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Response of Periphyton and Phytoplankton to Chemical Control of Hydrilla in Artificial Pools[1]

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ABSTRACT

The effects of the treatment of hydrilla with herbicides on periphyton and phytoplankton biomass were examined in experimental pools. Phytoplankton and periphyton abundance as measured by chlorophyll *a* significantly increased in pools treated with herbicides. Periphyton blooms were ephemeral, approaching pre-treatment levels as hydrilla regrowth began. Nutrient levels were higher, and pH lower, in treated pools relative to control pools.

Key words: chlorophyll *a*, attached algae, epiphytes, herbicides.

INTRODUCTION

An increase in algal growth due to the liberation of nutrients from decomposing watermilfoil (*Myriophyllum heterophyllum* Michx.) tissue was demonstrated by Rho and Gunner (1978) under laboratory conditions. They noted a decrease in pH, which they attributed to the nitrification of ammonia released by the decaying vegetation. Similarly, Carter and Hestand (1977) showed an increase of nutrients

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and phytoplankton, and a decrease of pH, after the decay of submersed macrophytes following chemical treatment in experimental pools.

Field observations also indicated increased algal standing crops subsequent to submersed macrophyte degradation. Landers (1982) demonstrated an increase in nutrients and increases in phytoplanktonic and periphytic chlorophyll *a* as watermilfoil naturally senesced in field enclosures in an Indiana reservoir. Hodgson and Carter (1982) observed a significant increase in periphyton biomass on glass slide samplers following treatment of hydrilla (*Hydrilla verticillata* (L.F.) Royle) with herbicides in Lake Pearl, Florida.

Data on the responses of both attached and planktonic algae within a system to the herbicide treatment of macrophytes are not extensively reported. Therefore, in this study, the effects of chemical treatment of hydrilla on periphyton and phytoplankton standing crops were examined.

MATERIALS AND METHODS

The bottoms of four plastic pools (3.05 m diameter, 1 m deep), located on the University of Florida campus, were covered with about 5 cm of quarry sand in which hydrilla was planted, in the last week of June 1981. Pools were filled with water from eutrophic Bivens Arm lake, and fertilized with 130 g of 8-8-8 fertilizer containing micronutrients, to encourage hydrilla growth. Pools were divided between two treatments: (1) Control, i.e., undisturbed hydrilla filled pools (pools C1 and C2), (2) Herbicide treated (pools H1 and H2).

Subsurface (0.5 m) water samples were collected weekly from each pool. Chemical analyses were performed on unfiltered water unless otherwise stated. Total phosphorus concentrations were determined by the procedures of Murphy and Riley (1962) with a persulfate digestion (Menzel and Corwin 1965). Total nitrogen concentrations were determined by using a modified Kjeldahl technique described by Nelson and Sommers (1975). An Orion Model 601A pH meter was used to measure pH. Specific conductance was measured with a Yellow Springs Instrument Company Model 31 conductivity bridge. Total alkalinity was determined by titration with 0.02 N sulfuric acid (A.P.H.A. 1976). Color determination was by the platinum-cobalt method and Nessler tubes (A.P.H.A. 1976) on water filtered through a Gelman type A-E glass fiber filter. Chlorophyll *a* concentrations were determined spectrophotometrically (A.P.H.A. 1976) and calculated by the equations in Lind (1974).

Periphyton communities were estimated by two methods: (1) growth on artificial substrate (glass slides) for 2-week intervals, and (2) standing crop washed directly from vegetation. Algae growing on macrophytes will be referred to as "epiphytes" and the more general term "periphyton" will be applied to algae on any substrate (Wetzel 1975). Glass slide samplers (Wildco, Saginaw, MI)[4] consisted of 8 standard microscope slides suspended at the water surface. Two samplers were maintained in each pool to be analyzed at overlapping 2-week intervals. Upon recovery, a pair of slides (3 replicates) was placed in 90% acetone with 1 g $MgCO_3$ as a buffer, sonicated for 1 min (80% power on a Fisher Sonic Dismembrator, Model 300), and incubated in a freezer overnight. Chlorophyll *a* concentrations were then determined spectrophotometrically as for phytoplankton. Resulting data were then expressed as mg chlorophyll a/m^2 of glass slide surface.

