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Winter Polyculture of Rainbow Trout and Fingerling Channel Catfish

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Abstract.—The feasibility of rearing rainbow trout (*Oncorhynchus mykiss*) with overwintering fingerling channel catfish (*Ictalurus punctatus*) at one of two densities was examined. Individual weight gain, net production, and feed conversion were better for rainbow trout in monoculture than in either polyculture treatment. There was a significant difference in growth but not in survival of channel catfish polycultured at low and high densities with rainbow trout.

Rainbow trout (*Oncorhynchus mykiss*) and channel catfish (*Ictalurus punctatus*) have been identified as the fish species best suited for aquacultural double-cropping or polyculture in many southern U.S. states (Hill et al. 1972; Tatum 1973; Perry 1975; Reagan and Robinette 1976; Tatum 1976). The climate in Kentucky is especially suited for double-cropping of these species because each production season ranges from 180 to 200 d (H. R. Schmittou and M. C. Cremer, Auburn University, unpublished report). Because of the limited growing seasons for both species, production strategies must be established for the most efficient use of pond resources, especially in the winter months. In previous studies, the polyculture of market-size channel catfish and rainbow trout in ponds (Reagan and Robinette 1976) and in cages (Beem et al. 1988) has been examined. However, there have been no studies on the production of market-size rainbow trout in combination with overwintering channel catfish fingerlings stocked in ponds.

Channel catfish normally reach harvestable size (from the egg) in about 18 months (Busch 1985). This requires that fingerlings be overwintered before second-year grow-out to harvestable sizes (>0.5 kg; Huner and Dupree 1984). Depending on overwintering density, water temperature, and feed consumption, catfish fingerlings may either lose weight during winter months (Robinette et al. 1985) or increase their weight up to 45% (Reagan and Robinette 1979). The objectives of this study were to determine the feasibility of polyculturing rainbow trout with overwintering channel catfish fingerlings and to investigate the effects of channel catfish fingerling density on the growth of both species during winter months.

Methods

Three treatments with two replications each were selected: (1) monoculture of rainbow trout (9,884 fish/hectare; monoculture); (2) polyculture of rainbow trout and a low density of catfish fingerlings (9,884 and 24,710 fish/hectare, respectively; low-density polyculture); and (3) polyculture of rainbow trout and a high density of catfish fingerlings (9,884 and 49,420 fish/hectare, respectively; high-density polyculture).

Six 0.04-hectare ponds used in this study were approximately 1.5 m deep and were supplied with water from a reservoir filled by rain runoff. Water levels were maintained by periodic additions to replace losses to evaporation. Outflow through standpipes occurred only when rain fell directly on pond surfaces; the ponds had no watersheds. Water temperature and dissolved oxygen (DO) levels were monitored daily, in mid-afternoon, with a meter (model 54A, Yellow Springs Instruments Corp., Yellow Springs, Ohio) at a depth of 0.5 m. Ponds were aerated if DO levels were predicted (by extrapolation) to decline to 5.0 mg/L or less during the night. A spectrophotometer (model DREL/5, Hach Co., Loveland, Colorado) was used to measure ammonia levels weekly and nitrite levels twice weekly; pH was measured weekly with an Omega pH meter (model PHH-43) at the time ammonia was measured.

Fingerling channel catfish were stocked on 21 October 1987 at an average weight of 95 g. Rainbow trout were stocked on 22 October 1987 at 82 g. The winter feeding schedule was based on a graduated weight–temperature chart for rainbow trout (Piper et al. 1982). Additional feed was provided for the channel catfish by feeding 25% above chart values for all three treatments when water temperature was 10°C or higher. No additional feed above chart values was provided when water temperature was below 10°C. Fish were fed a commercial sinking trout feed (38% protein, 12% fat), and the daily ration was divided into morning and evening feedings. Total feeding days were 120 out of 199 culture days. Missed feeding days were primarily due to ice cover. Fish were harvested on 6 April 1988.

Data were analyzed by analysis of variance with separation of means by least significant difference at $P = 0.05$. Two-group comparisons were made with Students t-test (Steel and Torrie 1980).

Results

Water Quality

Water temperatures were suitable for rainbow trout culture throughout the period 21 October 1987 to 6 April 1988 (mean, 7.7°C; maximum, 21°C). Dissolved oxygen concentrations averaged 11.9 mg/L and were maintained above 5.0 mg/L at all times. Total ammonia levels were higher than those reported by Halverson et al. (1980) for ponds in Alabama. However, un-ionized ammonia concentrations (Table 1) remained below 0.0125 mg/L and 0.12 mg/L, which are levels considered to reduce growth of salmonids and channel catfish, respectively (Piper et al. 1982). Nitrite concentrations were significantly higher in the high-density polyculture treatment than in the monoculture and low-density polyculture treatments. However, nitrite remained below stress levels for both species in all treatments (Table 1). In summary, temperature was the only measured water quality variable that likely affected fish growth. No disease problems were encountered with either species.

Fish Production

Rainbow trout in monoculture demonstrated significantly higher individual weight gain than rainbow trout polycultured with channel catfish at low or high density (Table 2). Survival was significantly higher for rainbow trout in monoculture than in polyculture with channel catfish fingerlings at high density. Rainbow trout polycultured with low-density channel catfish had higher survival than those reared with high-density channel catfish, though the difference was not statistically significant.

Channel catfish fingerlings overwintered in low-density polyculture showed significantly higher individual weight gain than those overwintered in high-density polyculture (Table 2). There was no significant difference in survival of channel catfish polycultured at the two densities.

Total pond production for both species combined was 1,672, 1,166, and 904 kg/hectare for the monoculture, low-density polyculture, and high-density polyculture treatments, respectively. Production from monoculture of rainbow trout was significantly higher than production from high-density polyculture. Differences in production between monoculture of rainbow trout and low-density polyculture, and between high- and low-density polyculture treatments were not statistically significant.

