Submitted for publication in the
Progressive Fish Culturist

Original: Progressive Fish Culturist
cc: Fish Division
Education - Game
Institute for Fisheries Research
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Regional Fisheries Supervisor
Region II

December 28, 1950

Report No. 1270

Delay of Spawning in Eastern Brook Trout by Artificially Prolonged Light Intervals[1]

[1] Contribution from the Michigan Institute for Fisheries Research

Leonard N. Allison

Michigan Department of Conservation

Grayling, Michigan

ABSTRACT

This study was undertaken in an attempt to reduce the high losses that occurred annually at Harrietta hatchery during the spawning season among brook trout eighteen months old being held over winter for spring stocking. One group of trout was divided into two groups of equal size. One of these groups was held in a pond over which six electric lights were suspended. Beginning on August 15, 1948, and ending on December 31, 1948, the pond was illuminated daily from 5 to 8 a.m. and from 5 to 10 p.m. The second group was used as a control and was held in another pond that was not illuminated by artificial lights. A sample of thirty male fish was collected from each pond every two weeks during the study. The body length and weight of the testes of each fish was applied to a formula (X Weight of testes / body length^3) to obtain a factor of gonadal development. The loss for each two-week period for each pond was also recorded. These data demonstrated that artificial illumination delayed spawning in brook trout for approximately six weeks. However, delayed spawning did not prevent excessive losses because a high loss was experienced when this group spawned in January.

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Introduction

At the Harrietta Hatchery, a facility of the Michigan Department of Conservation located in Wexford County, Michigan, a serious problem has been developing in recent years. Eighteen-month-old eastern brook trout (Salvelinus fontinalis), when held over the winter for stocking during the following year, have been subject to excessive fungus infections and high losses during the normal fall spawning season. Frequent treatment with oxalate crystals of malachite green (zinc free) helped to control heavy losses but failed to prevent them. Since the development of fungus followed injuries sustained in vigorous spawning activity which is, of course, foredoomed to failure when occurring in hatchery ponds, suppression of the reproductive urge appeared to be a possible solution to the problem.

It is now a well known fact that sexual cycles of animals can be modified by the use of certain hormones and by artificially changing the normal daylight interval. Hasler, Meyer and Field (1939) induced premature spawning in rainbow trout (Salmo gairdnerii) and in brown trout (Salmo fario) by the use of pituitary glands of carp. Bissonnette (1930, 1932, 1933, 1935, 1936), Bassett (1946) and others, have demonstrated that the normal gradual change in daylight interval is an important factor in sexual cycles of certain birds and mammals and that the cycles can be modified by manipulations of the daylight interval by artificial means. Hoover and Hubbard (1937) induced eastern brook trout to spawn from one to four months earlier than normal by artificially shortening the normal daylight interval and maintaining a constant water temperature.

Experiments reported to date concerning modification of the time of spawning in fish have been designed to accelerate, rather than to retard the process. The present study was based on the theory that by keeping light on the fish for a constant length of time every day and preventing the gradual shortening of the normal daylight interval prior to and during the spawning season, the spawning urge could be inhibited or at least retarded enough to prevent fighting and injury among the fish.

Materials and Methods

Two hatchery ponds (Numbers 14 and 18), of comparable size and with a similar history as to rearing of trout, were chosen for the experiment. One group of eastern brook trout eighteen months old was equally divided between each pond. Pond No. 18 was illuminated by electric lights every day from 5 to 8 a.m. and from 5 to 10 p.m., beginning on August 15 and ending on December 31, 1948. Over this pond (Figures 1 and 2), which is 90 feet long

Figure 1. Arrangement of lights over pond containing eastern brook trout.

