/m^3)	Mean growth (g/d)	Daily growth (%/d)	Daily ration (%/d)	Feed conversion	Survival (%)
10-tonne rectangular concrete tanks (one per feed)												
1	Salmon	156	200	190–270	0.85	177	2.8	1.13	3.42	4.92	1.44	80
2	HB8825	50	15	272–307	207	348	0.5	2.82	1.04	1.09	1.05	100
	Trout	50	15	262–297	205	307	0.5	2.04	0.81	1.09	1.34	100
3	HB8825	182	15	358–422	348	862	1.2	2.82	0.50	1.46	2.92	93
	Trout	182	15	325–389	307	592	0.9	1.56	0.36	1.75	4.87	100
4	HB9020	156	14	394–472	862	1,333	1.6	3.02	0.28	0.88	3.16	86
	Trout	156	15	340–407	592	894	1.2	1.94	0.26	1.08	4.17	87
5	HB9020	327	8	434–558	1,420	1,710	1.4	0.89	0.06	0.40	6.73	100
3.5-tonne circular fiberglass tanks (two per feed)												
2	HB8825	50	10	266–298	213 (1)	322 (8)	0.9	2.18 (0.12)[a]	0.83 (0.04)[a]	0.86 (0.01)[a]	1.05 (0.06)[a]	100
	Trout	50	10	254–296	214 (4)	279 (13)	0.8	1.30 (0.19)	0.53 (0.06)	0.87 (0.04)	1.56 (0.12)	100

[a] Significantly better than performance on the trout diet (t-test, $P = 0.001$).

rell et al. 1990; Van Olst and Carlberg 1990) (Table 3). Fish reared in ponds feed on a diverse array of natural foods as well as the formulated feeds given to them. Our sunshine bass grew from 207 g to 862 g in 232 d with an overall FC of 2.52 when fed experimental feed alone (no natural foods) once a day. Nearly all deaths occurred within a few days after weighing and probably were related to handling.

To grow from 0.85 g to 900 g mean weight, sunshine bass had to consume 291 g of salmon starter plus 2,816 g of trout grower between 1 and 19 months after hatching (FC 3.46), or 291 g salmon starter plus 1,770 g experimental grower between 1 and 14.5 months (FC 2.29). To reach 1,333 g, those reared on experimental diets needed 291 g salmon starter plus 3,257 g experimental grower between 1 and 19 months (FC 2.66). Reduced growth and higher FC during months 20–30 might have been related to the fish reaching maturity at about 2 years.

Although hybrid striped bass grow reasonably well on trout-grower diets, better growth and FC can be attained with more appropriate feeds. Protein, fat, and carbohydrate contents are factors, but variations in performance among feeds are also often related to the sources of those components. Salmon starter is a reasonably good first feed for young striped bass and hybrid striped bass. Some trout feeds perform fairly well in pond culture, when natural food is available, but higher-quality feeds can be more economical overall. Typical catfish feeds clearly are not appropriate. Since this study was done, commercial feeds designated for hybrid bass have begun to appear on the market, but there still is room for improvement. The diet studies reviewed here demonstrate the growth and FC potential of these fish.

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TABLE 3.—Summary of growth data from recent studies on sunshine bass, palmetto bass, and striped bass. Wet-weight means are given. Daily growth is specific growth rate. Except where noted, daily ration and feed conversion appear to have been given on an air-dry (as-fed) feed weight basis.

