THE EFFECTS OF THE EXCLUSION OF MUDMINNOWS ON THE INSECT AND ALGAE POPULATIONS IN A FRESHWATER LAKE

BIOS 569 - Practicum in Aquatic Biology

Maureen M. Busher
325 Walsh Hall
Jeff Runde, Advisor
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ABSTRACT

The effects of the exclusion of mudminnows on the periphyton present in Bog Pot Lake, via an indirect manipulation of the grazing insect population, was examined over a six week sampling period. Algal biomass and chlorophyll a production were quantified and subjected to an analysis of variance between treatment (mudminnows absent) and control (mudminnows present) sites, and over the duration of the experiment. Only the results from biomass vs. time were found to be significant (P=.008). Desmids and diatoms were identified at each site, while the predominant herbivores present were caddisfly larvae. Only three replicates were used for each type of environment; in the future, more duplication would probably ensure more confident results.

INTRODUCTION

Top -down forces can have significant control over trophic interactions in aquatic environments. In any one community, the presence or absence of higher trophic levels can determine the extent of growth of lower ones. These levels, which consist of predators, primary consumers, and plants, exhibit delicate patterns of interaction that determine the success of an entire ecosystem. The relationship that predators have with their environment is such that they can restructure the entire food web of which they are a part (Barnes and Mann 1991). By putting strain on the feeding habits and other behaviors of their prey, such as colonization of particular habitats, predators can greatly alter the impact their prey has on other organisms (Power et al. 1985).

This project is designed to test the hypothesis that if the predators in an environment are removed, the population of primary consumers will increase, and subsequently cause a decline in the abundance of plants in the community. The relationship between mudminnows, grazing insects, and algae in Bog Pot Lake at the University of Notre Dame's Environmental Research Center will be assessed. Mudminnows are small fish that characteristically inhabit small bog lakes and shallow muddy ponds. They are bottom feeders with a diet consisting primarily of insects (Becker 1983). These fish will be excluded from three experimental sites by means of a wire enclosure. The effects of the grazing population of insects which remain will then be determined. Through this indirect manipulation of the insect population, alterations in the amount of periphyton present should be observed.

MATERIALS AND METHODS

Experimental Design

This study was conducted at the University of Notre Dame Environmental Research Center, located in Gogebic County, Michigan (Fig 1). The experiment was set up along the western perimeter of Bog Pot Lake, a relatively shallow body of water with grassy shorelines (Fig. 2). Six sites were constructed, three of which were designated as treatment sites from which mudminnows would be excluded. Each site consisted of an 18in x 24in wire mesh support upon which six 15cm x 15cm unglazed clay tiles were placed (Fig. 3). The wire foundation was secured to metal stakes so that the clay tiles were approximately 1 inch off of the bottom of the lake. Due to variations in the depth of the water along the shoreline, each set of tiles was at a different distance from the surface of the water.

The clay tiles were put into Bog Pot on June 3, 1997. The exclusions placed around the three treatment sites were put into the lake on June 5, 1997. Chicken wire (0.5in x 0.5in sq. holes) was formed into rectangular boxes approximately two feet high and then placed around the wire support for the tiles (Fig. 4). The exclusions were set three inches deep into the sediment on the bottom of the lake.

Sampling Procedures and Analytical Methods

Sampling of the tiles began on June 7, 1997, and continued at one week intervals for six weeks. Sampling was conducted as in Lamberti et al. 1989. A known surface area of each tile was scraped with a razor blade to remove any sediment and algae present. After microscopic observation of each sample for the types of organisms and algae present, they were divided into two equal portions to determine biomass and chlorophyll a content. Biomass was found by vacuum filtration of the sample onto glass fiber filter paper of diameter 4.5cm. Chlorophyll a content was determined using Lorenzen's monochromatic method (Wetzel and Likens 1991). After filtering the sample in the same way used to find biomass, the filters were put into film canisters with 25ml of 90% acetone to extract the pigments present. The canisters were placed in a freezer for 20-24 hours. Before analysis, the canisters were removed from the freezer and allowed to warm to room temperature.

