Supplemental Feeding of Hybrid Striped Bass Fry

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Abstract: Phase–1 hybrid striped bass fry were fed trout pellets at 0, 6.7, and 13.4 kg/ha/day, in 7 culture ponds in 1986. Yield ranged from 45.6 to 239.7 kg/ha. Survival ranged from 11% to 70%. Five ponds in which fish were fed trout pellets had substantially greater yields of hybrid striped bass fingerlings than 1 pond in which fish were unfed. In 1987, two culture ponds in which fish were fed trout pellets at 13.4 kg/ha/day from the time of initial stocking had significantly greater ($P < 0.05$) yields of hybrid striped bass fry than 2 ponds initially fed 18 days after stocking. Yields ranged from 0 to 86 kg/ha and survival ranged from 0% to 61%. Feed allotment and time of initial feeding of trout pellets affected production of hybrid striped bass.

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The advent of successful induced spawning of the striped bass (*Morone saxatilis*) × white bass (*M. chrysops*) hybrid by Stevens (1965) led to its introduction into freshwater impoundments and created potential for hybrid striped bass culture. Survival and growth of hybrid striped bass sac fry to phase–1 (4- to 6-week-old fry) are important to hatchery personnel and field biologists.

The diet of striped bass fry has been extensively studied (Harper et al. 1968, Humphries and Cumming 1972, Harrell et al. 1977, Geiger et al. 1985, Fitzmayer et al. 1986). Striped bass fry initially feed upon copepods and cladocerans, and then switch to insects after reaching lengths of approximately 30 mm. In contrast, there are few diet studies for hybrid striped bass fry. Similar to striped bass fry, hybrid striped bass fry are generally planktivorous during their early life (Woods et al. 1985, Houde and Lubbers 1986, Morris 1988).

Through manipulation of zooplankton populations and repeated daily feedings of artificial feeds, researchers increased striped bass fry survival from 40% to 60% (Geiger and Parker 1985, Geiger et al. 1985, Fitzmayer et al. 1986). Good survival for hybrid striped bass is approximately 50% (Kerby et al. 1983).

Artificial diets have been used with some success in striped bass culture ponds.

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Fitzmayer et al. (1986) obtained 53% survival after a 42-day culture period when 15-day-old striped bass fry were fed hourly, and 35% survival when fish were fed twice per day in culture ponds. In both treatments, most fry contained feed in their guts when examined. These researchers suggested that artificial feeds supplemented rather than replaced the natural food supply of striped bass fry during phase–1.

Bonn et al. (1976) and Turner (1984) recommended that initial feeding of artificial diets start (5.6 kg/ha/day) when zooplankton depletion occurred in striped bass culture ponds. However, studies involving other cultured species, e.g. chondrosteans, indicate the importance of offering artificial diets prior to natural food depletion to improve diet acceptance (Buddington and Christofferson 1985).

This study was designed to evaluate whether an artificial diet (trout pellets) decreased dependence of hybrid striped bass fry upon zooplankton as a major food resource. The objectives of this study were to determine: (1) the acceptance of pelleted food by hybrid striped bass fry and (2) the effects of timing of initial feeding of artificial diets upon survival and production of hybrid striped bass phase–1 fry.

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Methods

1986

In 1986, 7 0.2-ha ponds were filled with filtered river water from the Pearl River, Mississippi, 4–5 days prior to stocking hybrid striped bass fry. Soon after inundation, and continuing to harvest time, ponds received weekly applications of cotton seed meal (112 kg/ha) and 10–35–2 liquid fertilizer (28 liters/ha).

Zooplankton was sampled weekly during the course of the study using a 12-volt D.C. pump apparatus developed by Farquhar and Geiger (1984). Surface (top meter) pH, ammonia-nitrogen (NH_3-N), and alkalinity readings were measured weekly by Mississippi Department of Wildlife Conservation personnel using a Hach model FF–1 kit (Hach Company, Loveland, Colo.). Chlorophyll *a* levels were obtained through the standard acetone extraction technique (Am. Public Health Assoc. 1985). Surface dissolved oxygen (DO) levels were measured weekly using a YSI model 57 oxygen meter (Yellow Springs Instrument Co., Yellow Springs, Ohio).

