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EFFECTS OF THE COMBINED USE OF TWO FISH TOXICANTS, ANTIMYCIN-A AND ROTENONE, ON THE ZOOPLANKTON OF A NORTHERN WISCONSIN BOG LAKE

By
Steven L. Serns and Michael H. Hoff,
Bureau of Research, Woodruff

Dept. of Natural Resources
Technical Library
3911 Fish Hatchery Road
Fitchburg, WI 53711 - 5397

ABSTRACT

The influence of the combined application of 3.8 µg/l a.i. of antimycin-A (Fintrol-5[R]) on 13 May 1980, and 0.05 mg/l a.i. rotenone (2.0 mg/l Prentox-Synpren-Fish[R]) on 21 May 1980, on the zooplankton of Spruce Lake, Wisconsin, was investigated. Samples collected before and after toxicant application indicated a drastic decrease in both copepods and cladocerans immediately after the application of antimycin. No copepods or cladocerans were collected until 18 July (none were found on 14 July) approximately 2 months after toxicant application. The major cladoceran species and cyclopoid copepods exhibited midsummer to early fall pulses during 1980. These pulses appeared to be somewhat delayed, however, when compared with pulses the following year (1981). Calanoid copepods did not rebound from the effects of the treatment until summer 1981, over one year after treatment.

CONTENTS

INTRODUCTION

Several studies have been conducted to determine the effects on zooplankton of the fish toxicants antimycin-A (Calaham and Huish 1969, Gilderhus et al. 1969, Rabe and Wismer 1969, Beard 1974) and rotenone (Brown and Ball 1942, Kiser et al. 1963, Anderson 1970, Serns 1979) when used singly to eradicate fish populations. In general, these studies indicted no long-term effects of the toxicants on zooplankton. However, to our knowledge, the effects on a zooplankton community of a combined antimycin-rotenone application have never been measured. A bioassay study of the effects of a combination of antimycin-A and rotenone on fish indicated that the two chemicals are compatible and the toxic effects are additive (Howland 1969).

Many small acidic bog lakes are present in north central Wisconsin. Over 50% of the lakes in Vilas County, whose area is included in one of the most concentrated lake regions in the world, are thought to be bog lakes (L. M. Andrews, pers. comm.). Because of their usual shallow depth, many of these lakes have frequent fish die-offs in late winter due to low dissolved oxygen concentrations as a result of aerobic decomposition of organic material. The fish communities which survive in these marginal habitats are usually comprised of species which are tolerant of reduced oxygen levels and low pH. These species often include: yellow perch (*Perca flavescens*), black bullhead (*Ictalurus melas*), and central mudminnows (*Umbra limi*).

As part of a more extensive study to determine the feasibility of converting the existing fishery of a bog lake into a more desirable species combination, Spruce Lake, Vilas County, Wisconsin, was chemically treated with 1.0 mg/l (0.025 mg/l rotenone a.i.) emulsifiable rotenone (Chem-Fish[R]) on 24 October 1978. Although yellow perch in cages suspended in Spruce Lake on the date of treatment all died within 48 hours after rotenone application and many dead perch were observed on the lake surface after treatment, subsequent netting in 1979 indicated that some adults had survived. Because of the overhanging sphagnum bog mat, it is possible that some perch found refuge from the rotenone until it detoxified. The fish repellent property of rotenone is well known (Miller 1950, Lennon 1970) and may have driven the fish to an uncontaminated area under the overhanging bog fringe. In addition to yellow perch, some black bullheads and mudminnows also survived the October 1978 treatment.

We decided to retreat Spruce Lake in spring 1980 with a combination of antimycin and rotenone. Antimycin was selected because its nonrepellent action on fish would minimize escape to the overhanging bog mat (Lennon and Berger 1970) and because of its high toxicity to yellow perch eggs and fry as well as adults (Gilderhus et al. 1969). Since black bullheads are very resistant to antimycin (Cumming 1975), the use of rotenone following antimycin was considered necessary to accomplish a complete fish eradication.

The purpose of this study was to determine the impact of the application of antimycin followed shortly with rotenone on the zooplankton community of Spruce Lake.