Chlorophyll a analysis was conducted in the dark using a HACH DR/2000 Direct Reading Spectrophotometer. Readings were taken at 750nm and 664nm, and then at 750nm and 665nm after adding 6 drops of 3M HCl to each sample. The latter readings were done to account for the presence of phaeophytin. Chlorophyll a content was determined using the following equation:

$$\text{Chl a (ug chl a /g algae)} = [kf\,(E_{665b}-E_{665a})V/A\cdot Z][A/\text{biomass}]$$

Where:

E_{665b} = turbidity-corrected absorbance at 664nm before acidification (E_{664b}-E_{750b})
E_{665a} = turbidity-corrected absorbance at 665nm after acidification (E_{665a}-E_{750a})
k = absorption coefficient of chl a (=11.0)
f = factor used to equate the reduction in absorbancy to initial chl a conc. (=2.43)
V = volume of acetone added
A =surface area sampled
Z = length of light path through cell in cm
biomass: determined using other half of sample

An analysis of variance was run for results for both biomass and chlorophyll a.

Supplemental variables including pH, dissolved 0_2 content, temperature, light, and conductivity were monitored throughout the experiment. Water chemistry analysis for PO_4, NO_3, and NH_3 was also done each week using the HACH spectrophotometer and supplemental methods. Sampling was concluded on July 11, 1997.