The second measure of periphyton abundance involved direct washing of hydrilla to remove as much epiphytic algae as possible. In a modification of the washing techniques of Gough and Woelkerling (1976), and Moss (1981), approximately six 10 cm apical lengths of hydrilla were placed in a flask and vigorously shaken, for 1 min, in 100 ml of distilled water. Epiphyte laden water was strained through cheesecloth to remove macrophyte debris. Eight successive agitation and decantation cycles were performed per sample. Chlorophyll *a* concentration of wash water was determined as for phytoplankton. The washed plant material was dried and weighed. Resulting data were then expressed as mg chlorophyll *a*/ gram dry weight of macrophyte. One sample per pool was collected on each sampling date before treatment. After treatment two samples per pool were taken.

Pools were divided into quarters by a string grid to estimate the percentage of water volume occupied by hydrilla. Visual estimates of percent horizontal and vertical cover were made, and relative hydrilla volume calculated, for each quarter. A mean value was then computed for each pool.

Pools H1 and H2 were treated on July 24 with 6,7-dihydrodipyrido pyrazinediium dibromide (Diquat)[4] in combination with copper-ethanolamine complexes (Cutrine)[4] at rates of 2.25 kg/ha and 4.49 kg/ha respectively.

In addition to regular sampling, phytoplankton and epiphyte chlorophyll *a* were sampled on 28 July, 4 days after treatment, in order to detect any short term treatment effects.

Because of large variability among pools, data were coded for analysis as change from pre-treatment values. The pre-treatment mean (3 weeks) for a given variable within a pool was subtracted from subsequent values. In order to more clearly explain system responses to herbicide application, differences among pool means, as well as differences between treatment means, were tested. Duncan's multiple range test was performed to determine significant differences among pool chlorophyll *a* means. Analysis of variance was performed to detect differences between treatment chlorophyll *a* means. Standard t tests were calculated to determine differences between treatment means for water chemistry parameters. All statistics were performed using the Statistical Analysis System (SAS Institute, Inc.) and computing facilities of the Northeast Regional Data Center (University of Florida).

RESULTS AND DISCUSSION

As indicated in Table 1, the herbicide application of 24 July was effective in controlling hydrilla in the pools. Control was more complete in pool H1 than in pool H2. Though pools were not flushed, and no additional water

[4]Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the University of Florida and does not imply its approval to the exclusion of other products that also may be suitable.

TABLE 1. PERCENT OF POOL VOLUME OCCUPIED BY HYDRILLA.

Date	Control C1	Control C2	Herbicide H1	Herbicide H2
	Before treatment			
July 9	65	42	57	52
July 14	58	42	56	64
July 21	48	66	51	80
	After treatment			
July 28	47	64	61[a]	85[a]
July 31	58	73	54[a]	82[a]
August 4	59	73	22[a]	60[a]
August 11	56	77	0	42[b]
August 18	49	65	0.3	15
August 25	70	72	1.5	29
September 1	59	81	8	30

[a]dead
[b]visibly decomposing

was added, regrowth of hydrilla had begun by 18 August in both pools.

The herbicide treatment mean for phytoplankton chlorophyll *a* was significantly higher than control on 11 August. A second significant phytoplankton peak occurred on 1 September (Figure 1). Phytoplankton chlorophyll *a* was quite variable among pools. Pool means were often significantly different within treatments. Therefore, from 11 August to 25 August, pool means for one or both treated pools were significantly higher than for other pools, but treatment means were not significantly different (Figure 1).

Large increases in epiphyte chlorophyll *a* washed from hydrilla occurred following herbicide treatment (Figure 2). Treatment means were significantly different on 31 July and 4 August. Treated pools returned to control levels 3 weeks following treatment, when hydrilla regrowth was also observed. Pool H1, however, had slightly higher mean values than control pools on the last two sampling dates, 18 August and 25 August.

Periphyton chlorophyll *a* collected on glass slides increased in the herbicide treated pools in a pattern similar to that observed for epiphyte chlorophyll *a* (Figure 3). Glass slide periphyton values were a measure of periphyton productivity over the preceeding 2 weeks. Periphyton chlorophyll *a* in both herbicide treated pools had thus returned to control levels 5 weeks after treatment, 2 weeks later than wash chlorophyll *a*. Treatment means were significantly different on 4 August. However, large differences in pool means within the herbicide treatment occurred. Therefore, though dramatic periphyton peaks were observed in pool H1 relative to all other pools on 11 August and 18 August, treatment means were not significantly different on these dates (Figure 3).

