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ATTEMPTED CONTROL OF BLUEGILL REPRODUCTION IN LAKES BY THE APPLICATION OF COPPER SULPHATE CRYSTALS TO SPAWNING NESTS[1]

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Abstract

The shorelines of eight southern Michigan lakes were seined at specific locations in the autumn of 1960 and 1961 to determine the relative abundance and size of young-of-the-year bluegills. In 1962 all observed bluegill nests on four of these lakes were treated with copper sulphate crystals every 3 or 4 days throughout the bluegill spawning season in an attempt to kill all bluegill eggs and fry. In the fall of 1962 all eight lakes were again seined, and the results compared with pre-treatment data.

The variability of the seining data was so great that no significant reduction in the fingerling bluegill populations could be demonstrated for the treatments. However, the mean lengths of the young-of-the-year bluegills in 1962 were significantly greater than in 1960 and 1961 in the treated lakes following treatment. Even if the treatments had been successful, the considerable effort required precludes the adoption of this technique as a management procedure for bluegill control in lakes.

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1 Contribution from Dingell-Johnson Project F-27-R, Michigan.

Introduction

This paper describes an attempt to control the reproduction of bluegills (Lepomis machrochirus) in four southern Michigan lakes by applying copper sulphate crystals to their nests throughout the spawning season.

Effective control of bluegill reproduction in many Michigan lakes is an unsolved management problem. Partial rotenone treatments, removal by seining, and the encouragement of predator fishes have failed to provide the long-term effectiveness required to control this prolific species. A method is needed that will control the recruitment of young bluegills into a fishery annually without harming older fish. Pending the possible development of a bluegill-specific piscicide that is size-selective, the most logical approach to the control of young bluegills is to eliminate most of them during the vulnerable egg and fry stages.

It has been shown that centrarchid eggs and fry can be killed by applying chemicals to spawning nests. Copper sulphate crystals (Allison, 1964) and sodium hydroxide pellets (Jackson, 1956) were used to kill the eggs and fry of bluegills and pumpkinseeds (Lepomis gibbosus), respectively, in ponds. In both experiments the crystals or pellets were applied directly to individual nests. The chemical dissolved and spread over the nest area, killing eggs or fry within 10 minutes. The adult centrarchids often returned intermittently to newly treated nests but they seemed to be no more than irritated by the spreading poison, and no mortality of adults was observed that could be related to the chemical treatment. Allison treated two of several bluegill spawning areas in a 2.75-acre pond (methyl orange alkalinity, 176 ppm) and reported that, after 4 hours, all adults had abandoned the treated areas and made no attempts to return and re-nest during the month following treatment. Apparently the bluegills may have spawned elsewhere. Thus, the question still remains as to whether or not such applications are effective when used as a management procedure to control reproduction in an entire pond or lake.

Copper sulphate first was tested as a bluegill ovicide in a Michigan lake by the junior author in 1958-59. For two consecutive years all visible bluegill nests in a 66-acre lake were treated weekly with copper sulphate crystals during the spawning season. Seining results in the autumn indicated that only half as many young-of-the-year bluegills were present in the treatment years as were present 2 years later. Anglers claimed that bluegill fishing had improved during the post-treatment years.

These encouraging results prompted the present study in which we hoped to (1) eliminate all bluegill eggs and fry in several lakes by periodic treatment of nests with copper sulphate during the spawning season, and (2) measure the results as accurately as possible, in terms of relative abundance and growth of young-of-the-year bluegills, thereby determining the feasibility of copper sulphate applications for the control of bluegill reproduction in lakes.

Methods

Eight lakes ranging in size from 80 to 200 acres and in methyl orange alkalinity from 13 to 140 ppm were selected for the experiment (Big, Duck, and Selkirk lakes in Allegan County; Head, Middle, Mill, Pleasant, and Podunk lakes in Barry County). All the lakes contained bluegills as the dominant fish species and were accessible for bluegill nest treatment and shoreline seining. For 2 years prior to treatment we used a 40-foot bobbinet seine in the autumn to capture young-of-the-year bluegills at ten locations selected at random on each lake. During the second year we duplicated as closely as possible, by site and technique, the seine hauls made the first year. A single haul covered approximately 1,600 square feet. Each haul was started either 40 feet out from shore or, in deeper water, at a depth of 4 feet and the seine was dragged directly in to the shore. After each haul, young-of-the-year bluegills were identified, measured, and counted. Usually young-of-the-year fish were identified by size alone but if the age of any bluegill was in doubt, a scale sample was taken and the age verified later.

After 2 years of pre-treatment seining, four of the lakes were chosen at random for treatment with copper sulphate. The remaining four lakes served as untreated or control waters. On May 17, 1962 the first bluegill spawning activity was noted in the lakes to be treated. The first application of copper sulphate crystals was made from a boat on May 18. Initially, only one or two large crystals were dropped into each bluegill nest, but a check of the treated nests the following day indicated that the concentration of copper sulphate was not strong enough to kill all the eggs. We then increased the dosage to approximately half a handful of crystals (about 25 grams) per nest. Later in the year this amount was increased or decreased depending on the size of the nest, the water turbulence in the vicinity, the proximity of other nests, and the quantity of eggs or fry in the nest. If many nests were found in one area, we often used a grass-seed spreader to broadcast rice-sized, copper sulphate crystals over the spawning area rather than treat each nest individually.

