TABLE 2. RANGE OF POPULATION DENSITIES (NO/L) OF ZOOPLANKTON IN POND AND LAKE WATER.

Group	Pond water	Lake water
Rotifera	867-1913 (94-83)*	660-1475 (94-87)
Copepoda	17-271 (2-12)	11-147 (2-9)
Cladocera	34-113 (4-5)	36-80 (5)
Total	919-2297	706-1702

*Values in parenthesis are persentages of the total.

A drastic reduction of phytoplankton species was observed shortly after fluridone application. The population of Cyanophyceae disappeared after about 2 months. This finding is of great importance, since the proliferation of these species is associated with the phenomenon of water bloom that affects the productivity of aquatic ecosystems. On the contrary, the persentage of diatoms increased substantialy, especially the epiphytic and benthic species. This increase suggests that they were released from the decomposed aquatic vegetation which was affected by fluridone.

In view of these encouraging results it seems that no detrimental effects occur in fish productive aquatic ecosystems treated with fluridone. However, further experiments are needed to establish whether this agent may adversely affect carp eggs and fry.

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Effects of Potassium Ricinoleate on Water Quality, Phytoplankton, and Off-Flavor in Channel Catfish Ponds

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ABSTRACT

Potassium ricinoleate (Solricin 135®) was marketed as an algicide to selectively inhibit the growth of blue-green algae in ponds and eliminate off-flavor of channel catfish, *Ictalurus punctatus* (Rafinesque). The algicide was evaluated in catfish culture ponds at the Auburn University Fisheries Research Unit from March through October of 1986. Potassium ricinoleate, in weekly applications of concentrations up to 1.00 ppm, did not significantly inhibit the growth of blue-green algae or positively affect the phytoplankton community structure in ponds with waters of low hardness (20-30 mg/l as $CaCO_3$). The compound did not eliminate off-flavor in channel catfish nor did it improve water quality of the ponds.

Key words: Algae control, Solricin 135®, blue-green algae, catfish culture, aquaculture.

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INTRODUCTION

Channel catfish, *Ictalurus punctatus* (Rafinesque), farmers normally supply large amounts of feed (39-67 kg/ha/d) to ponds to enhance production. In ponds which receive applications of fish feed, roughly 75% of the nutrients in the feed eventually reaches the water in excretory products (Boyd 1973b). These nutrients stimulate the growth of aquatic plants, particularly phytoplankton which, within limits, is desirable for optimum fish production. Phytoplankton produce dissolved oxygen during photosynthesis, remove and recycle toxic metabolites and waste nutrients, and contribute to the production of fish food organisms. However, unlimited proliferation of phytoplankton, especially blue-green algae (Cyanobacteria) can result in serious environmental deterioration of the pond.

Dense blooms of phytoplankton exert an excessive oxygen demand at night or during prolonged periods of cloudy weather, leading to low dissolved oxygen levels in ponds which stress or kill fish (Boyd et al. 1978). During periods of warm, calm weather, buoyant blue-green algae often accumulate to depths of several centimeters over the entire pond surface (Boyd 1979). The greater abundance of algae near the surface shades and reduces light penetration to deeper water leading to lower productivity and dissolved oxygen production in the pond (Boyd 1979). In addition, rapid photosynthetic rates of algae in this floating layer during periods of high light intensity cause high pH, low carbon dioxide concentrations, and supersaturation of dissolved oxygen, conditions that may result in algal mortality due to photooxidation (Abeliovich and Shilo 1972; Abeliovich et al. 1974). If the die-off is extensive, there is danger of a fish kill due to oxygen depletion and accumulation of toxic products brought on by algal decomposition (Boyd et al. 1975).

Absorption of disagreeable flavor from compounds in the aquatic environment is a serious problem in the pond culture of fish. Flavors described as "sewage," "stale," "rancid," "metallic," "moldy," "petroleum," and "weedy" have all been characterized from off-flavor fish (Lovell 1983). Geosmin and 2-methylisoborneol, compounds which have been identified as causes of earthy-musty (muddy) flavors and odors in cultured catfish, are synthesized by certain algae and actinomycetes (Lovell et al. 1986; Martin et al. 1988). These substances are imparted into the water and absorbed by fish, causing them to be unpalatable (Lovell and Sackey 1973) and often unmarketable.