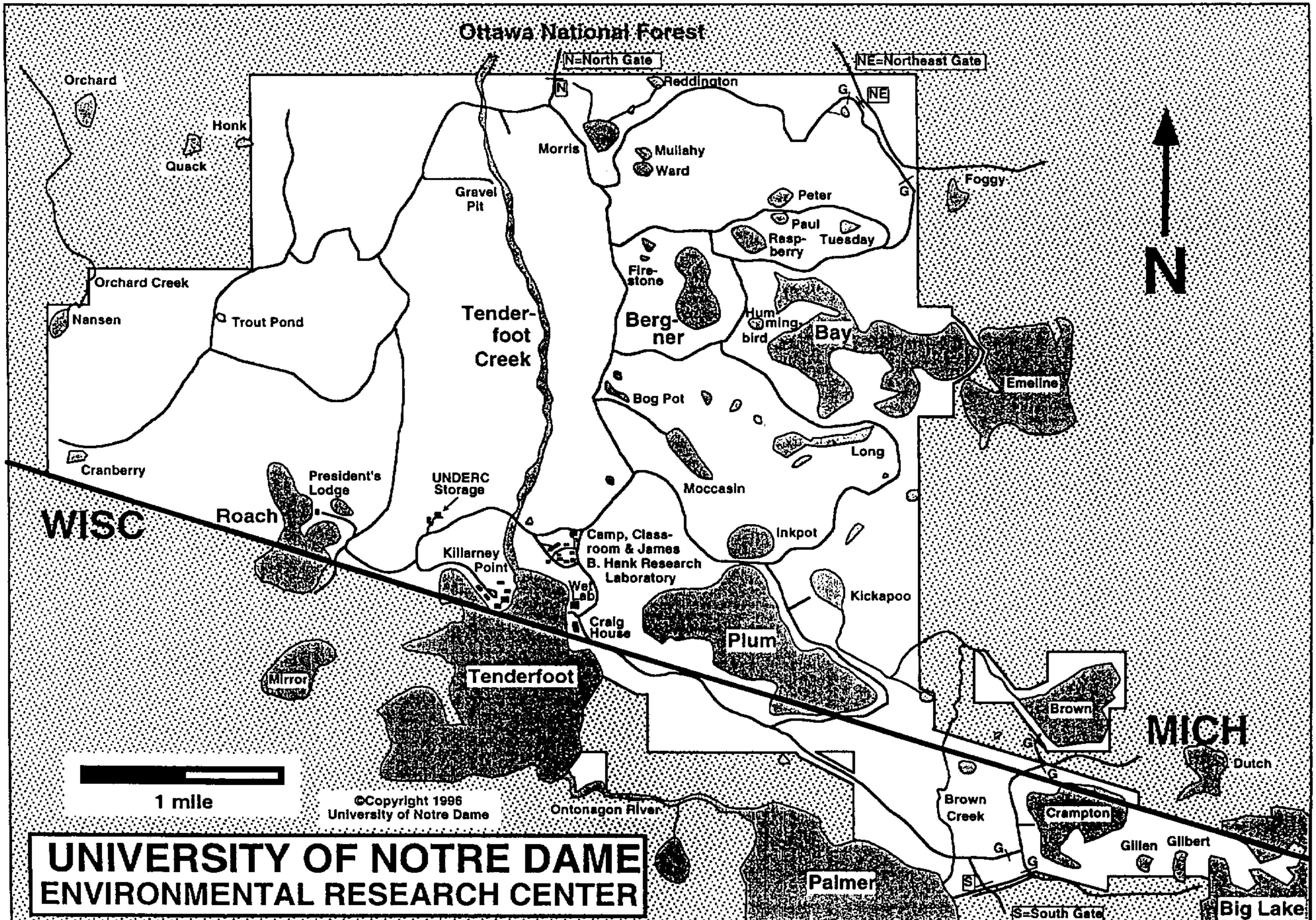


Fig.1. Layout of the University of Notre Dame Environmental Research Center.

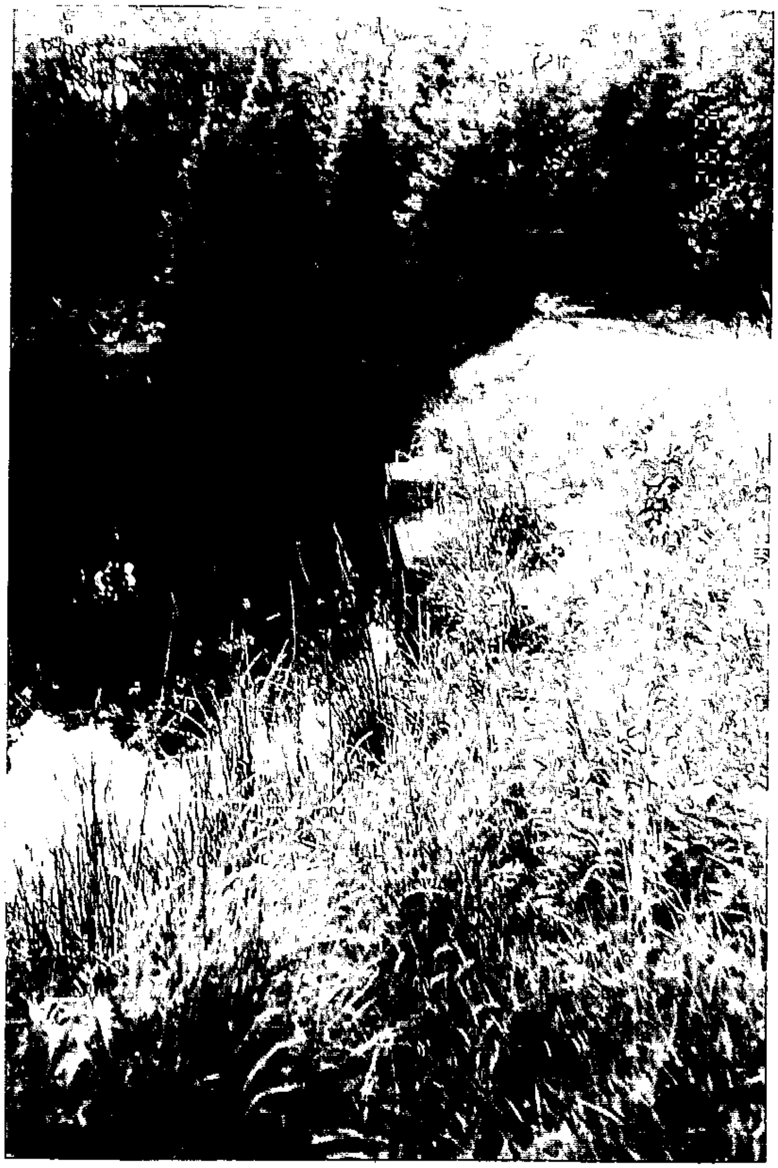


Fig.2. Western perimeter of Bog Pot Lake where experimental sites were set up.