Allison applied about 6 grams of copper sulphate crystals to each bluegill nest and estimated the copper sulphate concentration in the nests to be 101 ppm. We made no measurements of our concentrations but all bluegill eggs and fry were dead in many samples collected with a spawn-taking tube throughout the treatment period.

Smith (1940), Tompkins and Bridges (1958), and others have stressed the fact that the toxicity of copper sulphate to various organisms depends on such factors as water temperature, hardness, and amount of organic material present. Although the methyl orange alkalinity of the treated lakes varied from 13 ppm (Pleasant Lake) to 140 ppm (Middle Lake), our treatments appeared to be equally effective on all four lakes. Fishes other than bluegill fry apparently were not killed by the copper sulphate.

We had to visit each lake every third or fourth day to keep pace with the spawning activity because bluegill eggs hatch in 32 to 62 hours at 73 F (Morgan, 1951). Contrary to the experience of Allison, frequently bluegills would be found spawning in nests that were treated a few days previously. We also discovered that new spawning colonies (some with only a few nests) constantly were being developed in other locations, and the search for these new colonies took a considerable amount of time. Scuba diving equipment was used to find and treat nests in deeper water. Although considerable searching was done down to a depth of 15 feet, no bluegill nests were found in water deeper than 6 feet. One or two 2-man crews either were searching for or treating bluegill nests at one or more lakes nearly every day from May 18 to August 9, after which all observable bluegill spawning activity ceased. During the following September and October the shorelines of the treated and untreated lakes were seined at the sites used previously. The numbers and lengths of young bluegills captured were compared with fish taken in the two pre-treatment years.

Results

The mean numbers per seine haul and average lengths of young-of-the-year bluegills captured in each of the eight lakes before and after treatment are presented in Table 1. In three of the four treated lakes there was a pronounced drop in the catches between 1960 and 1961, followed by an increase in two lakes after the treatment in 1962. The average catch per seine haul in 1962 was greater than in 1961, prior to the copper sulphate application. For the control lakes, the mean catches indicate a marked drop in the fingerling population in 1962.

The catch data were tested by an analysis of variance (Table 2). The significant differences in the seining results between lakes were not unexpected but the significant annual variations among each set of lakes prior to treatment in 1962 were unfortunate. The variability of these catch data was so great that no significant reduction in the fingerling bluegill populations could be demonstrated for the treatments.

Annual variations in bluegill spawning success are to be expected and it is possible that 1961 was a "poor" year in the treatment lakes while 1962 was a "good" year. Thus we may have inflicted a higher mortality than the data indicate. However the data for control lakes suggest that 1961 was a "good" year and 1962 was a "poor" year.

Two other factors which were perhaps more important than spawning success in influencing the variation in the numbers of bluegills caught on all lakes were (1) extremely variable year-to-year temperatures in shoreline areas during seining and (2) a considerable drop in water level in most lakes in 1961. The poor catches in Pleasant Lake and Podunk Lake in 1961 and in Duck Lake in 1962 coincided with relatively low mean water temperatures of 53 F. The mean temperature for all lakes during all years was 61 F (range of 53 F to 71 F). In 1961 and 1962 the drop in water levels forced the relocation of several seining stations out to sites that were either considerably more favorable or less favorable for young bluegills than in 1960. For example, in Pleasant Lake in 1960 the seining stations were in weedy areas but in 1961 and 1962 low water levels forced us to move many of these stations out to muddy, weedless localities. Conversely, the stations in Head Lake in 1960 were in sandy areas with only moderate weed cover but, in the following 2 years, these stations had to be relocated in areas of dense weed growth.

The analysis of variance of the differences in mean lengths of young-of-the-year bluegills indicated there was a significant increase in mean length in the treated lakes but no significant growth differences in the control lakes (Table 3). An orthogonal contrast revealed that post-treatment mean lengths in the treated lakes were significantly greater (95% level) than pre-treatment lengths.

Several possible explanations are suggested for this improvement in growth despite no apparent drop in numbers. The first applications of copper sulphate during the early part of the spawning season could have been less efficient than later applications. Hence, proportionally more earlier-spawned (and therefore larger) bluegills were present in the fall of 1962 than in the pre-treatment years. It is also possible that the percentage of deaths caused by the treatments was similar to the natural mortality rate for May through September but occurred earlier (May through July). Therefore the surviving bluegills had less competition from the time of hatching through September and consequently attained a larger size. A third possibility is that the fall seining locations throughout the study were in areas (close to shore) that normally are favored by young bluegills at that time of year. Therefore, although we might have induced a significantly greater mortality of young bluegills than would occur normally, as suggested by the increase in mean length, the number of bluegills at the sampling sites (favored locations) was not significantly different from former years. Even if the third possibility were true, the slight increase in mean length (from 1.2 to 1.4 inches) indicates that only a moderate decrease in bluegill numbers was achieved.