Efforts to control phytoplankton in commercial catfish ponds with algicides offer temporary relief at best and are potentially devastating if used indiscriminately. Of the algicides registered for use in food fish waters, copper sulfate is the most widely used compound to control phytoplankton by catfish producers in the Southeast. Crance (1963) found that periodic applications of 0.84 kg/ha of copper sulfate controlled populations of the colonial blue-green algae, *Microcystis*. Tucker and Boyd (1978b) determined, however, that biweekly applications of this rate were ineffective in reducing total phytoplankton density. Due to the high toxicity of copper sulfate to fish and invertebrates, particularly in waters of low alkalinity, chelated copper compounds offer a safer alternative.

Simazine (2-chloro-4,6-bis(ethylamino)-s-triazine), sold under the trade name Aquazine® by the Ciba-Geigy Corporation is extremely toxic to phytoplankton and non-toxic to fish at recommended treatment rates. Applications of simazine totaling 1.3 mg/l were found to drastically reduce phytoplankton density and cause extended periods of low dissolved oxygen (Tucker and Boyd 1978a). Its use in catfish ponds stocked and managed for maximum production was accompanied by a decrease in fish yield of up to 20% (Tucker and Boyd 1978a, 1978b). Aeration was not used in either study. Since it appeared likely that the reduced fish yield in simazine-treated ponds was at least partially the result of exposure to chronic low dissolved oxygen concentrations, there is little doubt aeration would have been beneficial.

Potassium ricinoleate, sold under the trade name Solricin 135 (CasChem, Inc., Bayonne, N.J.), has been registered by the U.S. Environmental Protection Agency as an algicide for use in aquatic food-fish systems (Schnick et al. 1986). Results of early field studies (van Aller and Pessoney 1982) indicated that a single application of 2 mg/l of ricinoleic acid salt depressed growth of blue-green algae for about seven weeks while the green algal levels were unaffected. They later reported that 1.8 ppm potassium ricinoleate improved but did not eliminate off-flavor in pond-reared channel catfish (Pessoney et al. 1984).

Tucker and Lloyd (1987) evaluated Solricin 135 applied to experimental channel catfish ponds in Mississippi. Hard water (150-250 mg/l as $CaCO_3$) ponds treated with 0.8 mg/l potassium ricinoleate three times a week for 22 weeks showed no improvement in water quality, blue-green algal abundance or off-flavor of fish when compared to untreated control ponds.

The objective of our study was to determine the effects of potassium ricinoleate on certain water quality variables, estimated phytoplankton biomass and community structure, and off-flavor of channel catfish in experimental production ponds filled with waters low in total hardness (<50 mg/l as $CaCO_3$).

MATERIALS AND METHODS

Twelve earthen ponds (0.04-0.06 ha) similar in design and morphometry and having a common water supply were used in the present study. Water hardness of each pond was determined using the EDTA titrimetric method (American Public Health Association et al. 1985). All of the ponds were stocked with 9,884 fingerling channel catfish per ha (4,000/ac) on 7 February 1986. Fish were fed daily, Monday through Saturday, at rates commonly used in commercial catfish production (3-4% of body weight) until harvest on 15 October 1986. A total of 7,525 kg/ha of feed was applied to each pond during the 206-d experimental period.

Starting 17 March 1986, four randomly chosen ponds were treated with 1.00 ppm of potassium ricinoleate as Solricin 135, four were treated with 0.25 ppm, and four ponds remained untreated to serve as controls. The algicide was thoroughly mixed with water and evenly distributed on the pond surface. The treatment was repeated weekly for 31 weeks. These rates were decided upon after consultation with technical representatives of the manufacturer.

Two-liter water samples were collected weekly from each of the 12 ponds with a 90-cm column sampler (Boyd 1979) for determination of chlorophyll *a*, turbidity, and assessment of phytoplankton community structure. Phytoplankton samples consisted of 200 ml of water preserved with 14 ml of a merthiolate solution (APHA et al. 1985). A 5-ml aliquot of this sample was placed into a sedimentation chamber, and phytoplankton was identified to genus and counted with the aid of an inverted microscope (APHA et al. 1985). Water samples (100 ml) for chlorophyll *a* analysis were filtered through 0.45 μm, pore size, Millipore filters. The pads were then acetone extracted in darkness at 4 C for 24 h. Chlorophyll absorption was measured spectrophotometrically at 665 nm, and the chlorophyll *a* concentration calculated as suggested by Weber (1973).