The rapid decline of attached algae was most likely due to the deterioration of its host substrate. By 11 August there was no hydrilla in pool H1, and the hydrilla in pool H2 was in a state of advanced disintegration (Table 1). In addition, the decomposition of hydrilla in these small enclosed experimental units led to a significant darkening of the water, and it is possible that reduction in light penetration may have slowed algal growth. Decreased competition from attached algae may thus account for the phytoplankton peak of 1 September.

Treatment means for total alkalinity, specific conductance, turbidity, color, hydrogen ion concentration, and total nitrogen (TN) were significantly higher for the herbicide treatment relative to control, as might be expected for small, enclosed systems. There was no significant difference between treatment means for total phosphorus (TP). However, the TN/TP ratio in all pools was consistently lower than 10 for all sampling dates except the last (25 August), implying nitrogen limitation (Schindler 1975). Therefore, higher TN in herbicide treated pools may explain the observed increases in planktonic and attached algae (Table 2).

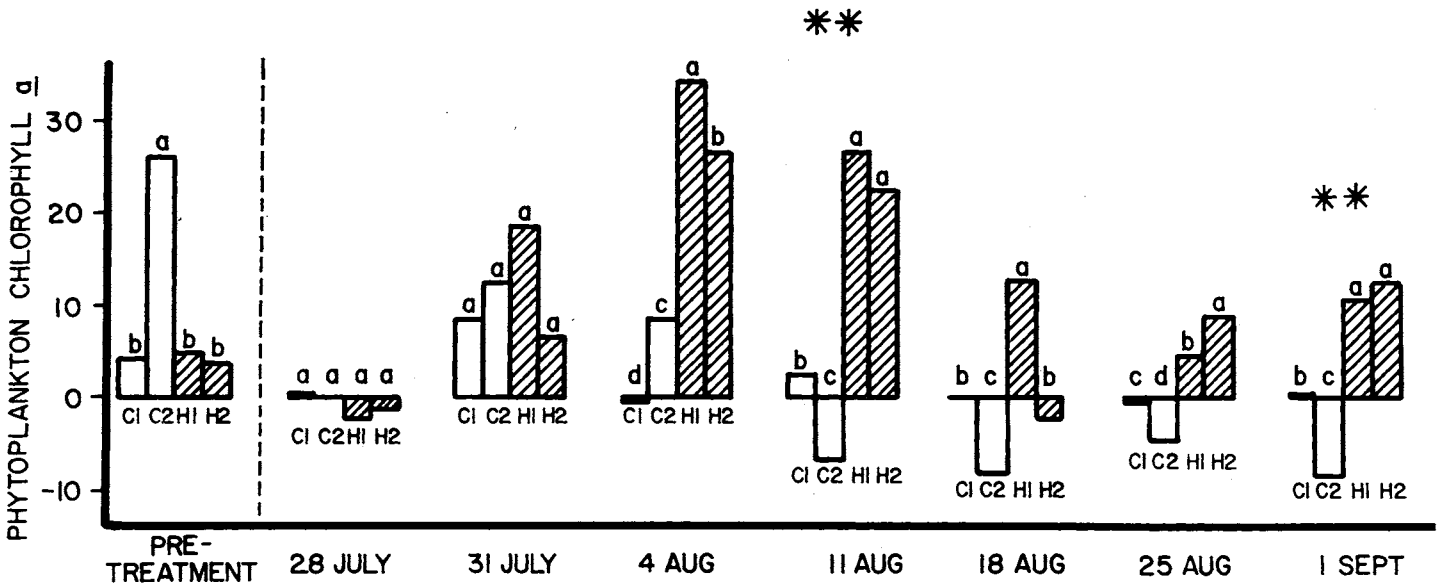

Figure 1. Phytoplankton chlorophyll *a* (mg/m³). Pretreatment mean (N=3), and subsequent mean change (N=2) from pre-treatment mean, for each pool. Broken line indicates treatment date. On a given date, pool means with the same letter are not significantly different (alpha level= 0.05). Dates on which treatment means were significantly different denoted by asterisks (*significant at the 0.05 level, **significant at the 0.01 level). Control treatment □, herbicide treatment ////////.