Six-day-old fry from the Marion Hatchery, Marion, Alabama, were stocked at approximately 450,000/ha in 7 ponds on 27 April after being held 5–6 days in aquaria with water supplied from 1 of the culture ponds. During this yolk absorption period, no additional food was supplied to the fry.

Using Bonn et al. (1976) and Turner (1984) as guidelines, the amounts of artificial diets (0, 6.7, and 13.4 kg/ha/day) used in this study were established. The experimental treatments (randomized design) included 1 pond receiving no feed (Treatment 1), 3 ponds receiving 48% protein trout pellets (Purina Mills Inc., St. Louis, Mo.) at 6.7 kg/ha/day (Treatment 2), and 3 ponds receiving feed at 13.4 kg/ha/day (Treatment 3). Eight days after stocking, all fish that were fed received 4 equal daily feedings. Fish were fed size–0 trout pellets during the initial 7 days of feeding and size–1 pellets for the remaining 10 days of the culture period.

1987

Eight 0.06-ha ponds were used for the 1987 site. Ponds were filled with well water and were fertilized in the same manner as the ponds in 1986 after being inoculated twice with mixtures of copepods and various cladocerans (total density approximately 2,000 organisms per mixture).

Zooplankton densities were obtained in a similar fashion as in 1986. A Hach DREL/5 Kit (Hach Company, Loveland, Colo.) was used to measure ammonia-nitrogen, nitrite-nitrogen (NO_2-N), nitrate-nitrogen (NO_3-N), and alkalinity in the shallow regions of ponds. Daily DO readings were obtained and a Fisher Accumet pH Meter model 805MP (Fisher Scientific, Norcross, Ga.) was used to measure pH weekly.

Chlorophyll *a* and pheophytin *a* levels were measured weekly via acetone-hexane extraction procedure proposed by Whitney and Darley (1979). This procedure provides a more conservative approximation of chlorophyll *a* than does the standard acetone extraction method.

Fry from the same spawn were obtained from Louisiana Department of Wildlife and Fisheries Toledo Bend Hatchery on 13 April 1987. In contrast to 1986, fry were fed *Artemia* nauplii ad libitum during their yolk absorption period.

Fry were stocked into ponds at approximately 90,000 larvae/ha on the evening of 21 April 1987. The randomized design of the experiment consisted of fry in 4 ponds receiving feed immediately after stocking (Treatment 1) and fry in 4 ponds initially receiving feed 18 days after stocking (Treatment 2). In both treatments, fry were fed 4 equal feedings of trout pellets size–0 at a rate of 13.4 kg/ha/day.

Statistical Analysis

To overcome the inherent difficulties of using survival and biomass data from ponds with unequal survival, the harvest data were modified by the normalized biomass increase (NBI) parameter (Conklin et al. 1975). The following equation was used: $NBI = ((W_f * N_f) - (W_i * N_i))/N_i$, where W_f is the final mean weight, N_f is the final number of fish, W_i is the initial mean weight, and N_i is the initial number of fish.

Zooplankton and physicochemical data from each year were analyzed with a repeated measures analysis of variance in the Statistical Analysis Systems (SAS) procedure (SAS Institute, Inc. 1985). T-tests were used to analyze production data. Appropriate transformation procedures were applied to normalize data.

Results

1986

Analysis of variance by repeated measures indicated that 1986 experimental feeding levels did not significantly affect most chemical parameters of water or zooplankton populations (Tables 1, 2). There were significant treatment differences in ($P < 0.05$), in pH reading among treatments, but these were not biologically important. Chemical parameters were within tolerance levels for fish culture (Piper et al. 1982) in all but 1 of the ponds. Toxic levels of un-ionized ammonia (Boyd 1979), approximately 0.70 mg/liter, in pond 3 were due to the combination of high pH, ammonia-nitrogen, and high water temperature on 22 May.

Fish survival ranged in 1986 from 11% to 70% over the 7 study ponds, and yields ranged from 45.6 to 239.7 kg/ha (Fig. 1). Two ponds fed 13.4 kg/ha/day (Treatment 3) had the highest survival and yield. However, pond 1 (unfed) had greater fish survival than did 3 ponds fed with trout pellets. There were no significant differences between treatments in either survival or production (Table 3). Low survival and yield of fry in pond 3 were probably due to toxic levels of un-ionized ammonia and are not included in the mean values for treatment 2.

