

Effects of *Physa integra* and *Orconectes propinqu^us*
on periphyton biomass, community structure, and chlorophyll A
production in a stream environment

BIOS 569- Practicum in Aquatic Biology

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1997

ABSTRACT

Changes in biomass and chlorophyll A production in algal communities were studied to determine the effects of herbivory on periphyton. The crayfish *Orconectes propinquis* and the snail *Physa integra* were housed in 12 experimental streams over a 35 day period. In comparison to the control streams, the biomass was lowest in the streams containing *Orconectes* only and those containing both *Orconectes* and *Physa*. The herbivores successfully grazed the chlorophyta in these communities, resulting in a population composed almost entirely of *bacillariophytes*. The highest biomass was observed in the control streams followed closely by those housing only *Physa* where the algal assemblage was dominated by *chlorophyta*. However, on average, chlorophyll A production in the streams with both herbivores and *Orconectes* only was higher than the other two treatments in spite of lower biomass. The experimental environments in which Chlorophyll A production was the highest are those dominated by the diatoms (*bacillariophyta*) as opposed to the larger filamentous *chlorophyta* which dominated the other streams.

algae are their ability to indicate water quality. (Hauer and Lamberti, 1996)

The Herbivores

The two herbivores used in this study are abundant in streams throughout Northern Wisconsin and Michigan. The varying morphological adaptations used by each to obtain food were expected to result in taxonomic differences among the algal populations. The snail, *Physa integra*, functions as a scraper. The radula is covered with many rows of small uniform teeth that scrapes the smaller algal species into the buccal mass. (Morton, 1960) In contrast, the crayfish, *Orconectes propinquus*, functions as a collector-gatherer. Locating food involves chemoreceptors on the underside of the antennules. While in search of food the surface is constantly probed by the chelate walking legs. The larger pincers possess rows of teeth specialized for food collection. These pincers act as a sort of sickle or blade as the crayfish senses food in its environment. (Holdich and Lowery, 1988)

The physa were collected from rocks in Tenderfoot Creek. The orconectes used were gathered from traps in shallow waters of Tenderfoot Lake which is connected to the creek where the experimental streams were located.

MATERIALS AND METHODS

Experimental Streams

Artificial streams were built to study the trophic interactions between the crayfish *Orconectes propinquus*, the snail *Physa integra*, and periphyton within a stream environment.

12 streams were constructed from plastic gutter one meter in length. The base of the gutter was three inches in width increasing to five inches at the top. The bottom of the gutter was lined with 12 square clay tiles which were also three inches in width. The ends of the gutter were secured with one/eighth inch wire mesh attached with fishing wire at each end. The entire length of the gutter was covered with a wire mesh top secured on one side so that the inside of the gutters could be easily accessed. This would ensure that only the organisms placed within an experimental stream would influence the algal growth. A strip of the wire mesh was also placed beneath the tiles, which were equally spaced throughout the length of the gutter, to provide traction for the crayfish. Bricks attached with twine through holes drilled in the bottom of the gutter secured the streams in the creek. The gutter was adjusted daily so that approximately three/fourths inch of the gutter was raised above the water level. One-half inch wire mesh was placed in front of the streams to obstruct sediment and other debris floating downstream. Each day the ends of each gutter were cleaned with a toothbrush to remove the organic build-up slowing the velocity of the water flow within the experimental streams. The inside walls of the gutters were also scrubbed to prevent algal growth anywhere within the streams except on the clay tiles.

The streams were all placed within two feet of the shore of Tenderfoot Creek located on the University of Notre Dame Environmental Research Center (UNDERC) property. (Gogebic Co., MI.) so that the velocity of the stream was not too great to impair the movement of the

crayfish within the stream. All were partially obstructed from direct sunlight by the riparian canopy. However, the variation among light reaching the individual gutters could have skewed results by affecting periphyton growth. Three gutters were designated for each of the following categories: control- no snails or crayfish, snails only, crayfish only, and both crayfish and snails. Natural densities of the individual species within the stream environment were established by sampling sites of known area. According to these values, one crayfish and three snails were placed in each of the respective gutters. To secure the gutters containing crayfish rocks were placed on the ends of the gutters to prevent escape. Multiple times during the course of the experiment the crayfish did escape and were replaced with another *Orconectes propinquus* of approximately equal size.