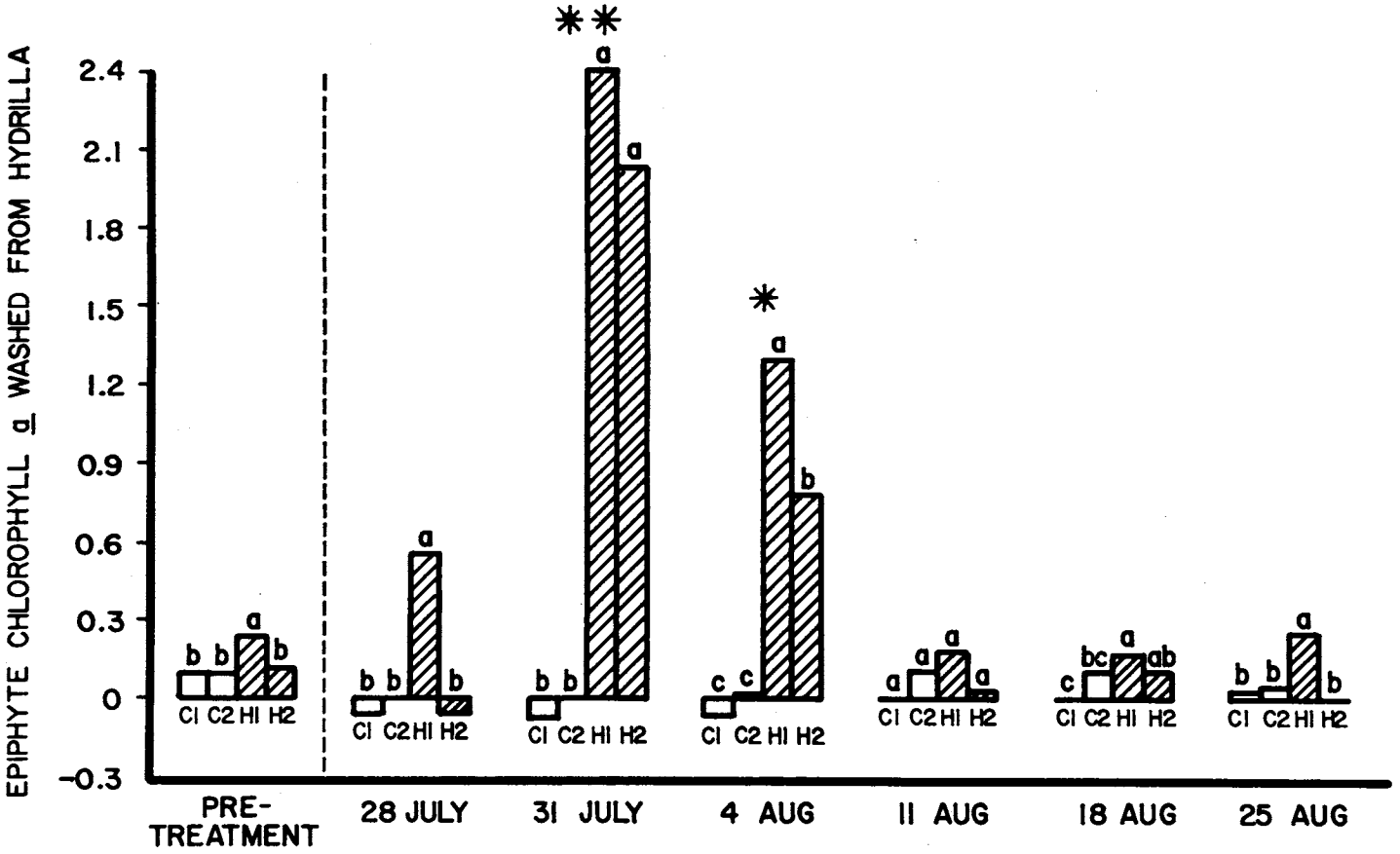

Figure 2. Epiphyte chlorophyll *a* washed from hydrilla (mg/g dry weight hydrilla). Pre-treatment mean (N=3), and subsequent mean change (N=2) from pre-treatment mean, for each pool. Data presentation as in Figure 1.

TABLE 2. TOTAL NITROGEN (MG/M³) IN POOLS.

Date	Pool C1	C2	H1	H2
	Pre-treatment			
July 21	1562	1555	1450	1283
	Change from pre-treatment values			
July 28*	15	-353	653	728
August 11**	-14	56	621	551
August 18*	-127	-84	328	258
August 25**	-168	-195	363	411

Dates on which treatment means were significantly different denoted by asterisks (*significant at 0.05 level, **significant at 0.01 level).