Normalized biomass increase (NBI) values for the 1986 ponds ranged from 0.14 in pond 3 to 0.64 in pond 6 (Fig. 1). Because toxic levels of un-ionized ammonia were evident in pond 3 just 5 days before harvest, the NBI value would

Table 1. Mean values for water quality variables measured weekly in 7 0.2-ha ponds at Turcotte Laboratory, Mississippi, 1986.

Variable[a]	Treatment[b]	Sample size (*N*)	Mean ± SD
Dissolved oxygen (mg/liter)	1	4	15.6 ± 2.80
	2	12	15.9 ± 3.17
	3	12	12.8 ± 5.19
NH_3-N (mg/liter)	1	4	0.4 ± 0.10
	2	12	0.4 ± 0.22
	3	12	0.5 ± 0.22
pH*	1	4	8.4 ± 1.38
	2	12	8.9 ± 0.96
	3	12	8.1 ± 0.94
Alkalinity[c] (mg/liter as $CaCO_3$)	1	4	51.0 ± 0.00
	2	12	53.4 ± 8.98
	3	12	60.2 ± 8.46
Chlorophyll *a*[c] (ug/liter)	1	3	10.5 ± 6.12
	2	9	15.1 ± 5.10
	3	9	10.6 ± 7.88

[a]Asterisk (*) indicates treatments were significantly different ($P < 0.05$), repeated measures design.
[b]1 = fish not fed, 2 = fish fed 6.7 kg/ha/day, 3 = fish fed 13.4 kg/ha/day.
[c]Data log transformed before statistical analysis.

Table 2. Mean values of zooplankton densities (*N*/liter) measured weekly in 7 0.2-ha ponds at Turcotte Laboratory, Mississippi, 1986. All data log transformed before statistical analysis.

Prey item	Treatment[a]	Sample size (*N*)	Mean ± SD
Rotifers	1	4	207.0 ± 163.85
	2	12	295.8 ± 388.53
	3	12	367.9 ± 383.08
Cladocera	1	4	77.8 ± 50.57
	2	12	87.9 ± 92.56
	3	12	169.1 ± 206.12
Copepoda	1	4	36.7 ± 46.00
	2	12	53.3 ± 59.21
	3	12	58.0 ± 67.84
Nauplii	1	4	92.2 ± 76.72
	2	12	76.8 ± 80.23
	3	12	314.4 ± 677.26

[a]1 = fish not fed, 2 = fish fed 6.7 kg/ha/day, 3 = fish fed 13.4 kg/ha/day.

not reflect the greater potential individual growth of fish, due to lower density, in that pond. Thus, the mean NBI value for fish in treatment 2 did not include observations obtained from pond 3. As with production and survival, there were substantial numerical differences but no significant differences between treatments concerning NBI values (Table 3).

1987

Ponds 3, 4, 6, and 7 in 1987 exhibited initial pH approaching 10 and ammonia-nitrogen readings often in excess of 1 mg/liter. High ammonia-nitrogen and pH levels combined with water temperature approaching 26° C resulted in approximately 80% of the ammonia occurring in the un-ionized form (Boyd 1979). High levels of

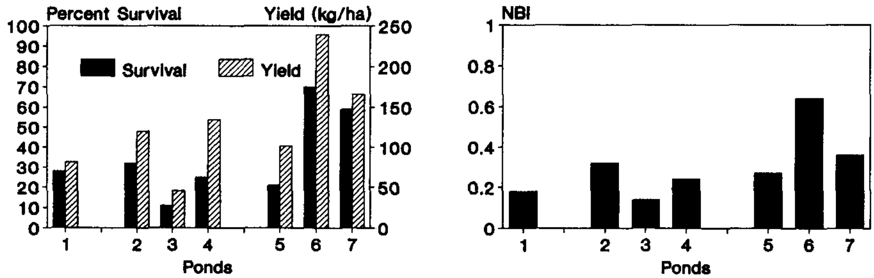

Figure 1. Hybrid striped bass survival, yield, and normalized biomass increase (NBI) in 7 0.2-ha ponds at Turcotte Laboratory, Mississippi, 1986. High un-ionized ammonia levels occurred in pond 3. Treatment 1: fish not fed (Pond 1); Treatment 2: fish fed 6.7 kg/ha/day (Ponds 2,3,4); Treatment 3: fish fed 13.4 kg/ha/day (Ponds 5,6,7).