STUDY AREA

Spruce Lake is located in Vilas County in north central Wisconsin at a latitude of approximately 46°05' and a longitude of 89°35'. The lake has a surface area of 6.7 ha and a maximum depth of 4.0 m. The lake is entirely surrounded by state-owned land and access is provided by a graded road passing within approximately 30 m of the lakeshore. About 99% of the 1.0 km of shoreline around the lake is comprised of quaking bog which is primarily composed of *Sphagnum* sp. on which wild cranberry (*Vaccinium* sp.), leatherleaf (*Chamaedaphne calyculata*), pitcher-plant (*Sarracenia purpurea*), spruce (*Picea* sp.), and tamarack (*Larix laricina*) grow. There are no tributary streams; however, an intermittent outlet flows during periods of high water, usually only in spring. Rooted aquatic vegetation is sparse with a few yellow water lilies (*Nuphar advena*) and pipewort (*Eriocaulon septangulare*) in the littoral zone and some watermoss (*Drepanocladus* sp.) in the deeper portions of the basin.

The water is acidic and light brown. Secchi disc readings during open water periods averaged 3.2 ± 0.5 m on 19 separate occasions between 14 July 1980 and 22 October 1981. pH readings taken on 19 occasions between 19 January and 22 October 1981, averaged 5.28 ± 0.39 on the surface and 5.25 ± 0.33 just above the bottom. pH values ranged from a high of 5.95 on the surface on 19 January 1981 to a low of 4.35 on the surface on 22 October 1981. Dissolved oxygen levels recorded on 43 separate dates from 3 January 1980-22 October 1981 averaged 8.3 ± 1.7 mg/l on the surface, 7.3 ± 1.7 mg/l at mid-depth (approx. 2.0 m) and 6.1 ± 2.2 mg/l near the bottom and were never below 6.3, 3.7, and 1.4 mg/l at those depths, respectively. Other Spruce Lake water chemistry parameters measured at spring turnover in 1969 were: NO_2-N, 0.005 mg/l; NO_3-N, 0.1 mg/l; Kjeldahl-N, 0.53 mg/l; dissolved phosphorous, 0.03 mg/l; total phosphorous, 0.05 mg/l; total alkalinity, 1.0 mg/l.

CHEMICAL TREATMENT AND FISH BIOASSAY

Spruce Lake was treated with 3.18 µg/l a.i. antimycin-A (Fintrol-5®) at 10:00 a.m. CDT on 13 May 1980, and with 0.05 mg/l rotenone a.i. (2.0 mg/l Prentox-Synpren-Fish®) at 12:00 noon CDT on 21 May 1980. The antimycin was applied initially to eliminate the yellow perch without repelling them under the bog fringe and the rotenone was added later to kill the black bullheads.

Several mudminnows and 1 adult yellow perch were found dead along the shore of Spruce Lake on 14 and 15 May, 1 and 2 days after the antimycin application. Also, on 15 May at 1:00 p.m. CDT, 10 adult yellow perch collected from a nearby lake were suspended in live cages (5 fish/cage) at depths of 1.5 and 3.0 m. When the cages were checked the following day at 10:00 a.m. all perch were dead indicating that the concentration of antimycin in the lake was toxic to perch. On 19 May several more dead mudminnows and 2 adult yellow perch were found in a tour of the shoreline. On 23 May, 2 days after the application with rotenone, 2 dead black bullheads and 1 adult yellow perch were collected. Also on this date, many dead *Chaoborus* sp. pupae were found windrowed along the bog shoreline surrounding the lake. No *Chaoborus* sp. were evident when the lake was checked on 22 May or during the entire period between the antimycin and rotenone applications, indicating that the rotenone was primarily responsible for their demise.

No adult yellow perch were collected during the two fyke netting periods (12-15 August and 9-15 October) and one gill netting period (21-23 October) during the 1980 open water season, indicating that the combined antimycin-rotenone treatment eliminated adult yellow perch from the lake. However, netting during the spring of 1981 indicated the presence of several yearling perch that had apparently survived the spring 1980 treatments in either the egg or fry stage.

METHODS

Zooplankton were collected on 57 separate occasions between 3 January 1980 and 9 October 1981. The samples were collected using a No. 10 mesh (0.158-mm aperture diameter) Clarke-Bumpus plankton net and cup with a 12.5-cm diameter and net mouth. The net was towed vertically from the bottom (~4.0 m) to the surface at the point of maximum water depth. Two samples were collected on each date and were analyzed independently of each other. The calculated density of each taxon on each sampling date was determined by summing the density in the samples and dividing by two.

