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WINTER TEMPERATURE REQUIREMENTS FOR MATURATION AND SPAWNING OF YELLOW PERCH *PERCA FLAVESCENS* (MITCHILL)

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INTRODUCTION

This is a report on a laboratory study of the winter temperature requirements for maturation and spawning of yellow perch, *Perca flavescens* (Mitchill).

The study was conducted to determine if addition of enough heat to the habitat of yellow perch to raise the winter temperature or shorten the period at usual low winter temperatures would be harmful to reproduction of this species. Information on this question would help predict the effects of heat addition to the aquatic environment and promote the adoption of water temperature standards related to seasonal biological needs.

Reports in the literature indicate that, for some fish, low temperatures in winter are essential to completion of gametogenesis. Examples are oogenesis in the four-spined stickleback, *Apeltes quadracus* (Merriman and Schedl, 1941) and spermatogenesis in the lake chub, *Couesius plumbeus* (Ashan, 1966).

Levels of reproductive success in relation to maturation temperatures have been reported for the fathead minnow, *Pimephales promelas* (Brungs, 1971) and the brook trout, *Salvelinus fontinalis* (Hokanson *et al.*, 1973) but not, to our knowledge, for the yellow perch.

Studies of gonads of yellow perch, however, show that in nature spermatogenesis starts in August and is completed between October and December, with the testes remaining full of spermatozoa until spawning (Turner, 1919; LeCren, 1951) and that ovaries increase in size from August to the time of spawning (LeCren, 1951).

This study determined the effects of various durations and temperatures on spawning and embryo survival in yellow perch.

METHODS

The study was conducted in 16 rectangular fiberglass tanks, 152 × 26 × 28 cm deep. The test temperatures were maintained by a chiller and by electronic controllers and valves that mixed hot and cold water in head boxes. The fish were held at the Duluth, Minnesota, photoperiod.

SEP 12 2001 10:35 FR UCB BIOSCI. LIB. 510 642 8217 TO 916179181992 P.04

At the start of the test in October, 16 fish were placed in each tank. At the start of the spring increase in temperature, the number of fish was reduced and the sex ratio was adjusted to 1 male to 3 females or a maximum of 3 males and 7 females per tank. Previous experience with yellow perch in the laboratory indicated they would spawn in the rectangular fiberglass tanks without a special substrate.

The total number of eggs was obtained from the volume of spawn and the average number of eggs (70) per milliliter. The percent viable eggs was obtained by incubating 3

TABLE 1. Test temperatures and durations

Winter		Spring[1]	
Constant temperature (°C)	Duration from Oct. 30 (days)	Increase from winter[2] (°C)	Duration of increase (days)
4	123	18.6	43
	143	19.7	55
	164	17.8	42
	185	12.8	25
	213	7.3	8
6	123	—	—
	143	19.8	56
	164	16.0	35
	185	13.5	27
	213	7.7	6
8	157	18.6	30
	201	18.2	29
	241	7.9	—
10	157	19.0	33
	201	10.2	—
	241	10.2	—

[1] Increased at rate of 2°C per week
[2] Temperature at last spawning

subsamples of about 100 eggs each at 12 degrees centigrade. Egg viability was determined at formation of the neural keel.

The total temperature experience of the fish from October 30, to the last spawning in spring is summarized in Table 1. The fish were exposed over winter to constant temperatures of 4, 6, 8 and 10 degrees centigrade and several durations at these temperatures starting from October 30. They were exposed to 5 durations ranging from 123–213 days at 4 and 6 degrees and 3 durations ranging from 157–241 days at 8 and 10 degrees. At the end of the durations the temperature was increased at the rate of 2 degrees centigrade per week. By the time of last spawning, temperatures had risen to those shown in Table 1 as spring temperatures.

RESULTS

The results of the 16 combinations of temperature and duration on production of eggs are summarized in Table 2. The data are averaged for the shorter and longer durations at 4

SEP 12 2001 10:35 FR UCB BIOSCI. LIB. 510 642 8217 TO 916179181992 P.05

and 6° and all durations at 8 and 10°. Some or all spawning occurred before the start of the spring increase in temperature at the longest durations at each temperature (213 days at 4 and 6°, 241 days at 8°, and 201 and 241 days at 10°). No spawning occurred at 6° and 123 days.

The average total numbers of eggs per female were greatest and about the same at the longer durations at 6° and the shorter and longer durations at 6°. Fewer eggs were produced at the shorter durations at 4° and fewer eggs were produced at the durations at 8 and 10°. Size of female may have had some influence on the total number of eggs produced (range in weight at termination was 42–200 g).