Fig.3. Control Site: Six 15cm by 15cm tiles were placed adjacent to one another on a wire mesh foundation. The tiles sat ~1 inch off the bottom of the lake.

Fig.4. Treatment site: Clay tiles with enclosure surrounding wire foundation. Mudminnows were prohibited from swimming into the enclosed area.

RESULTS

Algal and Insect Communities

The algal populations that colonized the tiles were either desmids (Phylum Chlorophyta) or diatoms (Phylum Chrysophyta). Algae were identified to genus using Prescott's Algae of the Western Great Lakes Area (1951). The majority of the algae were clearly desmids, including *Micrasterias* sp., *Pleurotaenium* sp., and *Cosmarium* sp. The diatoms identified were either *Anomoeoneis* sp. or *Frustulia* sp. The type of algae present did not vary from site to site.

The predominant type of insect found in each sample was caddisfly larvae. These larvae were in a very immature stage, none of which had yet begun to build cases, and were therefore unable to be identified. Other insects present included midge larvae (Family Chironomidae), water boatmen (Family Corixidae), and water striders (Family Gerridae), the latter two being found only on the surface of the water in the vicinity of the tiles. Insects were classified using Hilsenhoff's Aquatic Insects of Wisconsin (1975).

A noticeable population of zooplankton appeared in the samples each week. Those present included copepods and *Daphnia* sp., as well as two other species that could not be identified (Thorp and Covich 1991). The zooplankton, along with the caddisfly and midge larvae are all herbivores.

Periphyton Abundance

Biomass. An overall increase in algal biomass occurred for both the treatment and control sites between the initial and final sampling date (Fig. 5). However, from 6/7 to 6/14 (treatments and controls) and from 7/4 to 7/11 (controls only), a slight drop in biomass was found. Biomass was compared from one sampling date to the next (P=.008) and between the treatment and control sites (P=.113). While a difference in algal biomass was detected over the duration of the sampling period, there was no significant difference in accumulation of biomass between the treatment and control sites.

Chlorophyll a . Chlorophyll a abundance initially increased between the first and second analyses; however, the values for both the treatment and control sites declined in the last sampling period (Fig. 6). This is most likely reflective of algal senescence, which Lamberti et al. (1987) found to occur after ~32 days. Chlorophyll a abundance was compared over time (P=.105) and between the treatment and control sites (P=.151). There was no significant difference in chlorophyll a for either of these analyses.

Physical Parameters

Measurements at the exclusion sites for light, pH, dissolved O_2, and conductivity followed the same patterns for these values at the control sites (Fig. 7 A-D). Due to faulty equipment at one point or another during the experiment, the readings for pH, O_2, and conductivity should not be considered reliable. Only the light readings showed any fluctuation from site to site. This is most likely due to the various depths from the surface at which the tiles in each site were placed. However, the depths only ranged from 13.9cm-33.1cm, which does not seem to be a significant enough difference to have an impact on the results.

The levels of NO_3, PO_4, and NH_3 present in the water on each sampling date are presented in Figure 8. The values suggest nothing unusual about the chemical environment at each site.