Samples were preserved in the field in 5% formalin and 3 1-ml subsamples were later analyzed independently of each other in a 3-ml circular counting cell (Priegel 1970). Cladocerans were identified to species when possible, while copepods were identified to subclass (Pennak 1953). The number of each taxonomic group per liter of strained water was determined for each sampling date. Zooplankton from representative samples taken both prior to and after treatment with the piscicides were identified to species by Dr. Byron Torke of Ball State University, Muncie, Indiana.

RESULTS AND DISCUSSION

After treatment with antimycin-A on 13 May 1981, there was a decrease in estimated densities of both copepods and cladocerans (Fig. 1). After this treatment and the addition of rotenone on 21 May, no copepods or cladocerans were collected on 14 separate sampling dates from 21 May-14 July 1980. Both cladocerans and copepods reappeared in the samples on 18 July and increased in subsequent collections to a midsummer peak on 22 August. The midsummer to early fall peak of cladocerans was mainly comprised of *Eubosmina tubicen* and *Daphnia pulex* early in the summer and *Holopedium gibberum* in late summer and fall (Fig. 2). The large numbers of these three cladoceran species in the summer of 1980 indicates that any adverse effects on these organisms by combined antimycin-rotenone treatment in May of that year were not long-lived. However, a comparison of the densities of *Daphnia pulex* and *Holopedium gibberum* in 1980 and 1981 suggests that if the timing of the pulses of these species in the summer of 1981 were normal, the treatment in May 1980 may have postponed their pulses in the summer immediately following treatment (Fig. 2). A peak of cladocerans in the midwinter and early spring of 1981 (the winter following treatment) was composed almost entirely of *Eubosmina tubicen*.

The midsummer pulse of copepods in 1980 was comprised only of cyclopoids in contrast to the peak in 1981 which consisted of approximately equal numbers of cyclopoids and calanoids (Fig. 2). This suggests that the calanoids were negatively affected by the combined antimycin-rotenone treatment in 1980 and did not fully recover until the summer of 1981. A suspected postponement or delay in a pulse of a zooplankton taxon after the application of a chemical has been observed in a previous study. Serns (1979) felt that the spring pulse of Calanoida and some cladocerans was delayed due to a treatment with rotenone the previous fall. Cyclopoid copepods are often able to rebound from the initial effects of a toxicant more rapidly than calanoids because they have a juvenile resting stage which is much more advanced than calanoids and also have a greater reproductive ability than most species of Calanoida (B. G. Torke, pers. comm.).