Algal Sampling Methods

The clay tiles were placed in the stream approximately 21 days before they were placed in the gutters. Every seven days two tiles were removed from each gutter, one tile for biomass and the other for chlorophyll A production. Biomass was calculated by scraping the organic material accumulated on the tiles off and filtering. The filters were dried completely and then weighed. To determine Chlorophyll A production, the same procedure for removal of the algae from the tiles was followed. The filters were placed in canisters preventing light from entering and degrading the chlorophyll. 25 ml. of 90% acetone was added to the canisters and placed in a freezer for approx. 24 hours during which time the chlorophyll A was extracted from the algae into solution. A spectrophotometer was used to read the values at both 665 and 750 nanometers according the procedure documented in Lorenzen (1967) The following equation was used to calculate the chlorophyll A values from the absorbance values.

$$\text{Chlorophyll a (micrograms/gram)} = \frac{(K)(F)(E_{i665} - E_{f665})(V)}{(A)(Z)}$$

E_{i665} = absorbtion at 665nm before acidification

= A_{665i} - A_{750f}, where A = absorbtion value (nm)

E_{f665} = absorbtion at 665 nm before acidification after acidification

= A_{665i} - A_{750f}

k = absorbtion coefficient of chlorophyll a = 11

F = factor to equate the reduction in absorbancy to initial chlorophyll concentration. = 2.43

R = maximum value ratio of E_{i665} : E_{f665} in the absence of phaeopigments = 1.7

V = volume of extract in mls. = 25

Z = length of light path through cuvette or cell in cm.

RESULTS

Response in Algal Biomass

The various treatment environments in the artificial streams produced a response in algal growth. ($p=.001$) The control streams with neither of the grazers consistently maintained the highest algal biomass.(figure 1) Each week showed an increase in biomass relative to the first sampling date. A decrease in biomass from day 28 to day 35 of tile colonization could be attributed to senescence in the periphyton population. (Lamberti, 1987) There was a consistent increase in biomass throughout the duration of the experiment. While biomass increased throughout the experiment for those streams housing *Orconectes* only, the overall increase was less than both that of *Physa* only and control streams. The tiles exposed to grazing by both herbivores merely maintained a static population of algae. (figure 1)

Overall, the control and *Physa* only treatments maintained a significantly higher biomass of algae than the biomass in the *Orconectes* only and *Physa* and *Orconectes* experimental streams. The average biomass throughout the duration of the experiment for the control streams was .188 g/3cm² while the streams containing *Physa* only grew the second highest amount of algae with an average of .099g/cm². The *Orconectes* only streams produced a mean amount of .046 g/3cm² while even less biomass, .022 was present on the tiles with both grazers. There was a significant difference in the biomass between the both and *Orconectes* only treatments (Tukey Post Hoc=.0005). Significance was also seen between the crayfish only and the control treatments.(Tukey Post Hoc=.003)

Response in Community Structure

The response in biomass can best be explained by the grazers' effect on the species present in the varying treatment streams. The control streams were unaltered by herbivory and the tiles were dominated by *Ulothrix* and *Mougeotia* both of which are filamentous chlorophytes. These bulky chlorophytes are responsible for the maximum biomass seen in the control streams. Relatively high biomass was also seen in the treatments inhabited solely by *Physa*. When the chlorophyta in the streams containing both crayfish and *Physa* and crayfish alone was heavily grazed, the bacillariophytes dominated the periphyton population. The majority of the species *Fragilaria*, *Epithemia*, *Eunotia*, and *Tabellaria*.

Response in chlorophyll A production

The grazers present in the treatment streams had an effect in the the algal chlorophyll A production. While this data is not significant, the streams containing both grazers and those with *Orconectes* only produced on average the highest levels of Chl A.(figure 2) Over the duration of the study, the experimental streams containing both grazers had a chlorophyll A concentration of 2994.12 µg/L in comparison with the stream consisting solely of *Orconectes* with an average value of 2458.435 g/l. It was in these streams that diatoms dominated the algal population. The control streams and those with snails only had an overall lower chlorophyll A production. (figure 2) In the control streams chlorophyll A production averaged 358.81 g/L while the streams with *Physa* only produced an average concentration of 526.44 g/L. This data is in contrast with that of the biomass assay where the higher biomass, previously assumed more productive, tiles were those in the control and

Physa only streams. A negative correlation seems to exist between the amount of biomass and the concentration of chlorophyll A present in a sample algal population.