The average percent viable eggs per female, for the grouped durations, was highest (74%) at the longer durations at 4°, somewhat lower (41%) at the longer durations at 6°, and lower at the shorter durations at 4 and 6° and at 8 and 10°. The maximum percentages of viable eggs per female at any one combination of temperature and duration were 93% at

TABLE 2. Effects on Total Number of Eggs and Percent Viable Eggs per Female

°C	Duration (days)	Total eggs (×1000)	Viable eggs (%)
4	123, 143, 164	5	17
	185, 213	11	74
6	123, 143, 164	10	27
	185, 213	11	41
8	157, 201, 241	7	31
10	157, 201, 241	1	4

4° and 185 days' duration, 64% at 4° and 213 days' duration, and 64% at 6° and 164 days' duration.

Other responses which support these results were the number of spawnings per female and the quality of spawn. The number of spawnings per female were fewer and the quality of spawn was poorer at the shorter durations at 4 and 6° and at all durations at 8 and 10°. Good quality spawn consisted of complete, usually large (<100 m/1), accordian-folded ribbons as has been described for yellow perch (Mansueti, 1974). Poor quality spawn consisted of small volumes (10–100 ml) of fragments of ribbons.

The median spawning date at all test conditions ranged from May 4 to June 20 except one on April 12, and were within the spawning periods reported for yellow perch in natural waters (March to April, Mansueti, 1964; and May to June, Wells, 1970).

The average spawning temperatures at all test conditions ranged from 5.8 to 19°C. The greatest reproductive success, 93%, viable eggs at 4° and a duration of 185 days, occurred at an average spawning temperature of 11.3 degrees and within a range from 7.5–12°C. Reproductive success was poor when spawning occurred at temperatures above 15°.

The highest spawning temperatures occurred at the shortest durations at each temperature to suggest (since a temperature rise was not needed to trigger spawning) a need for higher "compensatory" spring temperatures to meet a total temperature requirement for maturation. Reproductive success was lowest under these conditions.

The conditions tested are related to percentage ranges of viable eggs in Table 3 to illustrate implications for fish production and in turn implications for water temperature

SEP 12 2001 10:35 FR UCB BIOSCI. LIB. 510 642 8217 TO 916179181992 P.06

criteria. Only one winter temperature regimen (4° for 185 days) falls in the 75–100% range, two (4° for 213 days and 6° for 164 days) fall in the 50–75% range, and five fall in the 25–50% range. The other 8 temperature regimens tested produced less than 25% viable eggs. It might be noted that durations of 213 days at 4 and 6° and 201 and 241 days at 8° are not likely to occur at the latitude at which the fish were collected and tested (47°N latitude).

TABLE 3. Potential for Production

% Viable eggs			
100–75	75–50	50–25	25–0
°C/days	°C/days	°C/days	
4° 185	4° 213 6° 164	4° 164 6° 185 6° 213 8° 210 8° 241	All other treatment

CONCLUSION

It appears from this study that yellow perch need a low temperature in winter for maturation and spawning and that yellow perch suffer increased impairment of reproductive success as winter temperatures increase from a low of approximately 4°C and as durations of exposure to low temperatures decrease from approximately 185 days.

REFERENCES

Ahsan, Syed Nazar (1966) Effects of temperature and light on the cyclical changes in the spermatogenetic activity of the lake chub, *Couesius plumbeus* (Agassiz). *Can. J. Zool.* **44**, 161–171.

Brungs, W. A. (1971) Chronic effects of constant elevated temperature on the fathead minnow (*Pimephales promelas* Rafinesque). *Trans. Am. Fish. Soc.* **100**, 659–664.

Hokanson, K. E. F., McCormick, J. H., Jones, B. R., and Tucker, J. H. (1973) Thermal requirements for maturation, spawning, and embryo survival of the brook trout, *Salvelinus fontinalis* (Mitchill). *J. Fish. Res. Board Can.* **30**, 975–984.

LeCren, E. D. (1951) The length–weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *J. Anim. Ecol.* **20**, 201–219.

Mansueti, A. J. (1964) Early development of the yellow perch, *Perca flavescens*. *Chesapeake Sci.* **5**, 46–66.

Merriman, D., and Schedl, H. P., (1941) The effects of light and temperature on gametogenesis in the four-spined stickleback, *Apeltes quardracus* (Mitchill). *J. Exp. Biol.* **12**, 413–449.

Turner, C. L. (1919) The seasonal cycle in the spermary of the perch. *J. Morph.* **32**, 681–711.

Wells, L. (1970) In: Part IV. Effects of temperature fluctuations on Lake Michigan fish. Physical and ecological effects of waste heat on Lake Michigan. *Rept. Great Lakes Fish. Lab.*, Bur. Comm. Fish., US Dept. Int., Ann Arbor, Michigan. 101 pp.

** TOTAL PAGE.06 **