Overwintering Paddlefish in Monoculture and in Polyculture with Channel Catfish and Rainbow Trout

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ABSTRACT. Paddlefish, *Polyodon spathula*, overwintered in monoculture and in polyculture with fingerling channel catfish, *Ictalurus punctatus*, or with rainbow trout, *Oncorhynchus mykiss*, were examined for growth and compatibility in nine 0.04-ha ponds. Paddlefish in polyculture had significantly greater ($P \leq 0.05$) individual weight gains than those in monoculture. Feed in polyculture treatments probably served as a fertilizer, promoting zooplankton production for paddlefish consumption and growth. Paddlefish in polyculture with fingerling channel catfish had significantly greater ($P < 0.05$) individual weight gains than paddlefish polycultured with rainbow trout, although there was less feed input with channel catfish than with rainbow trout. Bloody and frayed fins on paddlefish stocked with rainbow trout suggested fin nipping by rainbow trout which may have interfered with paddlefish feeding and growth. Paddlefish overwintered in polyculture with fingerling channel catfish demonstrated increased weight gains and good species compatibility.

INTRODUCTION

Paddlefish, *Polyodon spathula*, have been considered a possible culture species in the United States (Kirkendall 1983; Semmens and Shelton 1986), because they possess many desirable qualities for polyculture systems. Paddlefish are native to 21 states (Carlson and Bonislawsky 1981); are indiscriminate filter feeders feeding mainly on zooplankton; and do not compete for food with other fish species

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such as channel catfish, *Ictalurus punctatus*, (Kirkendall 1983; Semmens and Shelton 1986).

Integrating paddlefish into existing management practices for channel catfish appears feasible. One-year-old paddlefish are capable of rapid growth in polyculture with channel catfish during summer months, due to enhancement of water fertility by feed input (Semmens and Shelton 1986). However, a second year of growth is necessary for paddlefish to reach marketable size(> 400 g) (Kirkendall 1983; Semmens and Shelton 1986). This requires that paddlefish be overwintered. No studies have been reported on the overwintering of paddlefish.

The objective of this study was to evaluate fingerling paddlefish growth and compatibility when overwintered (November to April) in monoculture and in polyculture with fingerling channel catfish or rainbow trout, *Oncorhynchus mykiss*.

MATERIALS AND METHODS

Nine 0.04-ha ponds (mean depth 1.2 m) located at the Kentucky State University Aquaculture Research Center, Frankfort, KY were used in this study. Ponds were supplied with water from a rain-filled reservoir. There were three treatments, with three replications per treatment. Paddlefish (118 ± 5.5 g) were stocked at 1,235/ha into all ponds. Fingerling channel catfish (51 ± 2.7 g) were stocked at 37,065/ha into 3 ponds. Rainbow trout (105 ± 2.8 g) were stocked at 9,884/ha into 3 ponds. The study began 1 November 1988.

The following feeding rates and schedules were used for each of the treatments: (1) paddlefish in monoculture were not fed; (2) rainbow trout in polyculture with paddlefish were fed a commercial diet according to a graduated body weight and water temperature chart for rainbow trout, with daily ration divided into morning and afternoon feedings (Piper et al. 1982); and (3) channel catfish in polyculture with paddlefish were fed each afternoon 10% of the daily ration fed to the rainbow trout. Fish were fed 108 of 167 culture days. Ice cover prevented feeding on the other days. Totals of feed added to the rainbow trout and channel catfish ponds were 1,470 kg/ha and 147 kg/ha, respectively. Fish in all ponds were harvested and weighed on 14 April 1989.

Water quality parameters were monitored throughout the study. Dissolved oxygen (DO) and temperature were measured at a depth of 0.5 m at 1400 h daily in each pond. Ponds were aerated if DO levels were predicted by graph (Boyd 1979) to fall below 50% of saturation (Andrew et al. 1973). Water samples were collected weekly from each pond. Total ammonia nitrogen (TAN; NH_3-N), nitrite nitrogen (NO_2^--N and pH were determined.