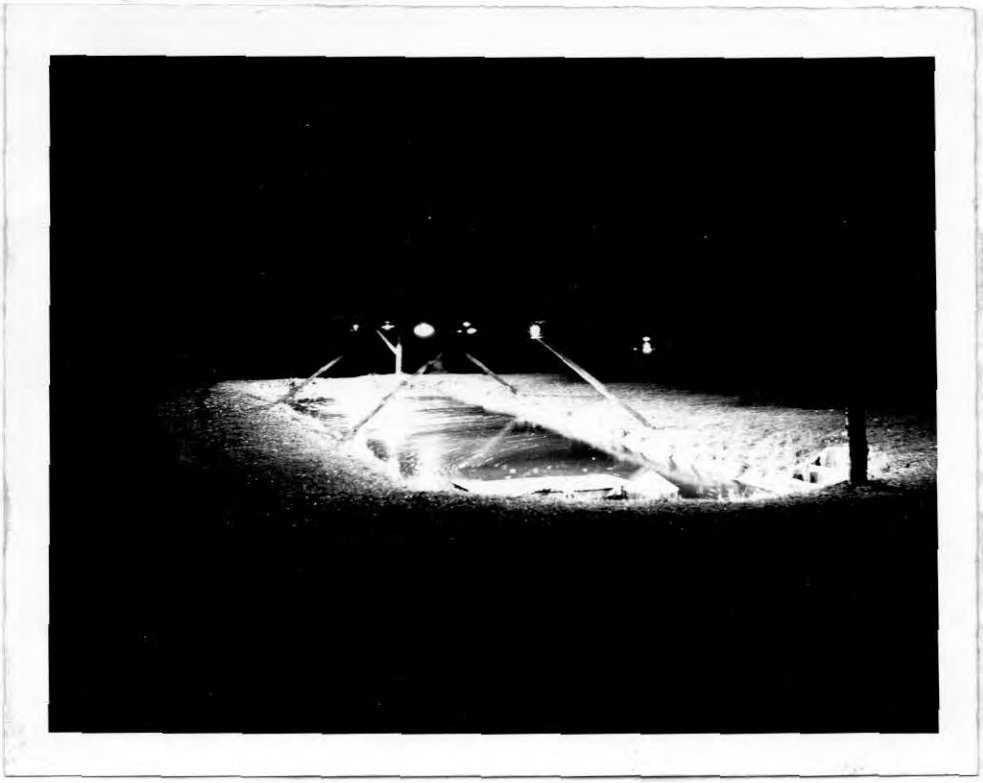


Figure 2. Lighted pond at night.

by 30 feet wide, four 100-watt and two 200-watt electric light bulbs were strung in a straight line, evenly spaced and suspended 7 feet above the water. The 200-watt bulbs were placed at each end of the series. Pond No. 14 was not artificially illuminated and served as a control pond.

Thirty specimens of what were believed to be male fish were collected from each pond every two weeks during the study. Owing to the difficulty of distinguishing between unripe male and female fish, the samples usually did not contain the exact desired number of males. All specimens were preserved in 10 percent formalin and examined one week after collection.

Dr. O. H. Robertson, then with the Department of Medicine, University of Chicago and currently with the Department of Biology, Stanford University, kindly offered to study the thyroid glands in a search for possible correlation of the effects of prolonged light with structural modification of the gland. Thyroids were removed from specimens of each group collected and preserved in Bouin's fluid. However, Dr. Robertson reported that any differences that might have been present were obscured by a very marked hyperplasia due to lack of sufficient iodine in the diet.

The experiment was first attempted in the fall of 1947 and resulted in suppression of trout spawning in the lighted pond for several weeks, although the pond was poorly lighted and the lights were not turned on until September 12. It was impossible to demonstrate any difference in loss between the lighted group and the controls because very little fungus developed on fish in any of the ponds during the fall of that year. In the first experiment, the weights of both testes and ovaries were used as an index of ripeness of the fish. However, since both sexes gave equivalent data, it was apparent that examination of one sex was sufficient to give an adequate index and only the testes were weighed in the present study.

Clarence L. Schloemer (1947) in his study of the reproduction cycles of five species of Texan centrarchids used the formula: ovary weight / body weight X 10^3 to obtain a factor of gonadal development. This formula was modified for use here. As a measure of the effects of artificial illumination, the testes of both groups of fish were weighed in grams and body length in millimeters was substituted for body weight, in the formula. Body length was used because visits to the hatchery were not always made at the same hour, so that some collections were made after the fish had been fed and others before feeding. Consequently, comparative weights would have varied from one collection to another, depending on when the collections were made and on the appetite of the individual fish. The cube of the body length was used to give an expression of length that would be closely related to body weight because as length increases, weight increases approximately by the cube. The formula then becomes: X = Weight of the testes / body length ^{3} ($X = \frac{Wt.\ T}{L^3}$).