Table 3. Yield (kg/ha), survival (%), and normalized biomass increase (NBI) in 6 0.2-ha ponds at Turcotte Laboratory, Mississippi, 1986.

Parameter	Treatment[a]	Sample size (N)	Mean ± SD
Yield	1	1	80.9[b]
	2	2[c]	127.2 ± 10.54
	3	3	169.1 ± 69.10
Survival[d]	1	1	28.0[b]
	2	2[c]	28.5 ± 4.95
	3	3	50.0 ± 25.71
NBI	1	1	0.18[b]
	2	2[c]	0.28 ± 0.06
	3	3	0.42 ± 0.19

[a]1 = fish not fed, 2 = fish fed 6.7 kg/ha/day, 3 = fish fed 13.4 kg/ha/day.

[b]Indicates the actual value of 1 observation.

[c]Sample does not include values from pond 3 due to toxic levels of un-ionized ammonia just prior to harvest.

[d]Data transformed by arcsin $\sqrt{\text{percent}}$ before statistical analysis.

un-ionized ammonia in these ponds was detrimental to the fry populations as was observed in pond 3 in 1986.

Analysis of variance by repeated measures indicated that treatments did not have a significant effect on chemical parameters of water or on individual zooplankton populations (Tables 4 and 5). During the initial culture period, pond 5 exhibited low morning DO (approximately 2 ppm), which may have been due to the application of a herbicide applied earlier in 1987 to control filamentous algae.

Ammonia toxicity resulted in a wide range of survival and yields in 1987 (Fig. 2). Ponds 3, 4, 6, and 7, ponds with toxic levels of un-ionized ammonia, had essentially no fry survival. Further discussion will entail only those ponds that did not have toxic levels of un-ionized ammonia. Ponds 1 and 2, containing fry that were fed initially (Treatment 1), had significantly greater ($P < 0.05$) yields than ponds fed later in the culture period (Treatment 2) (Table 6). Survival was variable within treatments, pond 2 having 63% survival and pond 5 with the lowest survival at 18%. Low fry survival in pond 5 may have resulted from low morning DO during the initial culture period.

NBI values for ponds fed from the onset of stocking were significantly greater ($P < 0.10$) than values for ponds not fed until 18 days later (Fig. 2, Table 6). In NBI terms, trout chow fed at the onset of stocking increased hybrid striped bass production.

Discussion

Several researchers have noted that artificial diets were poorly utilized by striped bass fry (Harper et al. 1968, Regan et al. 1968, Bishop 1968, Humphries and

Table 4. Mean values for water quality variables measured biweekly in 8 0.06-ha ponds fed 13.4 kg/ha/day at the Mississippi Agricultural and Forestry Experiment Station Aquaculture Unit, Mississippi, 1987. Dissolved oxygen measured daily.

Variable	Treatment[a]	Sample size (*N*)	Mean ± SD
Dissolved oxygen (mg/liter)	1	132	9.7 ± 3.69
	2	132	10.3 ± 4.20
pH	1	16	9.2 ± 0.61
	2	16	9.0 ± 0.70
NH_3-N (mg/liter)	1	20	0.6 ± 0.33
	2	20	0.7 ± 0.47
NO_2-N (mg/liter)	1	20	0.0 ± 0.01
	2	20	0.0 ± 0.01
NO_3-N (mg/liter)	1	20	1.0 ± 0.33
	2	20	1.8 ± 2.68
Alkalinity[b] (mg/1 liter as $CaCO_3$)	1	20	93.8 ± 14.56
	2	20	97.8 ± 14.62
Chlorophyl *a*[b] (ug/liter)	1	20	1.5 ± 3.59
	2	20	4.2 ± 6.68
Pheophytin *a*[b] (ug/liter)	1	20	21.1 ± 14.99
	2	20	28.1 ± 37.85

[a]1 = fish initially fed at stocking, 2 = fish initially fed 18 days after stocking.
[b]Data log transformed before statistical analysis.

Table 5. Mean values of zooplankton densities (*N*/liter) measured biweekly in 8 0.06-ha ponds fed 13.4 kg/ha/day at the Mississippi Agricultural and Forestry Experiment Station Aquaculture Unit, Mississippi, 1987. All data log transformed before statistical analysis.

