EFFECT OF TEMPERATURE ON WALLEYE EGG HATCH RATE[a]

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Abstract: This study was conducted to determine if water temperature increases during the walleye (*Stizostedion vitreum vitreum*) spawning period reduced egg hatch rate and if water temperature manipulation during egg fertilization would increase hatch rate. Walleye eggs were subjected, before and during fertilization, to 1 of 3 treatments involving water temperatures above and below 12 C. Water temperatures above 12 C were found to reduce hatch rates. Stripping and fertilizing eggs collected from reservoir water temperatures above 12 C into water chilled to 7.2 C significantly increased hatch rates. Use of this technique could improve walleye culture and management operations in some southern regions.

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Walleye production and stocking goals for Texas reservoirs in 1977 totaled 24,000,000 fry. Therefore management and culture efforts are aimed at providing efficient methods of maintaining or increasing walleye populations throughout the state. Water temperatures in most Texas reservoirs increase rapidly during the walleye spawning period and may exceed the temperature range needed at fertilization for optimum egg survival. Water temperatures during other stages of walleye development are suitable for good survival.

Walleye spawning has been reported to take place in temperature extremes of 2.2-15.6 C (Anderson 1969, Priegel 1970). But generally walleye spawn in a temperature range of 6-12 C (Cobb 1923, Rawson 1956, Johnson 1961, Ellis and Giles 1965, Niemuth et al. 1966, Priegel 1970, Grinstead 1971). Laboratory studies determined the temperature ranges for optimum survival of walleye to be 6-12 C during egg fertilization; 9-15 C during egg incubation; 9-21 C for hatched fry through yolk sac absorption; and 21 C for juvenile stages (Smith and Koenst 1975). This study was conducted to measure egg survival at various water temperatures found in Texas and New Mexico reservoirs and to determine whether egg survival could be increased by manipulating water temperatures at fertilization time.

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MATERIALS AND METHODS

Monitoring of walleye spawning runs and procurement operations was conducted on 6 reservoirs from March through April 1977. Five reservoirs were located from central to north Texas (O. C. Fisher, Tom Green Co.; Canyon, Comal Co.; Meredith, Hutchinson Co.; Twin Buttes, Tom Green Co.; and Ft. Phantom Hill, Jones Co.). One reservoir was located in northeastern New Mexico (Ute, Quay Co.). Flowing ripe males and females were collected from each reservoir using modified Wisconsin trap nets (1.3 cm bar mesh) and/or multi- and monofilament gill nets (30.5-53.4 m long X 1.8-2.4 m deep with 2.5-11.4 cm graduated bar mesh). Eggs were obtained from these fish by manual stripping. Typically, eggs from at least 2 females were stripped into 2 to 3 l plastic or enamel containers with a small amount of water. Sperm from at least 4 males were immediately stripped over the eggs and mixed by gentle stirring with a feather. Combination of sex

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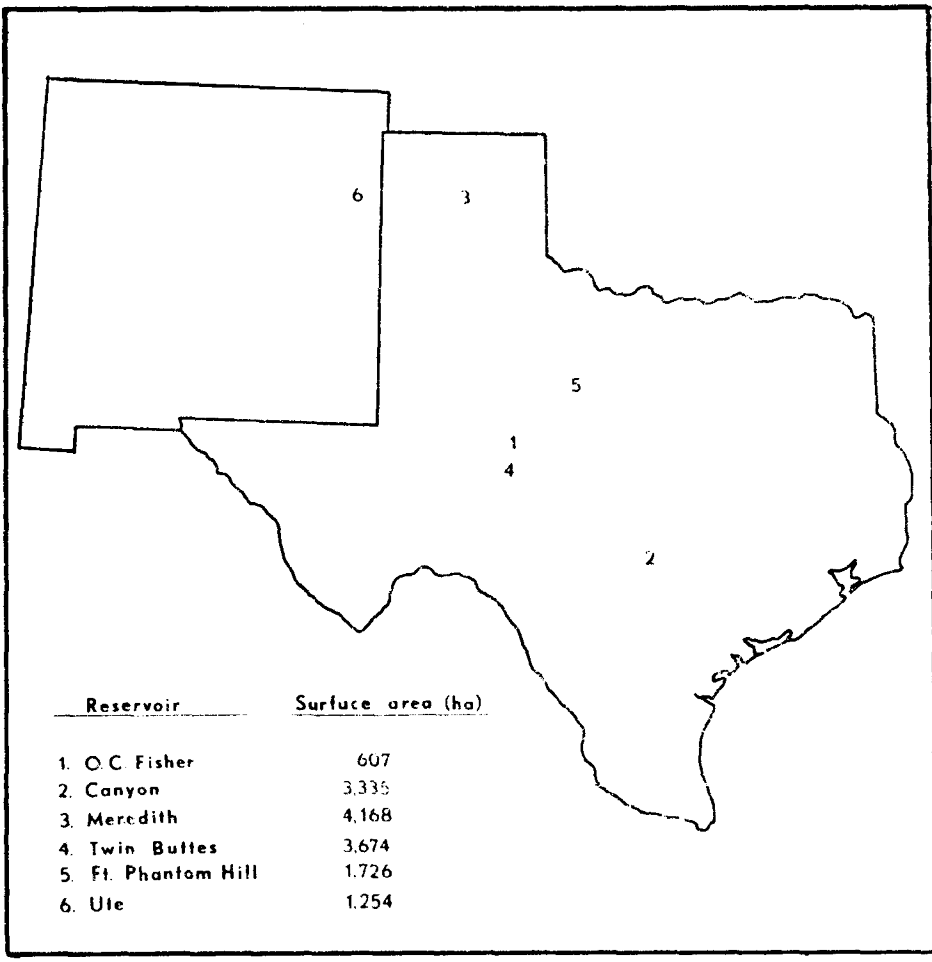