Results

Table I presents the data obtained and includes the percentage of loss in the ponds during each 2-week period. A curve (Figure 3) of the factor Wt. T./L^3 for the two groups demonstrates that the fish in Pond No. 18 (lighted) retained a higher factor of gonadal development for a longer period of time than those in Pond No. 14 (control). The curve indicates that some spawning occurred in the control group between October 5 and November 5, and again between November 3 and 16, but from the latter date until January 11, gonadal products were released slowly. In the lighted group, the curve demonstrates only a slight release of gonadal products

Table I
Average weight of testes, factor for gonadal development and percentage of loss during the experimental period.

Date	Pond number	Number of specimens	Average length of fish in millimeters	$1/L^3 \times 10^{-8}$	Average weight of testes in grams	X Wt. T.[1] / $L^3 \times 10^{-8}$	Percentage of loss
9/7/48	18	25	180.8	16.921	2.7	45.69	0.32
	14	14	183.0	16.317	2.90	47.32	0.021
9/21/48	18	10	156.3	26.190	1.34	35.09	0.19
	14	13	145.5	32.467	1.26	40.91	0.085
10/5/48	18	20	186.4	15,441	3.09	47.72	0.88
	14	12	172.4	19.517	2.11	41.18	0.24
10/19/48	18	27	200.4	12.436	3.61	44.89	0.50
	14	31	191.8	14.172	2.31	32.74	0.14
11/3/48	18	30	198.7	12.747	3.88	49.46	0.39
	14	29	192.0	14.128	1.88	26.56	0.09
11/16/48	18	28	200.1	12.481	3.08	38.44	0.60
	14	28	187.3	15.119	1.98	29.93	2.12
12/1/48	18	30	199.4	12.613	2.64	31.53	1.19
	14	29	185.6	15.641	1.92	30.03	9.35
12/13/48	18	30	206.1	11.423	2.76	31.53	2.52
	14	28	195.8	13.322	1.40	18.65	4.93
12/28/48	18	26	201.6	12.205	2.41	29.41	6.14
	14	26	191.0	14.352	1.26	18.08	7.95
1/11/49	18	29	205.8	11.473	2.50	28.68	7.06
	14	32	193.3	13.838	1.36	18.82	3.90
1/26/49	18	28	217.8	9.679	2.49	24.10	12.4
	14	27	201.6	12.204	1.08	13.18	2.83
2/8/49	18	27	209.1	10.938	1.97	21.55	8.17
	14	31	195.8	13.322	0.56	7.46	1.38
2/17/49	18		No collection made.				2.80
	14						0.95
3/1/49	18	30	209.6	10.870	1.82	19.78	2.18
	14	25	207.8	11.144	0.50	5.57	0.90

[1] Factor for gonadal development.