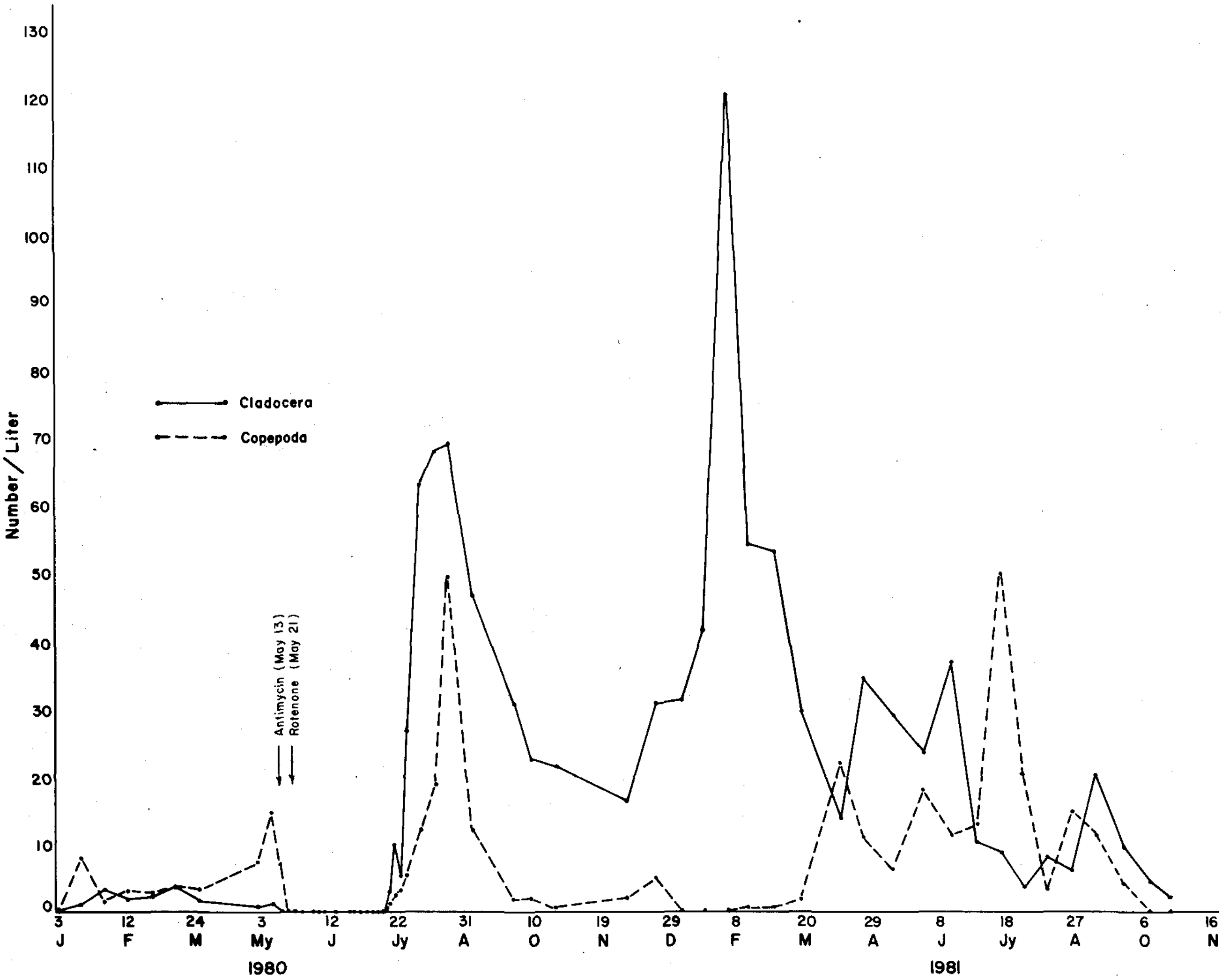

FIGURE 1. Estimated densities of zooplankton in Spruce Lake on 57 sampling dates before and after treatment with antimycin and rotenone in May 1980.

An examination of the species of zooplankton found in samples collected prior to and after the antimycin-rotenone treatment indicated that each species present before treatment was also found in samples collected after toxicant application (Table 1). Most of the species of Cyclopoida present during the winter months prior to toxicant application were noted in samples collected during the same months one year later indicating that members of this suborder recovered, at least in terms of their presence or absence in samples, within a relatively short time after treatment (Table 1). However, the two species of calanoid copepods (Skistodiaptomus oregonensis and Leptodiaptomus minutus) which were both present in moderate to large numbers during the winter months prior to treatment were not present in any samples collected during the following winter (Table 1). These species did not reappear until the following spring (Fig. 2) indicating that they took a full year to rebound from the effects of the toxicants.

This study indicates that the combined application of antimycin-A and rotenone, a logical technique for the eradication of a multispecies fish community in a bog lake, does not have a long-term adverse effect on the zooplankton community and, therefore, would not have an extended adverse impact on food availability for re-introduced planktivorous fishes.