Discussion

Previous studies indicated that bluegill eggs and fry in ponds could be killed by applying copper sulphate crystals to occupied nests. Unfortunately, our data suggest that we did not kill many (if any) more bluegills than would have died normally during the period involved. Certainly not enough fish were eliminated to cause any drastic change in bluegill growth. It is obvious that we did not approach our goal of eliminating all young bluegills in the treated lakes. In fact, we actually collected more bluegills in the treated lakes following treatment than in the preceding year.

Our attempts to control the size of an entire bluegill year class in four lakes by applying copper sulphate to bluegill nests involved considerable effort continuously by four men for almost 3 months. Even if the treatments had been effective, the effort involved makes this control method of questionable value as a general management procedure for lakes, especially since annual treatments probably would be necessary to prevent a compensating high survival rate in subsequent generations of bluegills. It is possible that bluegill reproduction could be controlled with copper sulphate in ponds and small lakes that have well defined, easily located spawning areas. However, great care must be taken to locate and treat all nests semiweekly during the spawning season. The number of young produced on a few untreated nests could overpopulate a small body of water.

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Literature cited

Allison, Darrell. 1964. Copper sulfate used in bluegill population control. Ohio Dept. Natural Resources, Division of Wildlife Publication W-10, 6 p.

Jackson, C. F. 1956. Control of the common sunfish or pumpkinseed, *Lepomis gibbosus* in New Hampshire. New Hampshire Fish and Game Dept. Tech. Circular No. 12, 16 p.

Morgan, G. D. 1951. The life history of the bluegill sunfish, *Lepomis macrochirus*, of Buckeye Lake (Ohio). Denison University Bull., J. Scientific Laboratories, 42(4): 21-59.

Smith, M. W. 1940. Copper sulphate and rotenone as fish poisons. Trans. Amer. Fish. Soc., 69: 141-157.

Tompkins, W. A., and C. Bridges. 1958. The use of copper sulfate to increase fyke-net catches. Prog. Fish-Cult., 20(1): 16-20.

Table 1. --Mean number per seine haul and average length of young-of-the-year bluegills captured in the autumn at 10 seining stations on each of four control and four treatment lakes before (1960 and 1961) and after (1962) nest treatment with copper sulphate in 1962. Post-treatment data on treated lakes are in parentheses.

Lake	Mean number per seine haul			Mean length (inches)		
	1960	1961	1962	1960	1961	1962
			Treatment Lakes			
Middle	61	63	(47)	1.12	1.18	(1.22)
Mill	24	13	(10)	1.22	1.30	(1.48)
Pleasant	205	12	(22)	1.12	1.33	(1.41)
Podunk	57	12	(46)	1.24	1.36	(1.59)
Averages	87	25	(31)	1.18	1.29	(1.42)
			Control Lakes			
Big	86	141	84	1.36	1.27	1.18
Duck	56	41	8	1.30	1.23	1.29
Head	29	82	9	1.63	1.56	1.64
Selkirk	84	72	53	1.34	1.30	1.40
Averages	64	84	38	1.41	1.34	1.38

Table 2.--Analysis of variance of the number per seine haul of young-of-the-year bluegills collected in four control and four treatment lakes before and after nest treatment with copper sulphate

Source of variation	ss	df	ms	F
I. Control lakes, all years				
Lakes	90,078	3	30,026	6.71**
Years	41,182	2	20,591	4.60*
Lakes x Years (Interaction)	24,961	6	4,160	0.93
Within	483,170	108	4,474	-
Total	639,391	119	-	-
II. Treatment lakes, all years				
Lakes	66,781	3	22,260	6.61**
Years	93,137	2	46,568	13.83**
Lakes x Years	156,885	6	26,148	7.76**
Within	363,691	108	3,368	-
Total	680,494	119	-	-
III. All lakes, all years				
Lakes	169,343	7	24,192	6.17**
Years	65,107	2	32,554	8.30**
Lakes x Years	251,060	14	17,933	4.57**
Within	846,860	216	3,921	-
Total	1,332,370	239	-	-
IV. Treatment versus Control lakes in Treatment year				
Lakes	51,960	7	7,423	3.93**
Treatment	1,125	1	1,125	0.60
Within	134,126	71	1,889	-
Total	187,211	79	-	-

** = Significant at 99% level.
* = Significant at 95% level.

Table 3.--Analysis of variance of differences in mean length of young-of-the-year bluegills collected in four control and four treatment lakes before and after nest treatment with copper sulphate

Source of variation	ss	df	ms	F
I. Control lakes, all years				
Years	.0091	2	.0046	0.16
Within	.2510	9	.0279	-
Total	.2601	11	-	-
II. Treatment lakes, all years				
Years	.1251	2	.0625	5.43*
Within	.1035	9	.0115	-
Total	.2286	11	-	-
III. All lakes, all years				
Years	.0053	2	.0026	0.11
Within	.5195	21	.0247	-
Total	.5248	23	-	-
IV. Treatment versus Control lakes in Treatment year				
Treatment	.0045	1	.0045	0.14
Within	.1886	6	.0314	-
Total	.1931	7	-	-

* = Significant at 95% level.