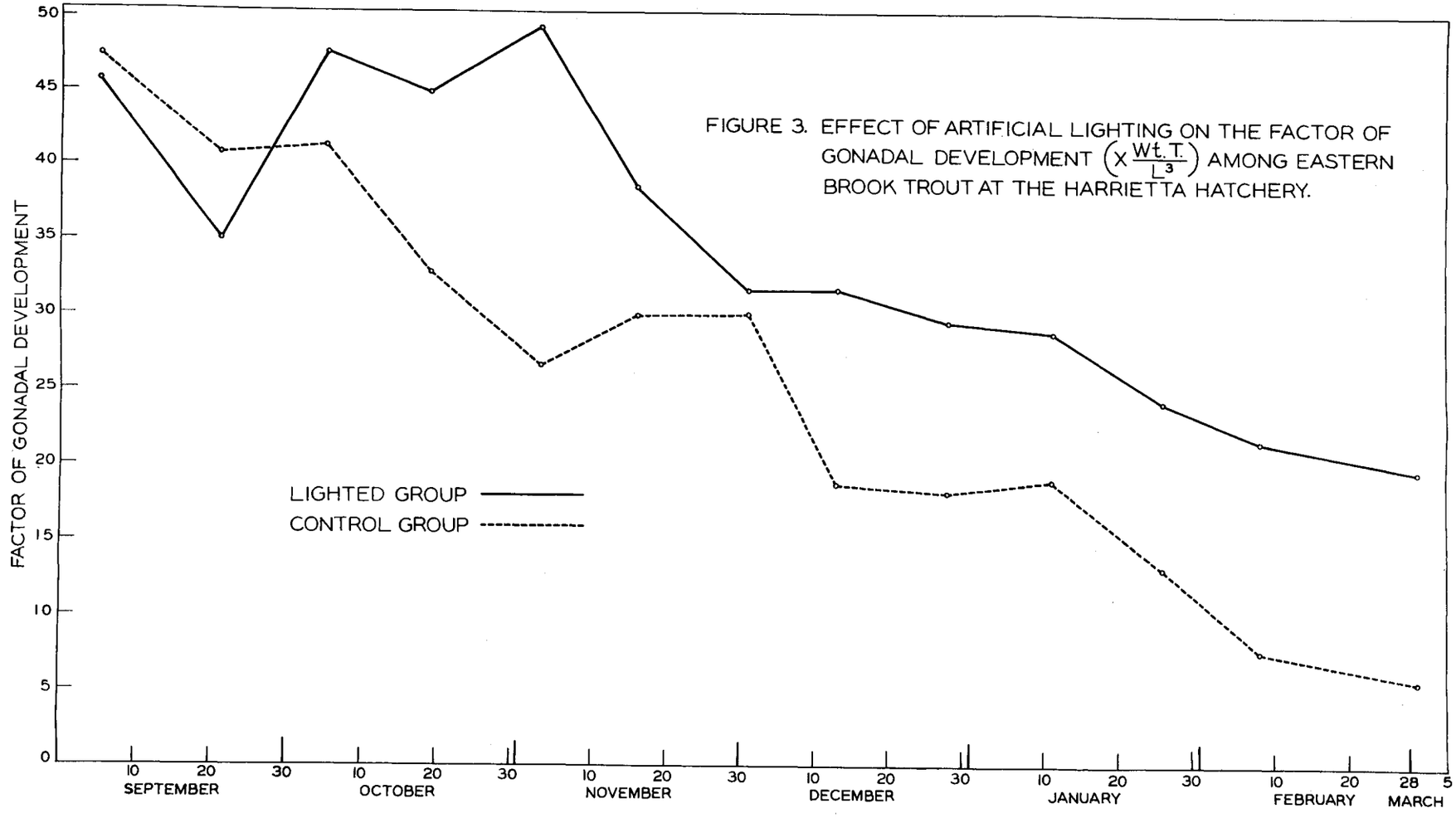
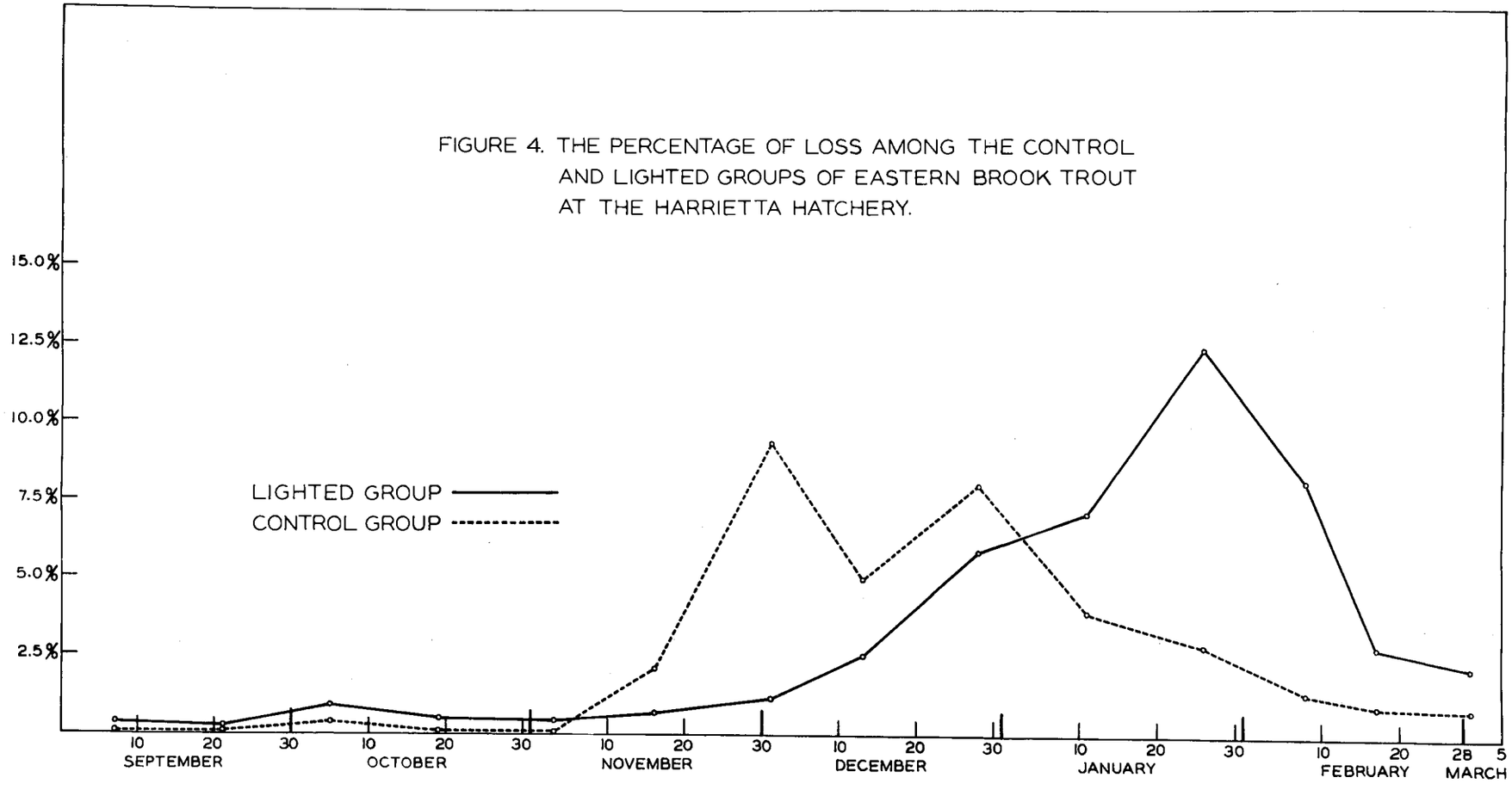