Dissolved oxygen concentrations were determined twice a week beginning in May until the end of the experimental period with a polarographic dissolved oxygen meter. Readings were taken between 0600 and 0700 h at

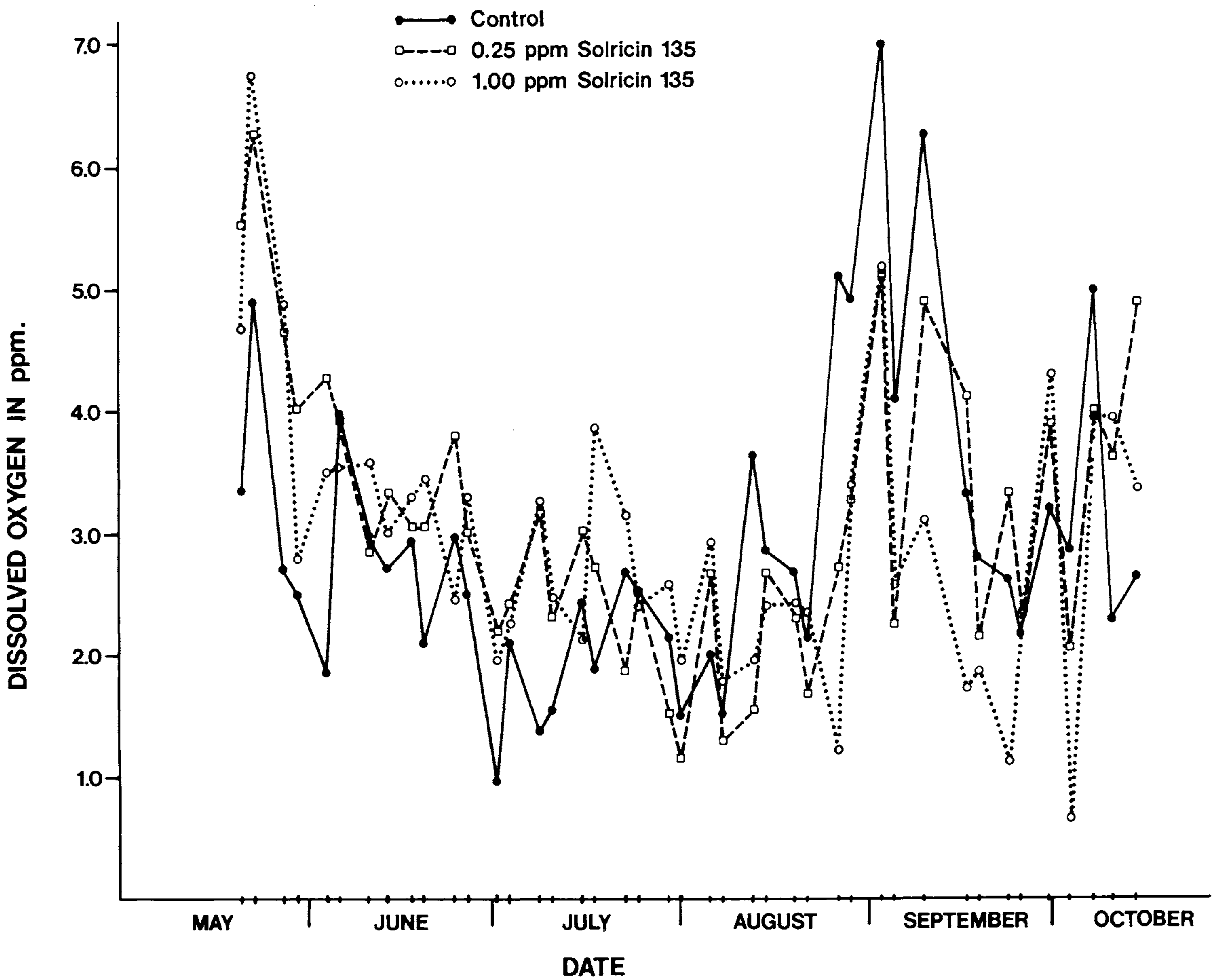

Figure 1. Mean concentration of dissolved oxygen in control ponds and ponds treated with potassium ricinoleate at rates of 0.25 ppm and 1.00 ppm. Each point represents the average of four replicates.

a depth of 20 cm. Turbidity was measured weekly using a turbidimeter and was reported in Jackson Turbidity Units (JTU).