Fig. 1. Location and size of Texas and New Mexico reservoirs sampled for walleye egg procurement from March through April 1977.

products from at least 2 females and 4 males composed a batch. A suspended mixture of clay and water was added to prevent egg clumping. Excess clay and foreign matter were removed and eggs water hardened 4-48 h.

Three methods (A, B and C) were tested to evaluate their effects on hatching success. Treatment A was the technique currently used in Texas walleye operations. This consisted of fertilizing eggs in reservoir water at existing reservoir water temperatures within or above the 6-12 C range for optimal survival. Treatment B consisted of removing flowing adults from reservoirs having water temperatures above 12 C and holding them in 7.2 C water for 30-32 h. Fish were then stripped and eggs fertilized in 7.2 C water. Treatment C consisted of manipulating the temperature of the reservoir water used for fertilization. Reservoir waters above the optimum 6-12 range were chilled to 7.2 C (Treatment C_1; Canyon and O. C. Fisher Reservoirs). Those within the optimum range were heated to 14.4 C (Treatment C_2; Meredith Reservoir).

Eggs fertilized using Treatments B and C were tempered for 2-4 h to an incubation temperature of 9-15 C. Eggs in all treatments were incubated in McDonald jars with a flow of water sufficient to maintain eggs in a constant, but mild, tumbling condition.

The number of eggs in each jar was estimated volumetrically. Eggs were observed daily throughout incubation and fungus-infected eggs were removed. Water temperatures during all incubations but one were constant and within the 9-15 C range. Water temperatures for the incubation on egg batches collected at Canyon Reservoir increased from 14.4 to 18.9 C during the fifth and sixth day of incubation and remained at 18.9 until all eggs hatched.

Egg counts were made when eyed embryos were observed in each particular jar. A minimum of 2 1-5 ml egg samples were taken and counted from each jar to determine the ratio of live and dead eggs. Total egg volumes were remeasured at this time and percentages of live eggs calculated. Counts at this stage of development allowed easy identification of live and dead eggs. Egg hatching usually occurred 1-3 days after eyed embryos were observed; therefore, counts were assumed to represent hatch rates.

The percentages of live eggs were combined by treatment by reservoir to obtain a mean percentage hatch. Standard errors were calculated for each mean percent. Individual egg counts for each treatment for all reservoirs were combined to make Student's *t-test* (for independent means) comparisons of mean hatch rates.

RESULTS AND DISCUSSION

Mean hatch rates for walleye eggs varied because of the variety of reservoirs and walleye populations sampled (Table 1). Manipulation of water temperature at fertilization caused marked differences in egg hatch rates.

Water temperatures for Treatment A in various reservoirs were within and above the 6-12 C range for optimum survival. Hatch rates of Treatment A "within" (when fertilization temperatures were within the 6-12 C range) were significantly greater ($t = 15.2$;

Table 1. Mean percentage hatches of walleye eggs subjected to one of three treatments at fertilization during 1977 spawning run collections at O. C. Fisher, Canyon, Meredith, Twin Buttes, Ft. Phantom Hill and Ute Reservoirs [Parentheses () indicate reservoir water temperature when adult walleye were captured].