FIGURE 3. EFFECT OF ARTIFICIAL LIGHTING ON THE FACTOR OF GONADAL DEVELOPMENT $\left(X \frac{Wt.T.}{L^3}\right)$ AMONG EASTERN BROOK TROUT AT THE HARRIETTA HATCHERY.

between October 5 and 19, a considerable release between November 3 and December 1, and a slow release between the latter date and March 1. Even at the termination of the experiment on March 1, the testes of fish from the lighted group weighed more than three times as much as those of fish from the control group.

Although the curve of the factor of gonadal development demonstrates that the release of milt was retarded in the lighted group, it is, however, disappointing in that it does not show very clearly the peak of spawning activity. Daily observation of the fish by hatchery personnel indicated that there was a direct correlation between heightened spawning activity and greater fish mortality. A graph of the percentage of loss among each group (Figure 4) shows a definite peak among the control group for the period of November 16 to December 1, a reduction for the December 2 to 13, period and another peak for the December 14 to 28, period. Due to a misunderstanding, the control group was treated with malachite green early in December, which undoubtedly accounts for the reduction in the percentage of loss for the December 2 to 13, period. It is therefore impossible to determine the exact period of greatest spawning activity in the control group. However, the sharp rise during the preceding period would indicate that the peak probably occurred between December 2 and 13. No treatment was administered to the lighted group so its graph can be considered a reliable index of spawning activity. The peak percentage of loss in this group did not occur until the period January 11 to 26, approximately six weeks later than among the control fish.

FIGURE 4. THE PERCENTAGE OF LOSS AMONG THE CONTROL AND LIGHTED GROUPS OF EASTERN BROOK TROUT AT THE HARRIETTA HATCHERY.



Conclusions

Spawning among eastern brook trout at the Harrietta Hatchery was delayed for approximately six weeks by the use of artificial lighting. Beginning on August 15, 1948, and ending on December 31, 1948, the experimental pond was illuminated daily from 5 to 8 a.m. and from 5 to 10 p.m.

The peak of spawning activity was reflected more clearly by the percentage of loss among the control and lighted groups than by a factor for gonadal development in which body length of the fish and weight of the testes were used.

Delaying spawning did not prevent excessive mortality because a high loss was sustained by the lighted fish when spawning did occur.

Acknowledgments

The fine cooperation of the staff of the Harrietta Hatchery, particularly of Louis Root, foreman, and Ed Basford, superintendent, is gratefully acknowledged. Thanks are also due to Dr. Ralph Hile of the U. S. Fish and Wildlife Service and Dr. Justin W. Leonard of the Institute for Fisheries Research for invaluable advice concerning statistics and preparation of the manuscript.

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