Feed[a]	Meals per day	Temperature (°C)	Rearing unit	Time (d)	Initial weight (g)	Final weight (g)
Sunshine bass						
E. Semipurified (35-2.5-42,d)	2	24–27	38-L aquarium	~56	1.5	15.3
C. Floating trout (38,ad)			1.9-tonne tank	147	17	203
C. Catfish (35-5,ad)	2		0.04-hectare pond	180	90	364
C. Trout (38-8,ad)	2		0.04-hectare pond	180	97	497
E. Grower (45-10,ad)	2		0.05-hectare pond	193	113	747
C. Catfish (32-4,ad)	2		0.04-hectare pond	195	128	717
C. Trout (38-8,ad)	2		0.04-hectare pond	195	128	672
E. Grower (42-14,ad)	2		0.04-hectare pond	195	128	789
C. Trout	Several		0.5-hectare pond	~240	203	857
Palmetto bass						
C. Salmon starter (57-16,d)	6–8	20–25	2-tonne tank	50	1.75	25
C. Floating trout (38,ad)			1.9-tonne tank	147	26	305
E. Semimoist (68-17-10,d)	2	24	37-L chamber	30	27.5	44.2
E. Semimoist (68-17-10,d)	2	28	37-L chamber	33	47.8	107.0
C. Trout	Several		0.5-hectare pond	~240	220	755
Striped bass						
C. Salmon starter (57-16,d)	6–8	20–25	2-tonne tank	50	2.29	16
C. Fish byproduct (51-20-5,d)	3	20	100-L tank	42	20.8	21.6
E. Catfish (44-4-38,d)	3	20	100-L tank	42	25.1	34.3
C. Trout (43-9-37,d)	3	20	100-L tank	42	28.0	52.4
ASD-2-30 salmon (63-17-8,d)[d]	3	20	100-L tank	42	25.4	52.2
GR-6-30 trout (49-15-24,d)[d]	3	20	100-L tank	42	26.7	56.0

[a] E. = experimental; C. = commercial. Parenthetic formulas give % protein-% fat-% carbohydrate (carbohydrate data are unavailable for some commercial feeds), d (dry) or ad (air dry = as fed).

[b] References: (1) Nematipour et al. 1992; (2) W. Jenkins, T. Smith, and D. Alessi, unpublished; (3) H. Robinette, personal communication; (4) S. Newton and M. Subramanyam, unpublished; (5) S. Newton and others, unpublished; (6) T. Smith and others, unpublished; (7) Tuncer et al. 1990; (8) Woiwode and Adelman 1991; (9) Klar and Parker 1989.

[c] Daily ration and feed conversion are on a dry-feed/wet-fish-weight basis.

[d] U.S. Fish and Wildlife Service diets.

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TABLE 3.—Extended.

Feed[a]	Mean growth (g/d)	Daily growth (%/d)	Daily ration (%/d)	Feed conversion	Survival (%)	Reference[b]
			Sunshine bass			
E. Semipurified (35-2.5-42,d)	~0.25	~4.1	~6.93	1.69[c]	98	1
C. Floating trout (38,ad)	1.26	1.69	2.65	1.57	93	2
C. Catfish (35-5,ad)	1.52	0.78	2.08	2.67	89	3
C. Trout (38-8,ad)	2.22	0.91	1.72	1.89	92	3
E. Grower (45-10,ad)	3.28	0.98	2.25	2.3	61	4
C. Catfish (32-4,ad)	3.02	0.88	10.30	11.7	35	5
C. Trout (38-8,ad)	2.79	0.85	2.30	2.7	75	5
E. Grower (42-14,ad)	3.39	0.93	1.95	2.1	83	5
C. Trout	~2.72	~0.60	~1.36	2.27	93	6
			Palmetto bass			
C. Salmon starter (57-16,d)	0.46	5.3	5	1.04[c]	99	7
C. Floating trout (38,ad)	1.90	1.67	2.62	1.57	93	2
E. Semimoist (68-17-10,d)	0.56	1.58	3.00	1.90[c]	100?	8
E. Semimoist (68-17-10,d)	1.79	2.44	2.51	1.03[c]	100?	8
C. Trout	~2.23	~0.51	~1.16	2.27	93	6
			Striped bass			
C. Salmon starter (57-16,d)	0.27	3.9	5	1.38[c]	96	7
C. Fish byproduct (51-20-5,d)	0.02	0.09	3.32	36.84	100?	9
E. Catfish (44-4-38,d)	0.22	0.74	6.08	8.21	100?	9
C. Trout (43-9-37,d)	0.58	1.49	4.62	3.10	100?	9
ASD-2-30 salmon (63-17-8,d)[d]	0.64	1.72	4.99	2.90	100?	9
GR-6-30 trout (49-15-24,d)[d]	0.70	1.76	4.52	2.57	100?	9