Prey item	Treatment[a]	Sample size (*N*)	Mean ± SD
Rotifers	1	36	984.2 ± 1806.42
	2	36	367.8 ± 685.52
Cladocera	1	36	96.4 ± 135.45
	2	36	119.5 ± 149.32
Copepoda	1	36	24.5 ± 43.46
	2	36	40.1 ± 58.39
Nauplii	1	36	103.8 ± 164.99
	2	36	109.1 ± 132.29

[a]1 = fish initially fed at stocking, 2 = fish initially fed 18 days after stocking.

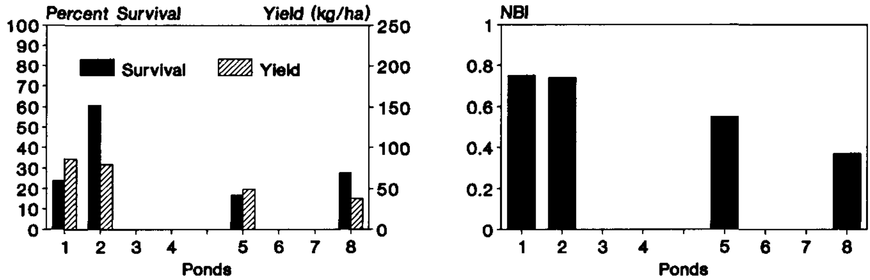

Figure 2. Hybrid striped bass survival, yield, and normalized biomass increase (NBI) in 8 0.06-ha ponds fed 13.4 kg/ha/day at the Mississippi Agricultural and Forestry Experiment Station Aquaculture Unit, Mississippi, 1987. Treatment 1: fish initially fed at stocking (Ponds 1,2,3,4); Treatment 2: fish initially fed 18 days after stocking (Ponds 5,6,7,8).

Cumming 1972). In contrast, Harper and Jarman (1972) determined that supplemental feeding did help to increase striped bass fingerling production in culture ponds. Morris (1988) noted that 8-day-old hybrid striped bass fry consumed trout pellets 3 days following stocking into culture ponds.

The use of an artificial feed had a positive effect upon the production of phase-1 hybrid striped bass fry in this study. The amount of trout pellet fed in 1986 and the timing of the initial feeding in 1987 increased both pond yields and normalized biomass (NBI) yields. However, fry survival was highly variable in both years, and only the 1987 data exhibited significant treatment effects upon production and NBI

Table 6. Yield (kg/ha), survival (%), and normalized biomass increase (NBI) per treatment in 4 0.06-ha ponds fed 13.4 kg/ha/day at the Mississippi Agricultural and Forestry Experiment Station Aquaculture Unit, Mississippi, 1987.

Parameter[a]	Treatment[b]	Sample size (N)[c]	Mean ± SD
Yield*	1	2	83.0 ± 4.62
	2	2	43.7 ± 8.37
Survival[d]	1	2	42.5 ± 26.16
	2	2	22.5 ± 7.78
NBI**	1	2	0.75 ± 0.01
	2	2	0.46 ± 0.13

[a]Asterisk (*) indicates significant treatment effects ($P < 0.05$), asterisks (**) indicate significant treatment effects ($P < 0.10$).

[b]1 = fish initially fed at stocking, 2 = fish initially fed 18 days after stocking.

[c]Sample includes only those ponds that did not have toxic levels of un-ionized ammonia.

[d]Data transformed by arcsin $\sqrt{\text{percent}}$ before statistical analysis.

values. As is evident in other pond studies, statistical analyses were hampered by small sample sizes available per treatment.

Though pond yields were greater in some ponds in 1986 than in 1987, the NBI values for fish collected in 1987 from ponds fed from the onset of stocking were larger than NBI values in 1986. Differing NBI values between the 2 sites may have resulted from the 5-fold stocking rate differences of 450,000 fry/ha in 1986 versus 90,000 fry/ha in 1987. This difference in stocking rates was due to a different number of fry available in each year.

This study suggests that fish culturists should place more importance upon the use of artificial diets in aquaculture of hybrid striped bass fry. Also, this study indicates the importance of feeding hybrid striped bass fry immediately following stocking.

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