Feed conversion (amount fed, kg/weight gain, kg) was significantly better for rainbow trout in monoculture ponds than for fish in high-density polyculture (Table 2). Feed conversion was lower in low-density polyculture ponds than in high-density ponds (1.9 and 2.4, respectively), though the difference was not significant.

Discussion

These results indicate that rainbow trout perform better in monoculture than in polyculture and agree with the findings of Reagan and Robinette (1976) and Beem et al. (1988), who polycultured rainbow trout with large channel catfish. The difference in rainbow trout growth between those in monoculture and those in polyculture was even more pronounced in our study with channel catfish fingerlings because rainbow trout in monoculture reached harvestable weights (>225 g; Bardach et al. 1972), whereas those in polyculture did not.

Production of catfish fingerlings did not appear to be negatively affected by the presence of rainbow trout. Weight gains for catfish fingerlings were good for the water temperatures in this study and were similar to fingerling gains obtained in monoculture feeding experiments in U.S. deep-south states (Robinette et al. 1985; Reagan and Robinette 1979).

Reduced rainbow trout growth, increased feed conversion, and increased rainbow trout mortality under polyculture conditions could not be attributed to water quality as measured in this study. Rainbow trout mortality increased in direct proportion with increased channel catfish density in this study. Beem et al. (1988) also reported increased rainbow trout mortality as the stocking ratio of channel catfish to rainbow trout was increased, and they attributed this to possible aggression between the two species.

The reduced rainbow trout growth and increased feed conversion observed under polyculture indicate significant competition between the

TABLE 1.—Summary of water quality analyses for monoculture and polyculture ponds, 21 October 1987–6 April 1988. Each fish culture treatment was replicated two times. Means ± SE are based on samples from two replicate ponds taken daily for temperature and dissolved oxygen, weekly for ammonia and pH, and twice weekly for nitrite. Means in a single row without a letter in common are significantly different (Fisher's least significant difference; $P < 0.05$).

Variable	Fish culture treatment		
	Rainbow trout monoculture[a]	Low-density polyculture[b]	High-density polyculture[c]
Temperature (°C)	7.5±0.4 z	7.9±0.2 z	7.7±0.1 z
Dissolved oxygen (mg/L)	11.6±1.1 z	11.8±0.0 z	12.3±0.3 z
pH	7.6±0.2 z	7.7±0.1 z	7.6±0.0 z
Total ammonia nitrogen (mg/L as N)	0.31±0.01 z	0.58±0.01 z	0.88±0.29 z
Un-ionized ammonia nitrogen (mg/L as N)	0.002±0.001 z	0.005±0.002 z	0.007±0.004 z
Nitrite (mg/L as N)	0.01±0.00 z	0.01±0.00 z	0.02±0.00 y

[a] Density: 9,884 rainbow trout per hectare.
[b] Densities: 9,884 rainbow trout and 24,710 channel catfish per hectare.
[c] Densities: 9,884 rainbow trout and 49,420 channel catfish per hectare.

two species for feed. In polyculture, the average individual gain for rainbow trout was only 20–25 g higher than the average gain for channel catfish during the same period, even though channel catfish are reported to not feed actively at temperatures below 10°C (Dupree and Huner 1984). Also, feed amounts were adjusted 25% above feed chart levels for rainbow trout to provide additional feed for channel catfish.

Increasing channel catfish density apparently increased competition for feed. No additional feed allowance was made for the channel catfish in the high-density polyculture treatment. This might explain the less-efficient feed conversion and decreasing pond production with increasing channel catfish densities. Catfish do not convert feed to flesh as efficiently at low temperatures (Stickney and Andrews 1971). Below 15°C, the efficiency of digestion in catfish drops markedly (Piper et al. 1982). As the density of channel catfish in polyculture treatments was increased, the channel catfish may have consumed an increasing proportion of the feed without a proportional increase in weight gain.

Additional feed amounts might improve rainbow trout growth in monoculture and polyculture, but may not improve combined feed conversions for rainbow trout and channel catfish in polyculture. A feeding methodology that would allow separate or differential feeding of the two species in polyculture might improve rainbow trout growth and feed conversions for both species combined.

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TABLE 2.—Treatment values for individual gain, survival, feed conversion, and total pond production of rainbow trout in monoculture and rainbow trout and fingerling catfish in polyculture. Values are means ± SE of two replicates. Values within a column without a letter in common are significantly different (Fisher's least significant difference; $P < 0.05$).

Treatment	Rainbow trout		Channel catfish			
	Mean weight gain per fish (g)	Survival (%)	Mean weight gain per fish (g)	Survival (%)	Feed conversion[a]	Total pond production[b] (kg/hectare)
Rainbow trout monoculture[c]	177.0±13.7 z	97.1±3.2 z			1.3±0.0 z	1,672.2±49.4 z
Low-density polyculture[d]	56.7±2.7 y	85.3±5.3 yz	35.2±2.14 z	98.0±1.8 z	1.9±0.2 yz	1,165.8±160.6 yz
High-density polyculture[e]	42.6±24.8 y	75.4±0.9 y	17.1±8.5 y	100.0±0.1 z	2.4±0.1 y	904.0±17.3 y

[a] Feed conversion = weight of feed offered (kg)/net gain in fish weight (kg); includes both species in polyculture.
[b] Includes both species in polyculture.
[c] Density: 9,884 rainbow trout per hectare.
[d] Densities: 9,884 rainbow trout and 24,710 channel catfish per hectare.
[e] Densities: 9,884 rainbow trout and 49,420 channel catfish per hectare.

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