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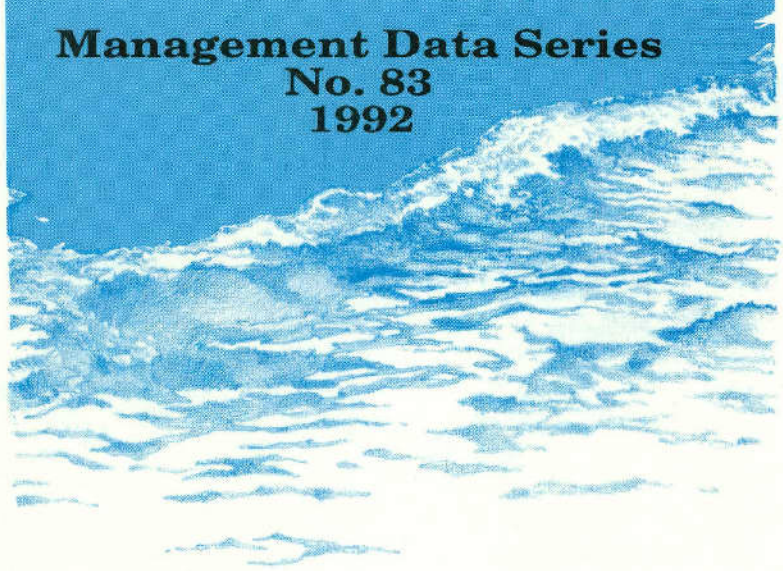

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Abstract

Paddlefish (Polyodon spathula) fry and fingerlings were tested for upper temperature tolerance using the critical thermal maxima method. The upper temperature tolerance of paddlefish was determined to be 33.4±1.18 C for 5-day-old fry (18 mm Total Length), 33.5±0.41 C for 25-day-old fingerlings (61 mm Total Length), and 35.2±0.30 C for 80-day-old fingerlings (226 mm Total Length). Temperature tolerance increased with age according to the equation $y = 0.026x + 33.078$ ($r^2=0.539$, $P<0.001$). The results indicate that temperatures above 31 C should be avoided when stocking and rearing paddlefish.

Introduction

Paddlefish (Polyodon spathula) are widely distributed and inhabit the entire Mississippi River drainage from near the Canadian border to the Gulf of Mexico (Gengerke et al. 1986). This distribution encompasses a wide range of climatic zones. Spawning and egg collection temperatures range from 10 to 16 C (Purkett 1961; Purkett 1963; Pasch et al. 1980; Russell et al. 1980; Wallus 1986), and egg incubation temperatures range from 11 to 21 C (Purkett 1961; Purkett 1963; Friberg 1973; Russell 1973; Brandt 1978; Russell et al. 1980). Graham et al. (1986) raised paddlefish to 305 mm total length (TL) in Missouri at pond temperatures increasing from 17 C in the spring to 29 C by midsummer and suggested an optimal temperature range of 18-32 C. A survey of 11 paddlefish authorities by Crance (1987) yielded the following optimal temperature ranges: early fry, 12-29 C; advanced fry and early fingerlings, 16-30 C; and advanced fingerlings and adults, 14-24 C. However, the upper temperature tolerance of paddlefish has not been determined experimentally.

In 1987, the Texas Parks and Wildlife Department began a project to enhance paddlefish populations in east Texas rivers. Paddlefish eggs were obtained from out-of-state sources. Eggs were incubated and fry were reared to 203 mm TL in indoor raceways at the A.E. Wood Fish Hatchery in San Marcos, Texas.

At the A.E. Wood Fish Hatchery paddlefish fingerlings are reared under a near constant thermal regime (21±2 C) and then stocked to reservoirs and rivers in mid-summer. Often, stocking sites, especially backwater and shallow areas, are of considerably higher temperature than the rearing temperatures. Additionally, attempts to rear paddlefish in hatchery ponds, in Texas, where afternoon pond temperatures reach 35 C have been unsuccessful. Although desired zooplankton organisms are generally abundant, few paddlefish are observed after two to three weeks. Production and stocking of paddlefish at high temperatures may affect survival. The objective of this study was to determine the response of three age groups of paddlefish to rapidly rising temperatures using the critical thermal maxima (CTM) method.