From 1 July until 6 October, two catfish were removed from each pond weekly for flavor evaluation. Off-flavor was evaluated by a panel of five trained tasters who were sensitive to the taste of geosmin and associated off-flavors in channel catfish. Each of the tasters rated the two fish on a scale of 1 (no off-flavor) to 5 (extreme off-flavor).

Data were analyzed by analysis of variance (ANOVA) for a completely randomized design. Differences in treatment means were determined using contrasts within the ANOVA at the 0.10 probability level (Steel and Torrie 1980). This level was chosen due to the expected variability of the data that could result in a Type I error.

RESULTS AND DISCUSSION

There were no statistical differences in mean dissolved oxygen (DO) among the treatments (Figure 1). The mean DO for all the ponds during the experiment was 3.00 ppm. Unlike many previous algicide experiments, potassium ricinoleate did not significantly reduce DO. Emergency aeration was used during the study when the catfish in the ponds appeared to be stressed.

Mean turbidity values for the treatments were 23, 41, and 24 JTU's for the control, low, and high rate treatments, respectively. There were no statistical differences in mean turbidity among the treatments.

The mean chlorophyll *a* concentrations of the low rate treatment ponds were significantly higher than both the

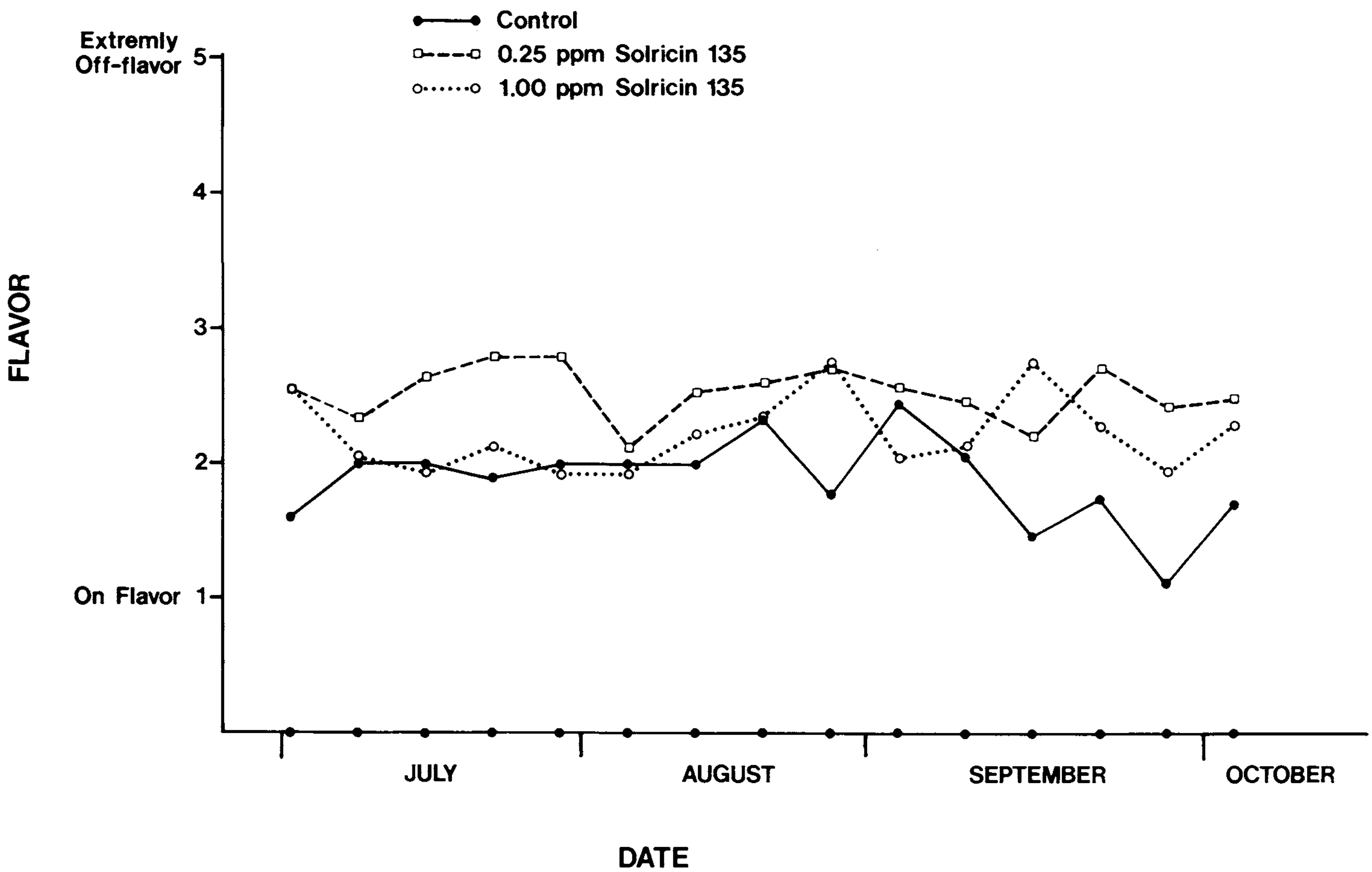

Figure 2. Mean flavor rating of channel catfish from control ponds and ponds treated with potassium ricinoleate at rates of 0.25 ppm and 1.00 ppm. Each point represents the average of eight fish per treatment.