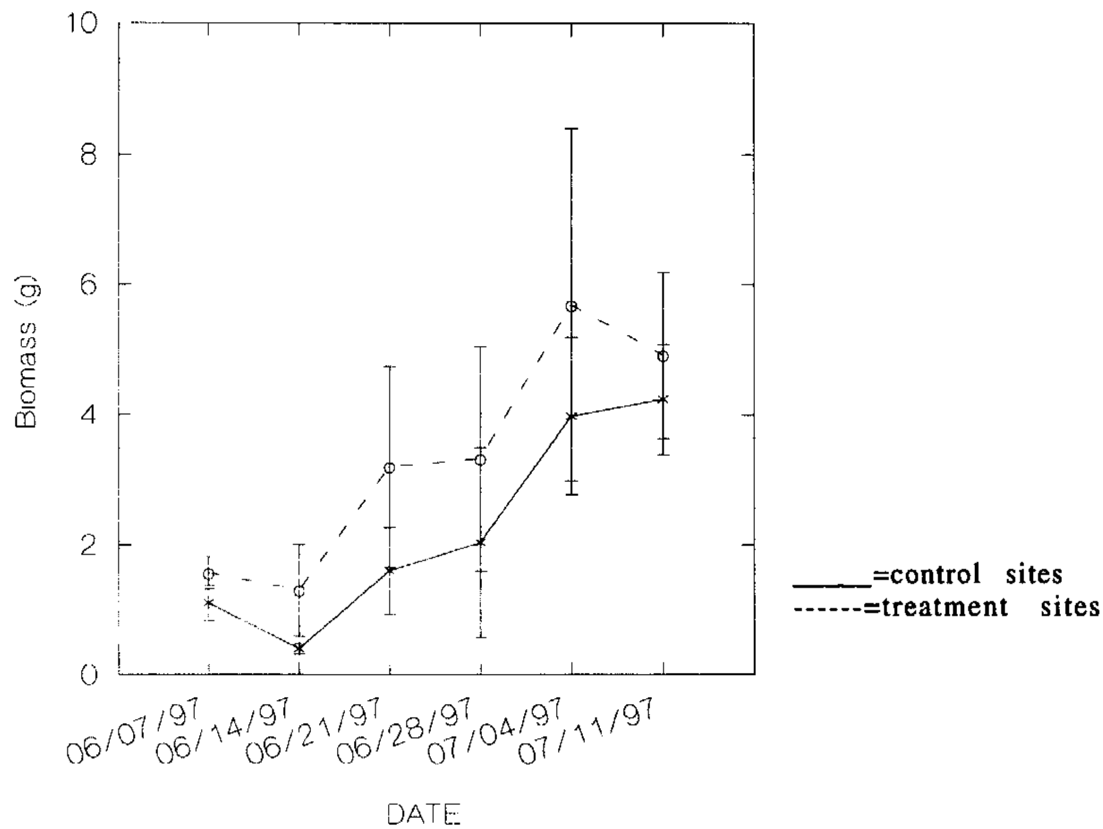
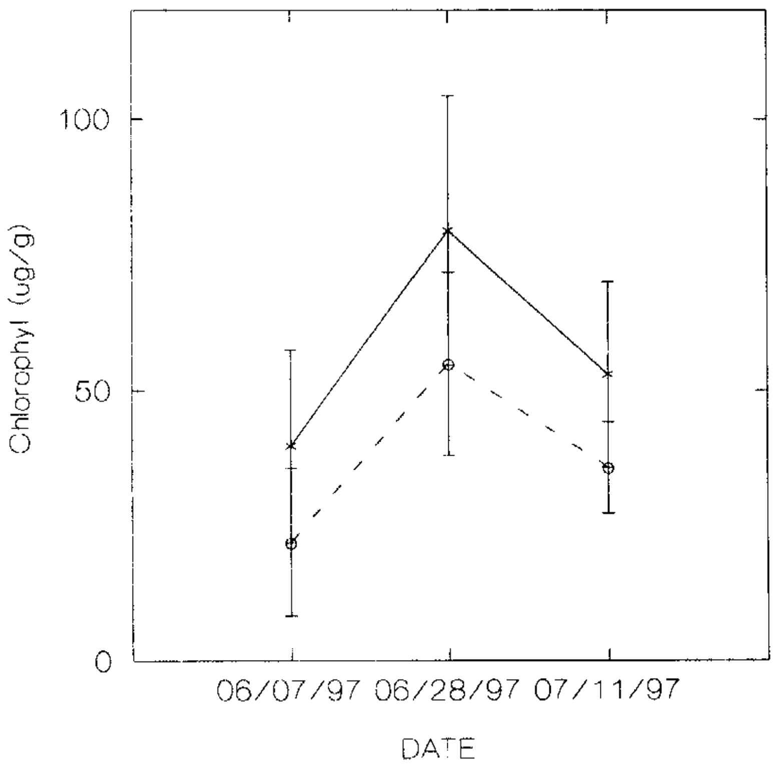