Materials and Methods

Paddlefish used for thermal tolerance testing were hatched and reared at the A.E. Wood Fish Hatchery in San Marcos, Texas. Paddlefish eggs were obtained from the U. S. Fish and Wildlife Service and originated from wild broodfish taken from the Missouri River at Chamberlain, South Dakota. Eggs were air-shipped to San Marcos, Texas on 31 May 90 and incubated in McDonald hatching jars at 17 C. Fry were stocked on 4 June 90 in an indoor raceway for growout on a commercial diet (Rangen Trout and Salmon Chow, Buhl, Idaho) at ambient river water temperatures of 21±2 C. Paddlefish were tested at five days (18.1±1.10 mm TL), 25 days (61.2±7.67 mm TL), and 80 days (226.3±35.51 mm TL) posthatch.

Upper lethal temperatures were determined for the three sizes of paddlefish reared at 21±2 C using the modified critical thermal maximum method described by Fields et al. (1987). Paddlefish were subjected to a temperature increase of 0.2 C/min. This rate is sufficiently fast enough to reduce cumulative stress on fish yet slow enough to allow observation of fish response to individual temperature increments (Fields et al. 1987). The critical thermal maximum determined by this test may not reflect the absolute upper thermal tolerance of fish acclimated for long periods of time to higher temperatures. However, the CTM may be a good indicator of fish response to rapid environmental temperature increases such as those encountered when stocking paddlefish to warmer sites or afternoon increases in shallow culture ponds during summer.

Thirty fish in groups of 10 each were used for each size tested. Paddlefish were moved to a 92 L laboratory water bath (Blue M Electric Co., Blue Island, Il.) filled with water from the rearing unit. Water was kept well mixed by agitation and by bubbling air in the middle of the unit with a 150-mm airstone. After a 15-min acclimation period to the test unit, water temperature was increased 0.2 C/minute. Mortalities and temperatures, noted to the nearest 0.1 C with a 30-cm mercury thermometer, were recorded at one minute intervals. Death was presumed when paddlefish ceased forward swimming and sank to the bottom of the test unit. At this point less than 5% of the fish recovered when returned to the original water temperature. Dissolved oxygen (D.O.) was measured continously with a Yellow Springs Instrument (YSI) Model 58 D.O. meter. Ten fish of each size were also held in the unit for two hours with no temperature change as controls for each test.

After testing, TL and weight were recorded for each fish to the nearest 0.1 mg on a Metler AE 163 balance. Mean CTM for each size tested was calculated as the mean temperature at which mortality occurred for each group. CTM of the three age groups of paddlefish were compared by analysis of variance.

Results

Mean CTM ranged from 33.4 to 35.2 C (Table 1). Mean CTM of paddlefish differed significantly ($P<0.0005$) by age. Scheffe's F-test demonstrated a significant difference between the mean CTM of 5 and 80 day old paddlefish ($P<0.05$) and between 25 and 80 day old fish ($P<0.05$), but no significant difference was indicated between the mean CTM of 5-and 25-day-old-fish. Temperature tolerance increased with age according to the regression equation $y = 0.026x + 33.078$ ($r^2 = 0.539$, $P<0.001$). No mortalities occurred in the control groups for each age group tested.

Discussion

The upper temperature tolerances established in this study agree with the thermal tolerances anticipated by Crance (1987) and Graham (1986). These temperatures also correlate to observations of paddlefish moving out of back water areas when water temperatures rise to 30 C (Southall 1982). The thermal tolerance differences between the ages of paddlefish tested are probably size related. Older, larger fish may be able to withstand higher temperatures for longer periods of time due to their greater mass.