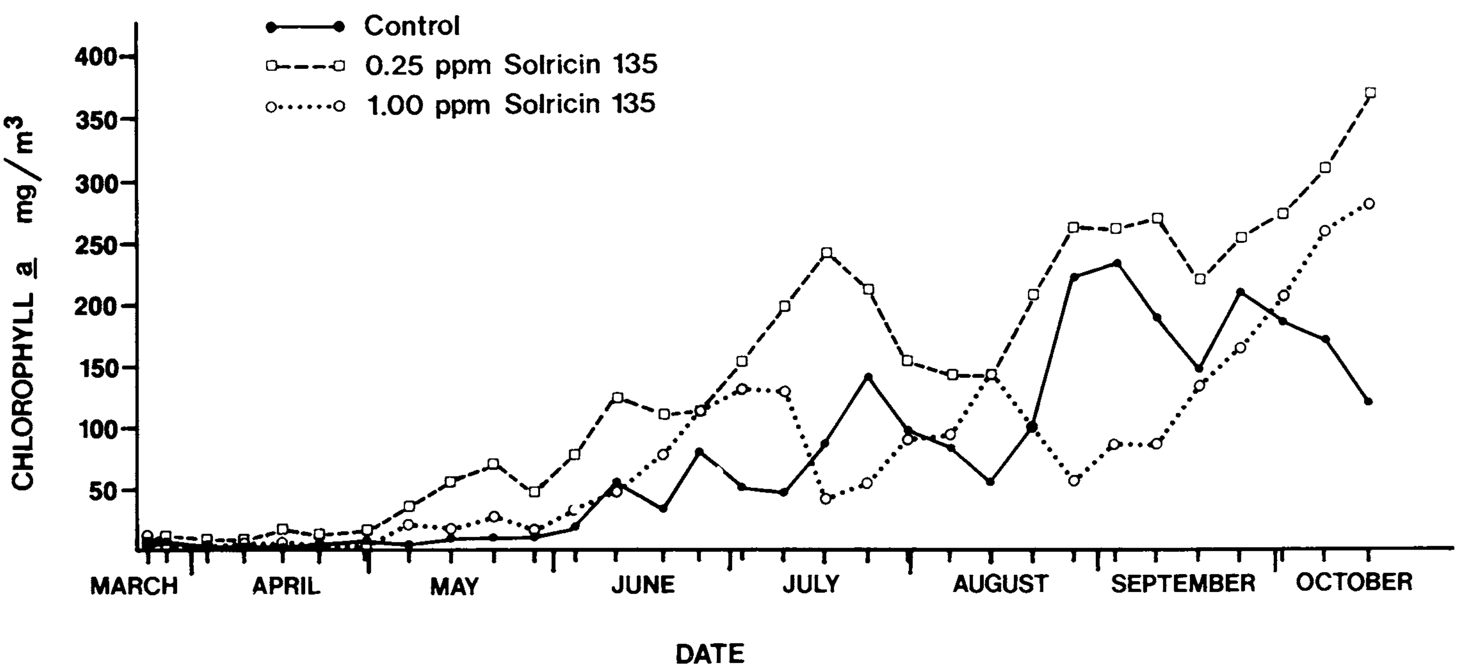

Figure 3. Mean chlorophyll *a* concentrations (mg/m^3) from control ponds and ponds treated with potassium ricinoleate at rates of 0.25 ppm and 1.00 ppm. Each point represents the average of four replicates.

control and the high rate treatment ponds (Figure 3). Boyd (1973a) reported a mean chlorophyll *a* concentration for 14 channel catfish ponds of 102.2 mg/m^3 on a single August sampling date. Tucker and Lloyd (1987) reported mean chlorophyll *a* concentrations during the growing season in excess of 300 mg/m^3 in experimental catfish ponds in Mississippi. Mean chlorophyll *a* values in our study were 77.6, 143.2, and 80.5 mg/m^3 in the control, low, and high rate treatments, respectively.

In fed and fertilized ponds at Auburn University, green (Chlorophyta) and blue-green (Cyanobacteria) algae account for 90% or more of the phytoplankton in almost all ponds during the summer months (Boyd 1973a). In our study, green and blue-green algae comprised over 89% of the phytoplankton present during the experimental period (Figure 4). Throughout the growing season green algae predominated in all of the treatments, comprising 61% or more of the phytoplankton community. There were no statistical differences in the mean density of green algae among treatments.

During the first 10 weeks of the experiment, blue-green algae comprised 18% of the algal community of the control ponds. Blue-green proportions in the low and high treatment ponds during this period were 1% and 9%, respectively. This proportion shifted over the growing season, and in the final 10 weeks of the experiment 3% of the phytoplankton in the control ponds were blue-green algae, while the low and high rate treatments had risen to 13% and 25%, respectively. The high rate treatment had a significantly greater density of blue-green algae than the control. Potassium ricinoleate did not decrease the number of blue-green algae in ponds. In fact, the mean number of blue-green algae in the high rate treatment ponds was 5.5 times greater than the control ponds.

All algae other than green and blue-green were grouped together as "others." This grouping included euglenophytes (Euglenophyta), dinoflagellates (Pyrrhophyta), and diatoms (Chrysophyta). Statistically, there were no differences among the treatment means for the algae grouped as "others."

The potassium ricinoleate treatments did not prevent fish off-flavor problems. In fact, fish cultured in the control ponds had a significantly better mean flavor rating than fish from either treatment (Figure 2). Control fish