Reservoir	*Egg batches collected*	*Treatment*[a]	*Temperature at fertilization* (C)	*Mean hatch* (%)	*Standard error*
O. C. Fisher	3	A	12.8 - 13.9	27.6	8.2
	1	B	7.2 (13.3)	25.7	0.6
	5	C_1	7.2 (13.3)	56.4	4.1
Canyon	2	A	15.0	2.6	0.6
	0	B	7.2 (15.5)	0.0	0.0
	2	C_1	7.2 (15)	43.9	1.0
Meredith	18	A	8.3 - 10	76.5	1.7
	1	C_2	14.4 (8.4)	55.8	3.4
Twin Buttes	1	A	12.2	12.2	4.5
	1	A	15.0	1.0	0.05
Ft. Phantom Hill	4	A	11.5	74.4	3.9
Ute	3	A	11.5	61.0	2.3
	6	A	15.0	21.7	1.3

[a]Treatment A consisted of fertilizing eggs in reservoir water of existing reservoir water temperatures.

Treatment B consisted of removing flowing mature walleye from reservoirs having water temperatures above 12 C and placing them in 72 C water 30-32 h. After 32 h eggs were fertilized in 7.2 C water.

Treatment C_1 consisted of fertilizing eggs in reservoir water chilled to 72 C while in Treatment C_2 reservoir water was heated to 14.4 C.

df = 77; $P < 0.05$) than those of Treatment A "above" (when fertilization temperatures were above 12 C). This reduction of hatch rate as fertilization temperature exceeds 12 C indicates Treatment A (the only method currently used in Texas walleye culture operations) will provide reduced, if any, amounts of viable eggs from some southern reservoirs in egg procurement operations. Also, if applicable to field situations, natural walleye spawning success in many southern reservoirs will be reduced.

Results of the limited samples taken showed Treatment B was not successful in increasing hatch rate. Hatch rates of Treatment B were not significantly different ($P > 0.05$) from those of Treatment A "above". Adult walleye showed no ill effects from being held in 7.2 C water for 30-32 h. Also, no problems were encountered with disease or fungus. Male walleye remained in a flowing state of maturity throughout and after exposure to 7.2 C water. However, state of maturity of females placed in 7.2 C water reverted from flowing to mature. Ovaries became hard and increased pressure was necessary to force eggs out of the body cavity. No eggs could be forced from 1 female collected from Canyon Reservoir after she was held in 7.2 C water even though she was free flowing when captured.

Promising results were obtained from chilling reservoir waters to 7.2 C at fertilization (Treatment C_1). Hatch rates of Treatment C_1 were significantly greater ($t = 7.4$; df = 47; $P < 0.05$) than those of Treatment A "above". Data from individual reservoirs showed increases in hatch rates resulting from Treatment C_1 were highly significant for 0 C. Fisher ($t = 3.5$; df = 22; $P < 0.01$) and Canyon ($t = 36.2$; df = 10; $P < 0.01$) Reservoirs when compared to Treatment A "above" for each respective reservoir. These results show walleye egg viability can be improved in reservoirs where water temperatures during egg fertilization are 12-15 C by simply stripping and fertilizing eggs in water chilled to 7.2 C.

Data from Meredith Reservoir showed hatch rates using reservoir water heated to 14.4 C at fertilization (Treatment C_2) were significantly less ($t = 3.2$; df = 42; $P < 0.05$) than those for Treatment A "within" for that reservoir. These results showed that even though adult walleye developed in optimum temperature ranges the hatch rates of walleye eggs were decreased by fertilization temperatures above 12 C.

CONCLUSIONS

Most Texas reservoirs have water temperatures suitable for optimum survival in all walleye developmental stages except egg fertilization. Results of this study showed that rapidly reduced hatch rates can be expected when water temperatures at fertilization exceed 12 C. Hatching success of walleye eggs in Texas reservoirs is dependent on many factors not well defined, but this study indicates temperature is a major factor.

This study demonstrated a simple technique of chilling reservoir water to 7.2 C for egg fertilization (Treatment C_1) that can significantly improve walleye egg hatch rates at a low cost involving a small amount of equipment. Use of this technique should have value to walleye culture in any regions where walleye populations are subject to water temperatures above the range for optimum survival at fertilization. For example, use of Treatment C_1 would increase efficiency and stability of walleye egg procurement and culture operations in situations where weather changes might cause abrupt water temperature increases above 12 C. Treatment C_1 would also promise success during years when weather conditions cause water temperatures to be marginal throughout spawning runs and in reservoirs existing in a climate regime causing marginal conditions each year.

Use of Treatment C_1 as a management tool would benefit management biologists and the fishing public by allowing a wider distribution of walleye populations. Walleye population maintenance could be accomplished even with limited or no natural walleye reproduction on reservoirs where favorable management or sport fishing objective could be met. Eggs could be collected from these reservoirs, fertilized at 7.2 C, and tempered to incubation temperatures. Eggs could then be incubated at the reservoirs which are at or near the optimum temperature range for incubation survival. This will reduce time and space now necessary for walleye propagation on state fish hatcheries.

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