Thus, following herbicide treatment of hydrilla, increases in periphyton, epiphyte, and phytoplankton biomass occurred, presumably caused by nitrogen released from decomposing vegetation. However, periphyton and epiphyte peaks were short lived, ending as hydrilla regrowth began.

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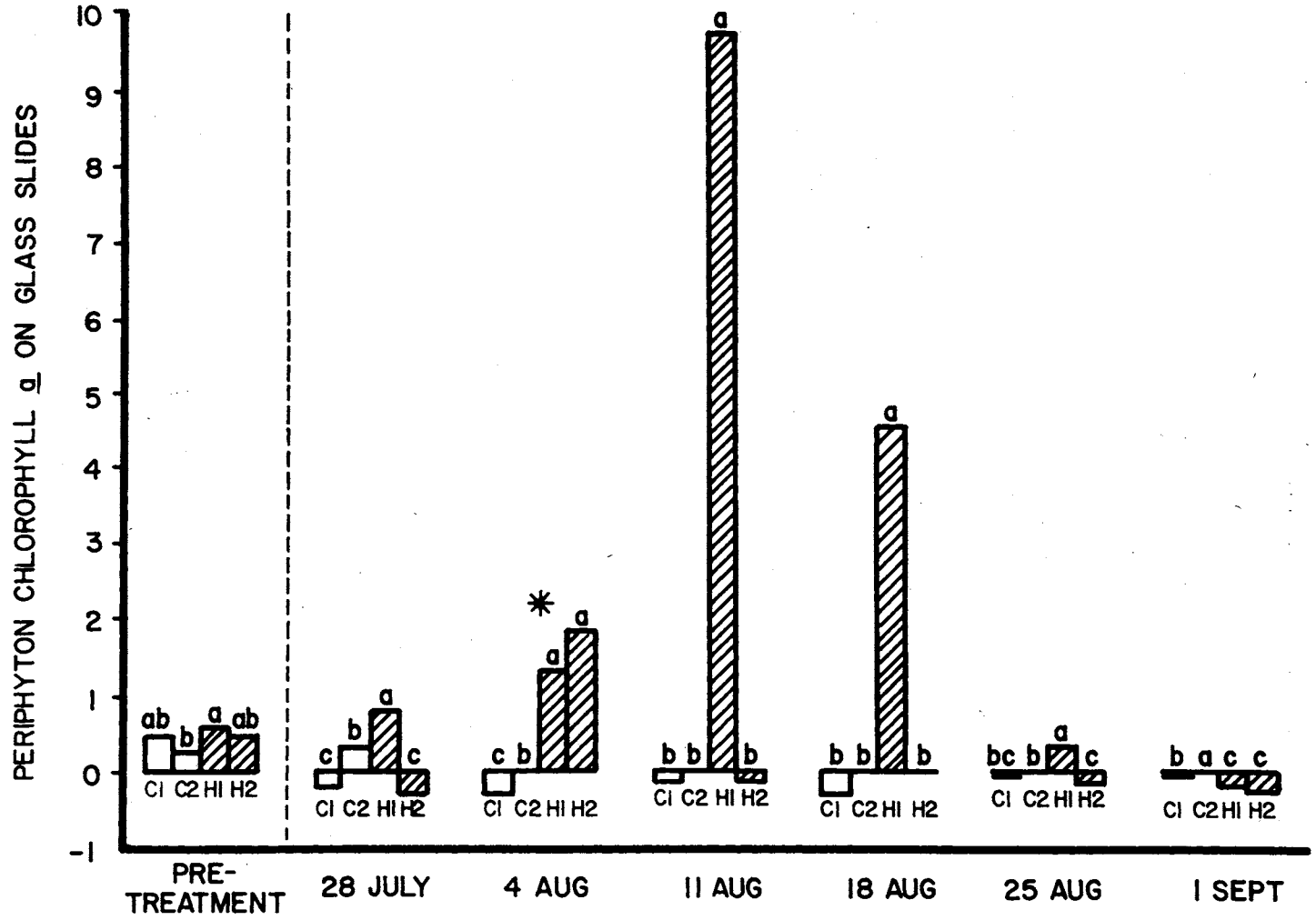

Figure 3. Periphyton chlorophyll *a* on glass slides (mg/m²). Pre-treatment mean (N=3), and subsequent mean change (N=3) from pre-treatment mean, for each pool. Data presentation as in Figure 1.