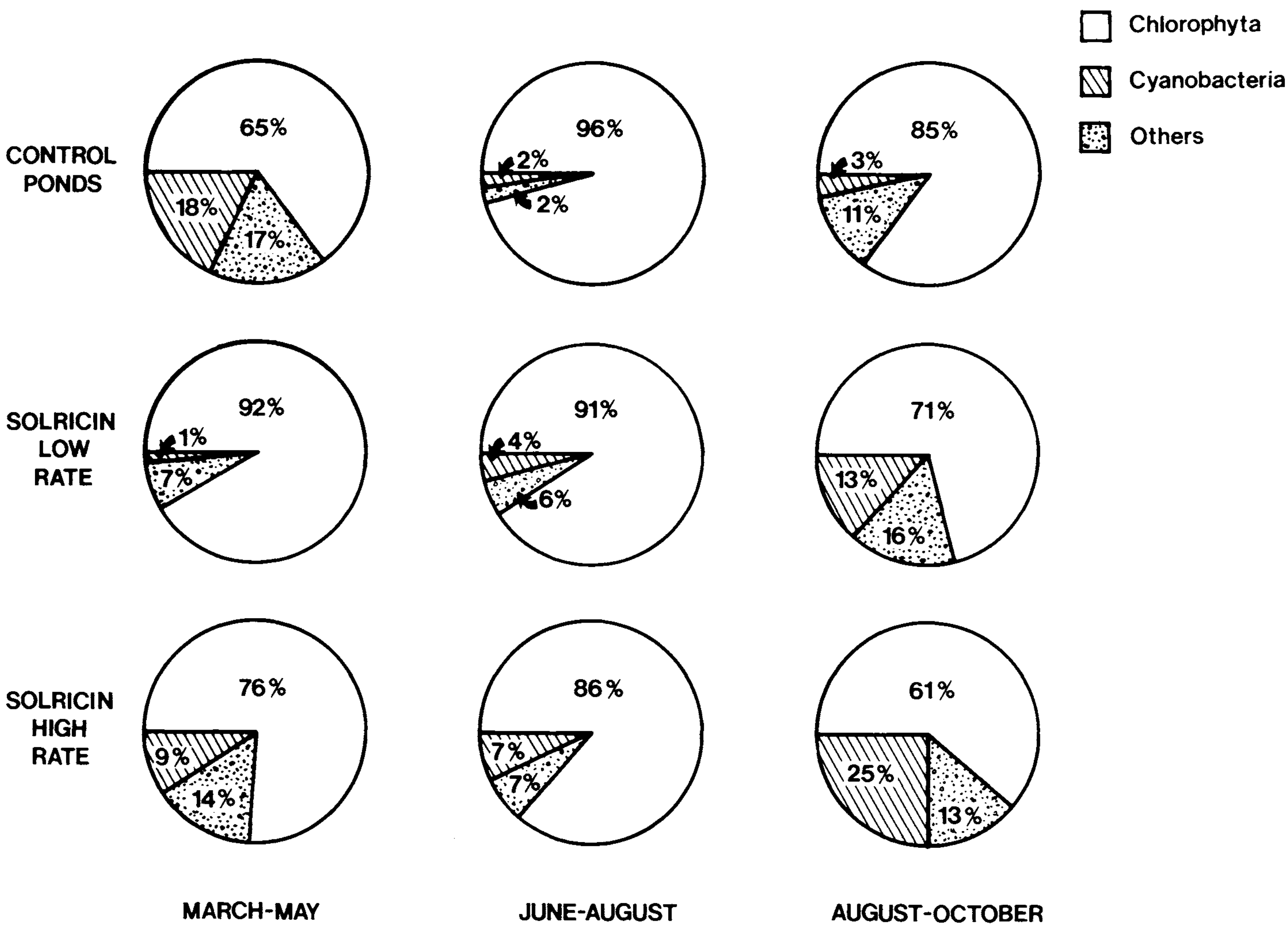

Figure 4. Percent composition of phytoplankton communities by taxonomic division in control ponds and ponds treated with potassium ricinoleate at rates of 0.25 ppm and 1.00 ppm. The experimental period was divided into three 10- week periods. Others category includes species of Euglenophyta, Pyrrhophyta, and Chrysophyta.

remained marketable (flavor rating of 2 or less) on most sampling dates, whereas fish from the treatment ponds would have been rejected by the buyer.

In laboratory trials using Solricin 135, concentrations of the product as high as 64 ppm failed to show any effect on green and blue-green algal cultures. Blue-green algae tested included species of *Aphanizomenon*, *Anabaena*, *Oscillatoria*, and *Microcystis* (Martine van der Ploeg, personal communication). Our inability to corroborate any of the beneficial effects of potassium ricinoleate as reported by van Aller and Pessoney (1982) and Pessoney et al. (1984) is puzzling. Tucker et al. (1986) found that ricinoleate would form relatively insoluble salts with divalent cations found in hard waters. Tucker and Lloyd (1987) felt that the precipitation of these insoluble salts may have led to failure of the algicide in their study conducted in ponds with moderately hard to hard waters. Water hardness in our ponds ranged between 20 and 30 mg/l as $CaCO_3$, a hardness level near the lower end of the range expected in channel catfish ponds. Precipitation as calcium or magnesium salts would have been minimal. Results of our study do not support the claims made by the manufacturer that the use of Solricin 135 reduces the incidence of low dissolved oxygen content of pond waters, limits growth of blue-green algae, or effectively eliminates off-flavor of channel catfish.

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