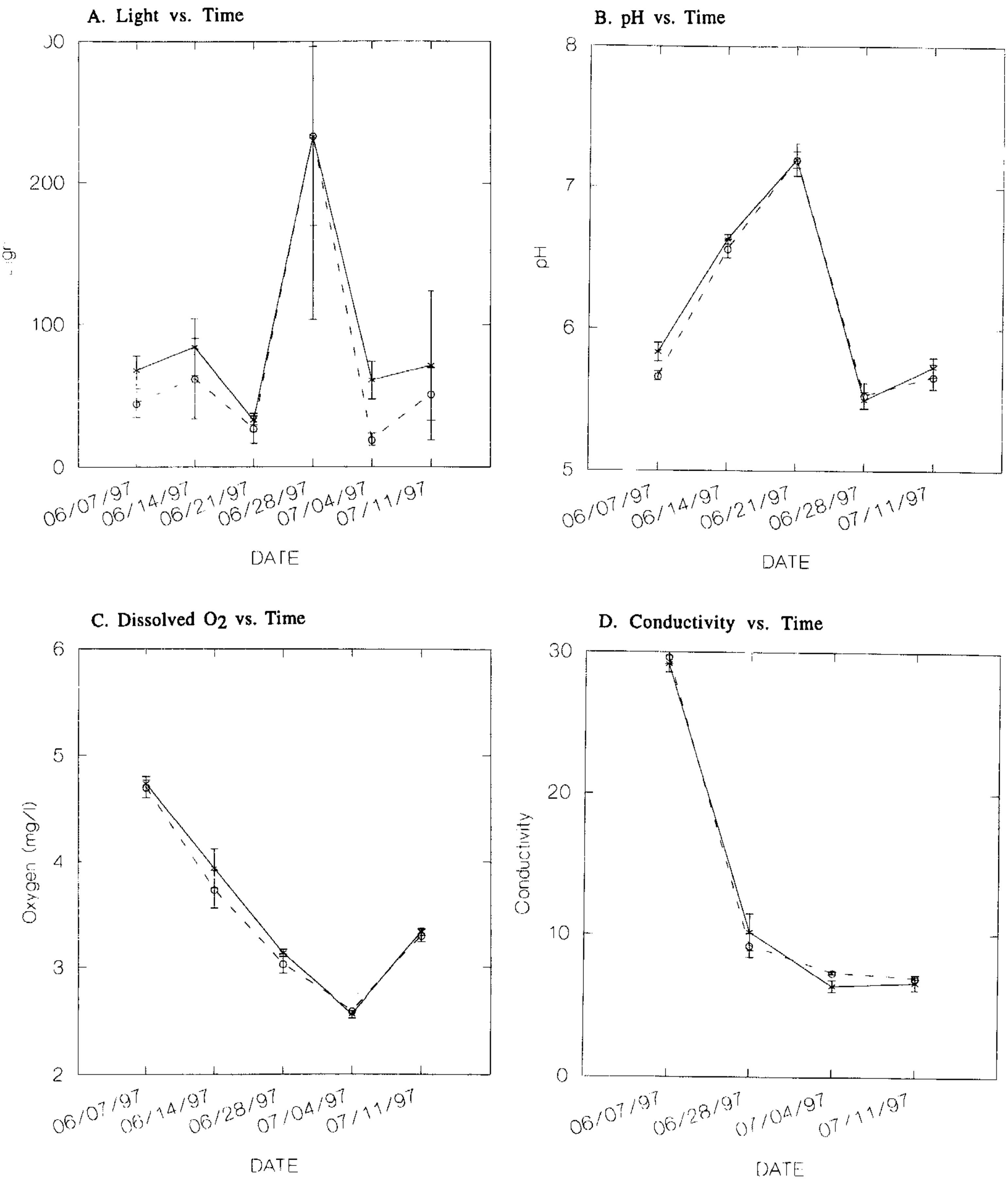
Fig.5. **Biomass vs. Time. A comparison of biomass between treatment and control sites was not found to be significant (P=.113), while biomass accumulation over the duration of the experiment was (P=.008).**



_____=control sites
------=treatment sites

Fig.6. Chlorophyll a vs. Time. Neither a comparison of chlorophyll a between sites (P=.151) or over time (P=.105) were found to be significant.

Fig.7.