Mean values of chemical and biological parameters were compared using analysis of variance with separation of means by Fisher's Least Significant Difference Test (Steel and Torrie 1960). Statements of significant differences were based on $P \leq 0.05$

RESULTS and DISCUSSION

Paddlefish gained weight in all treatments (Table 1). Paddlefish polycultured with fingerling channel catfish or rainbow trout had significantly greater ($P \leq 0.05$) individual weight gains than paddlefish in monoculture. Paddlefish in polyculture with channel cat-

TABLE 1. Survival and growth of paddlefish in monoculture and in polyculture with rainbow trout or fingerling channel catfish during the period 1 November 1988 through 14 April 1989. Each treatment was replicated three times. Mean ±SE values within a column followed by different letters are significantly different ($P \leq 0.05$).

Treatment	Survival (%)	Mean weight gain per fish (g)
Monoculture		
Paddlefish	98.6±2.4a	15.1±9.4c
Polyculture		
Paddlefish	93.4±11.6a	61.9±6.9b
Rainbow trout	95.3±0.3	139.2±5.3
Paddlefish	100.0±0.0a	81.6±12.0a
Channel catfish	74.2±35.4	-3.1±0.7

fish had significantly greater ($P \leq 0.05$) individual weight gain than paddlefish polycultured with rainbow trout. Percentage weight gain of paddlefish polycultured with channel catfish averaged 71%, compared to 51% and 13% for paddlefish in rainbow trout polyculture and paddlefish monoculture treatments, respectively. Overall paddlefish survival averaged 97.3%, and no significant differences ($P > 0.05$) were found among treatments.

Kirkendall (1983) found that paddlefish (140 g) stocked with fingerling channel catfish from March to September demonstrated growth rates of 2 g/d. Paddlefish in this winter study grew 0.5 g/d in polyculture with channel catfish. Reduced growth at low temperatures (< 7°C) has also been reported for paddlefish in impoundments (Houser and Bross 1959; Rosen and Hales 1981).

Total ammonia nitrogen was significantly higher ($P \leq 0.05$) in channel catfish polyculture ponds than in paddlefish monoculture ponds (Table 2). Other water quality variables were not significantly different ($P > 0.05$) among treatments.

In this study, total ammonia nitrogen levels were not significantly different ($P > 0.05$) between the two polyculture treatments. Fish feeds supply large amounts of total ammonia nitrogen to ponds, with only small proportions of nitrogen removed by the fish (Boyd 1982). Total ammonia nitrogen can be used by aquatic plants or by nitrifying bacteria to promote growth of zooplankton, which in turn can increase fish production (Boyd 1976). However, channel catfish were fed only one-tenth the amount of feed that the rainbow trout received during the same period. The high ammonia levels with less feed input suggest that uneaten feed accumulated in channel catfish polyculture ponds and probably provided more nutrients for natural food production. Several studies on overwintering channel catfish have reported poor feed conversion and water quality deterioration because of uneaten feed (Reagan and Robinette 1978; Mims and Tidwell 1989). Burke and Bayne (1986) found that increasing ammonia concentrations coincided with increasing cladoceran populations. The consumption of zooplankton by paddlefish should remove some nutrients which could be beneficial to the production system.

At harvest, all paddlefish polycultured with rainbow trout had bloody, ragged caudal fins suggesting fin nipping by the rainbow

TABLE 2. Summary of water quality analyses of monoculture and polyculture ponds during the period 1 November 1988 through 14 April 1989. Each treatment was replicated three times. Mean ±SE values are based on samples taken daily for temperature and dissolved oxygen and weekly for total ammonia nitrogen (TAN), nitrite, and pH. Mean values in a column followed by different letters are significantly different ($P \leq 0.05$).