Management implications for stocking paddlefish fingerlings into reservoirs suggest sloughs and backwaters should be avoided in late summer, if temperatures are above 30 C. Stocking by boat in open water areas may provide opportunities for paddlefish to find areas of lower water temperatures and would seem to be a good strategy to avoid additional stress. Additionally, culture of juvenile paddlefish may be inappropriate in areas where pond temperatures are likely to exceed 31 C for extended periods of time.

References Cited

Brandt, R.L. 1978. Fungal control methods, diets and water temperatures used to culture paddlefish, Polyodon spathula. Master of Science Thesis. South Dakota State University, Brookings, South Dakota, USA. 39 pages.

Crance, J.H. 1987. Habitat suitability index curves for paddlefish, developed by the Delphi technique. North American Journal of Fisheries Management 7:123-130.

Fields, R., S.S. Lowe, C. Kaminski, G.S. Whitt, and D.P. Phillip. 1987. Critical and chronic thermal maxima of northern and Florida largemouth bass and their reciprocal F_1 and F_2 hybrids. Transactions of the American Fisheries Society 116:856-863.

Friberg, D.V. 1973. Investigation of paddlefish populations in South Dakota and the development of management plans, 1972. South Dakota Department of Game, Fish and Parks. Dingell-Johnson Project F-15-R-7, Study 9, Job Numbers 1-5. Progress Report. 37 pages.

Gengerke, T.W. 1986. Distribution and abundance of paddlefish in the United States. Pages 22-35 In J.G. Dillard, L.K. Graham, and T.R. Russell, editors. The paddlefish: status, management and propagation. North Central Division, American Fisheries Society, Special Publication Number 7. 159 pages.

Graham, L.K., E.J. Hamilton, T.R. Russell, and C.E. Hicks. 1986. The culture of paddlefish - a review of methods. Pages 78-94 In J.G. Dillard, L.K. Graham, and T.R. Russell, editors. The paddlefish: status, management and propagation. North Central Division, American Fisheries Society, Special Publication Number 7. 159 pages.

Pasch, R.W., P.A. Hackney, and J.A. Holbrock. 1980. Ecology of the paddlefish in Old Hickory Reservoir, Tennessee, with emphasis on the first year life history. Transactions of The American Fisheries Society 109(2):157-167.

Purkett, C.A. 1961. Reproduction and early development of the paddlefish. Transactions of the American Fisheries Society 90(2): 125-129.

Purkett, C.A. 1963. Artificial Propagation of the paddlefish. The Progressive Fish-Culturist 25(1): 31-33.

Russell, T.R. 1973. A study of artificial propagation of the paddlefish. Missouri Department of Conservation. Dingell-Johnson Project F-1-R-21, Study S-5, Job Numbers 1 and 2. Final Report. 16 pages.

Russell, T.R., L.K. Graham, D.M. Carlson, and E.J. Hamilton. 1980. Maintenance of the Osage River - Lake of the Ozarks paddlefish fishery. Missouri Department of Conservation, Columbia, Missouri, USA. Final Report. 33 pages.

Southall, P.D. 1982. Paddlefish movement and habitat use in the upper Mississippi River. Master of Science Thesis. Iowa State University, Ames, Iowa, USA. 100 pages.

Wallus, R. 1986. Paddlefish reproduction in the Cumberland and Tennessee River systems. Transactions of the American Fisheries Society 115:424-428.

Table 1. Critical thermal maxima for 5 day, 25 day and 80 day old paddlefish fingerlings reared at 21±2 C. Each value is the mean ± SD for 3 groups of 10 fish.

Age (days)	Critical thermal maximum (C)	Mean weight (g)	Total length (mm)
5	33.4±1.18	0.031±0.003	18.1±1.10
25	33.5±0.41	1.310±0.356	61.2±7.67
80	35.2±0.30	28.977±12.773	226.3±35.51

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