_____=control sites
------=treatment sites

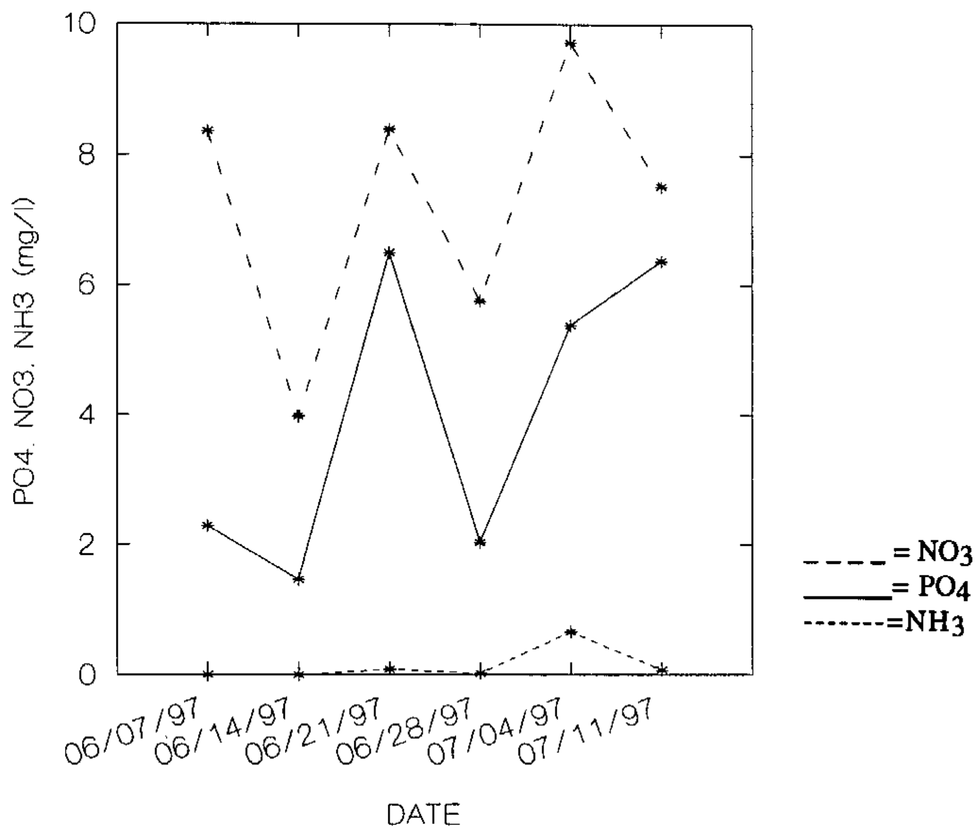


Fig.8. **Water chemistry analysis of samples during each week.**

DISCUSSION

It was predicted that removal of the population of mudminnows from an enclosed aquatic environment would cause an increase in the number of grazing insects present; due to this increase in herbivores, a decline in the amount of periphyton at the exclusion sites should have been seen. Unfortunately, statistical analysis of the results obtained from this study did not lend support to this theory. The amounts of algal biomass and chlorophyll a present at each site did not differ from one another, regardless of whether mudminnows were present or not.

A previous study by Lamberti and Resh (1983) found that in communities where grazing by invertebrates was allowed to occur uninhibited, less algae colonized the substrate in the environment. Lamberti et al. (1987 and 1989) have also reported an inverse relationship between algal biomass and chlorophyll a production, where greater biomass corresponded to lower chlorophyll a values, and vice versa. Both of these findings were expected to be duplicated in this experiment. The most likely reason this did not occur is due to the number of replicates used for this study. A larger number of sites along the perimeter of the lake would have reduced the element of error in the analyses, giving more weight to the results. The large caddisfly population present in the exclusion sites should have had some effect on the reduction of algal communities, as Lamberti et al. (1992) have previously proven. However, after sampling period number two (6/14/97), a large number of tadpoles became noticeable at both the exclusion and control sites. Since tadpoles also rely on algae as a main component of their diet (Lamberti et al. 1992), their presence made it impossible to measure the effects of insects alone on algal growth.

The patterns of interaction between organisms in different trophic levels, in various aquatic environments, are important to the stability of that community. While this experiment was unable to define a sturdy relationship between the mudminnows, insects, and algae studied in Bog Pot, others may be more successful in the future.

ACKNOWLEDGMENTS

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