Treatment	Temperature (°C)	Dissolved oxygen mg/l	TAN (mg/l as N)	Nitrite (mg/l as N)	pH
Paddlefish monoculture	8.1 ± 0.2a	12.3 ± 1.2a	0.04 ± 0.02a	0.002 ± 0.001a	8.4 ± 0.3a
Paddlefish/rainbow trout polyculture	8.0 ± 0.3a	11.4 ± 0.4a	0.13 ± 0.10ab	0.005 ± 0.002a	8.3 ± 0.02a
Paddlefish/channel catfish polyculture	8.1 ± 0.1a	11.7 ± 0.5a	0.22 ± 0.08b	0.005 ± 0.004a	8.2 ± 0.2a

trout. The fins of paddlefish in the other treatments did not show physical injury. Lower weight gains of paddlefish were found in polyculture with rainbow trout than in that with channel catfish. A possible explanation is that both rainbow trout and paddlefish are pelagic feeders, whereas channel catfish are benthic feeders. Negative species interaction between rainbow trout and paddlefish could have interfered with paddlefish feeding and growth.

Channel catfish lost 2% of body weight, and average survival was 74% (Table 1). This is less weight loss than reported by Lovell and Sirikul (1974) for overwintered channel catfish. Rainbow trout gained 150% of body weight and survival averaged 95%, which is in agreement with the values reported by Cremer and Mims (1989).

Kirkendall (1983) reported rapid growth and high survival of paddlefish polycultured with channel catfish during the summer. Our study indicates that paddlefish are capable of significant weight gains in polyculture with channel catfish during the winter period. Paddlefish appear to be more compatible with fingerling channel catfish than with rainbow trout. Polyculture of paddlefish and channel catfish appears feasible throughout the production cycle.

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REFERENCES

Andrew, J. W., T. Murai, and G. Gibbons. 1973. The influence of dissolved oxygen on growth of channel catfish. Transactions of the American Fisheries Society 102:835-838.

Boyd, C. E. 1976. Nitrogen fertilizer effects on production of tilapia in ponds fertilized with phosphorus and potassium. Aquaculture 7:385-390.

Boyd, C. E. 1979. Water quality in warmwater fish ponds. Alabama Agriculture Experiment Station, Auburn University, Alabama.

Boyd, C. E. 1982. Water quality management for pond fish culture. Elsevier Science Publishers, Amsterdam, The Netherlands.

Burke, J. S., and D. R. Bayne. 1986. Impact of paddlefish on plankton and water quality of catfish ponds. Progressive Fish-Culturist 48:177-183.

Carlson, D. M., and P. S. Bonislawsky. 1981. The paddlefish (*Polyodon spathula*) fisheries of the midwestern United States. Fisheries 6(2):17-26.

Cremer M. C., and S. D. Mims. 1989. Effects of stocking size and density on winter trout culture in cages in Kentucky. Transactions of the Kentucky Academy of Science 50:11-15.

Houser, A., and M. G. Bross. 1959. Observations on the growth and reproduction of the paddlefish. Transactions of the American Fisheries Society 88:50-52

Kirkendall, K. R. 1983. Polyculture of catfish, chinese carp and paddlefish. Master's thesis, Auburn University, Alabama.

Lovell, R. T., and B. Sirikul. 1974. Winter feeding of channel catfish. Proceedings Southeastern Association of Game and Fish Commissioners 28:208-216.

Mims, S. D., and J. H. Tidwell. 1989. Winter feeding of fingerling channel catfish in Kentucky. Transactions of the Kentucky Academy of Science 50:174-176.

Piper, R. G., I. B. McElwain, L. E. Orme, J. D. McCraren, L. G. Fowler, and J. R. Leonard. 1982. Fish hatchery management. United States Fish and Wildlife Service, Washington, D.C.

Reagan, R. E., and H. R. Robinette. 1978. Feeding of channel catfish fingerlings in mild and severe winters in Mississippi. Proceedings Southeastern Association of Fish and Wildlife Agencies 32:426-428.

Rosen, R. A., and D. C. Hales. 1981. Feeding of paddlefish, *Polyodon spathula*. Copeia 1981:441-455.

Semmens, K. J., and W. L. Shelton. 1986. Opportunities in paddlefish aquaculture. Pages 106-113 *in* J. G. Dillard, L. K. Graham and T. R. Russell, eds. The Paddlefish: Status, Management and Propagation. American Fisheries Society Special Publication No. 7, Jefferson City, Missouri.

Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill, New York, New York.