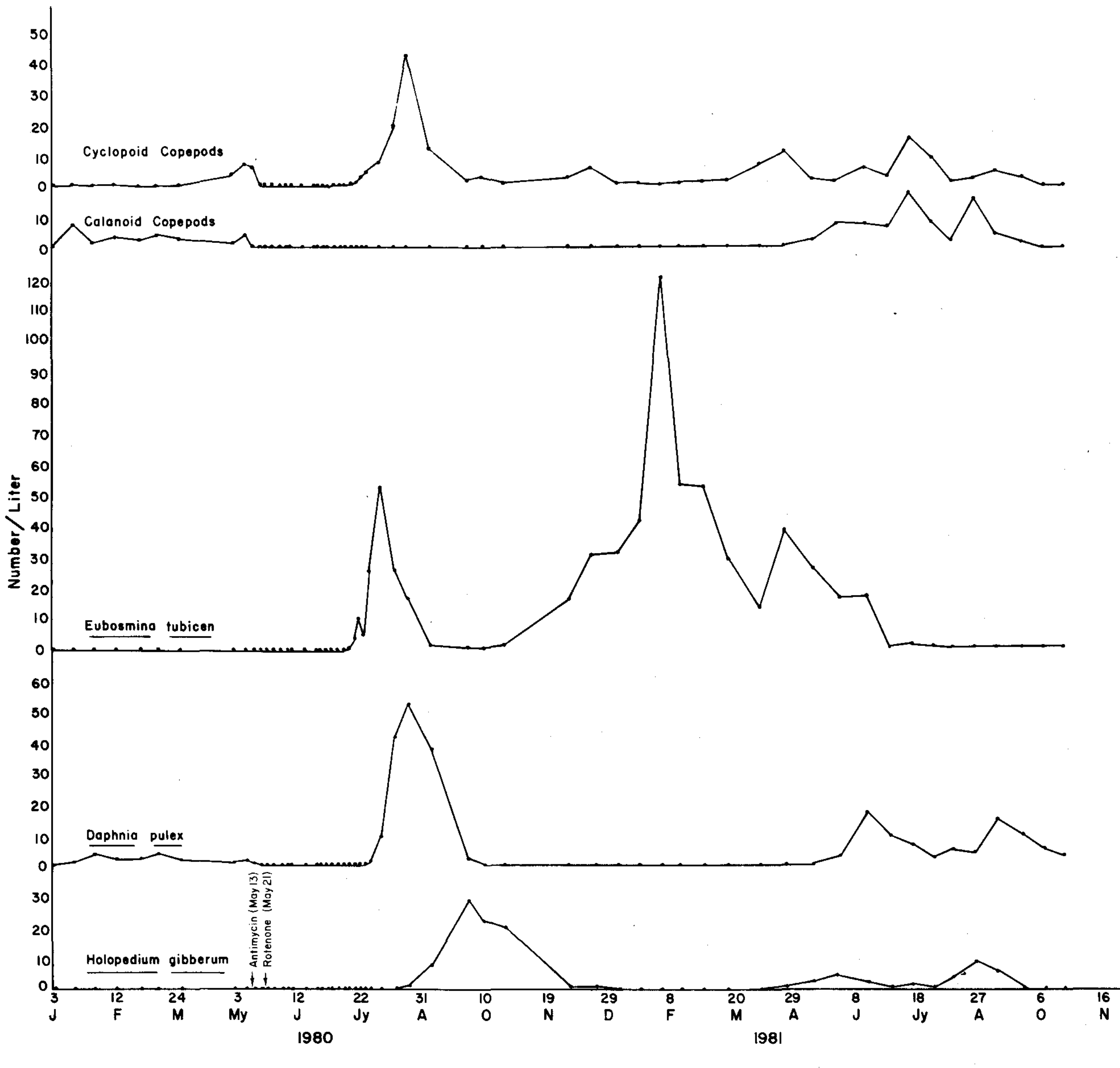

FIGURE 2. Estimated densities of the major cladoceran species and copepod suborders in Spruce Lake on 57 sampling dates before and after treatment with antimycin and rotenone in May 1980.

TABLE 1. Zooplankton noted in samples collected in Spruce Lake before and after the combined treatment with antimycin and rotenone in May 1980.

Taxon	Before Treatment*	After Treatment	
	Winter 1980	Winter 1982**	Summer 1981***
Cladocera			
Polyphemus pediculus			X
Diaphanosoma sp.			X
Holopedium gibberum			X
Chydorus sphaericus	X		X
Daphnia pulex	X		X
Eubosmina tubicen	X	X	X
Alona quadrangularis			X
Copepoda			
Calanoida			
Skistodiaptomus oregonensis	X		X
Leptodiaptomus minutus	X		X
Cyclopoida			
Eucyclops serrulatus		X	
Diacyclops sp.	X	X	
Mesocyclops edax	X		X
Macrocyclops albidus	X	X	X
Macrocyclops sp.	X	X	
Orthocyclops modestus		X	
Acanthocyclops vernalis		X	

*Combined samples of January 3, 17 and 30; February 13 and 28; and March 13, 1980.
**Combined samples of January 5 and 19; February 3 and 15; and March 2 and 18, 1981.
***Combined samples of July 14 and 28, 1981.

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About the Authors

The authors are fishery biologists at the Northern Highland Fishery Research Area, Bureau of Research, Woodruff.

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