DISCUSSION

Response in Algal Biomass

The data indicates that the *Orconectes* are a more successful grazer than the *Physa*. In both treatments where the crayfish were present, the data was significantly different from the control streams. From the qualitative observations of the tiles, those from the streams with snails only appeared to have an approximately equal amount of biomass as the control streams while visibly contrasting with the heavily grazed crayfish containing streams. It would also be expected from these results that the crayfish containing streams would be significantly different from the streams containing *Physa* only. These differences are rooted in the morphological differences between the two organisms. The blade-like appendages of the crayfish removed a greater amount of algae from the tiles than the radula of the snails. The larger size of the crayfish most likely increased the amount of algae that was uprooted and washed off of the tiles.

A variability in the raw data explains this aberration from the expected results. This variability could have been eliminated by increasing the number of replicates. Another source of error is the fluctuating sunlight reaching the streams due to the varying riparian canopy that covered the region of the Tenderfoot Creek where the experimental streams were placed. Differences among individual organisms could have effected their grazing behavior, especially for the *Orconectes* which molted during the duration of the study.

Response in Taxonomic Composition

Again, the morphology of the feeding mechanisms directly affected the results of the study. In both treatments where *Orconectes* were present, *bacillariophyta* dominated. The larger size and claws of *Orconectes* allow the crayfish to clip along the chlorophyta-covered surface of the tiles much like a lawn mower cuts grass, while the *bacillariophyta* remains unscathed. In contrast, streams containing only snails had a dominant chlorophyta population in addition to the *bacillariophyta*. In the absence of the grazing behaviors of the *Orconectes*, the *Physa* are unable to scrape along the surface of the tile where the *bacillariophyta* are because of obstruction due to the chlorophytes. The combination of the two grazers successfully eliminated the majority of both dominant algal species in contrast to the control streams where both types of algal taxon were present.

Response in Chlorophyll A

While not statistically significant, trends in the data indicate that the varying grazers effected the concentrations of Chlorophyll A produced by the algal populations. In the streams where grazing was presumedly the highest, the streams with both herbivores and *Orconectes* only, the chlorophyll A values were on average the highest throughout the duration of the experiment. Productivity was lowest in the streams with no, control treatment, or little, *Physa* only treatment, herbivory. Perhaps this increased productivity is due a higher chlorophyll A production rate in crysophyta relative to chlorophyta regardless of the environmental pressures. Another possibility is that the heightened productivity is a behavioral adaptation by the algae to the increased herbivory.

Statistical significance was thwarted again by the variability of the data. More replicates would have most likely supported the above conclusions.

General Conclusions

The three parameters tested in this experiment are all interconnected by their response to herbivory by the two grazers with different morphological feeding behaviors. The streams that were only grazed by *Orconectes* were populated dominantly by chrysophyta whose biomass is practically negligible in relation to that of chlorophyta. While the biomass of these streams was relatively low, their production was higher. A similar case of low biomass accompanied by high productivity was also observed in streams where both herbivores grazed. Again, the *bacillariophyta* were the predominant taxon on these files. In contrast, the control streams exhibited a higher biomass, due to the presence of chlorophytes, but a lower productivity, measured by chlorophyll A concentrations. It is possible that the chrysophytes are able to produce more chlorophyll because less of their energy is used for growth. The chlorophytes expend energy by increasing their height to absorb more light. In contrast the chlorophytes maintain a low surface area to volume ratio so their energy can be focused on photosynthetic activity. This situation of the control streams mirrors that of the treatments where *Physa* is the sole herbivore. Without the *Orconectes*, the *Physa* could not fully utilize the *bacillariophyta* as a food source.

Variability in the data is rooted in the nature of a field experiment where the environment cannot be controlled as it can be in a laboratory experiment. While all factors were attempted to be equalized among the

treatment streams, unforeseen differences could have affected the algal growth and productivity.

In further studies, the interaction between two grazers that also have a predator-prey relationship between them could be studied so that in the streams with both grazers, the growth of the algae might flourish when another food source is available for the primary herbivore.

ACKNOWLEDGEMENTS

I would like to thank all of the UNDERC students who worked at the riffle for their assistance in the field. I would also like to thank Jeff Runde for his guidance and time throughout the duration of this study. Lastly, I would like to thank the Bernard J. Hank Family for financially supporting the UNDERC class.

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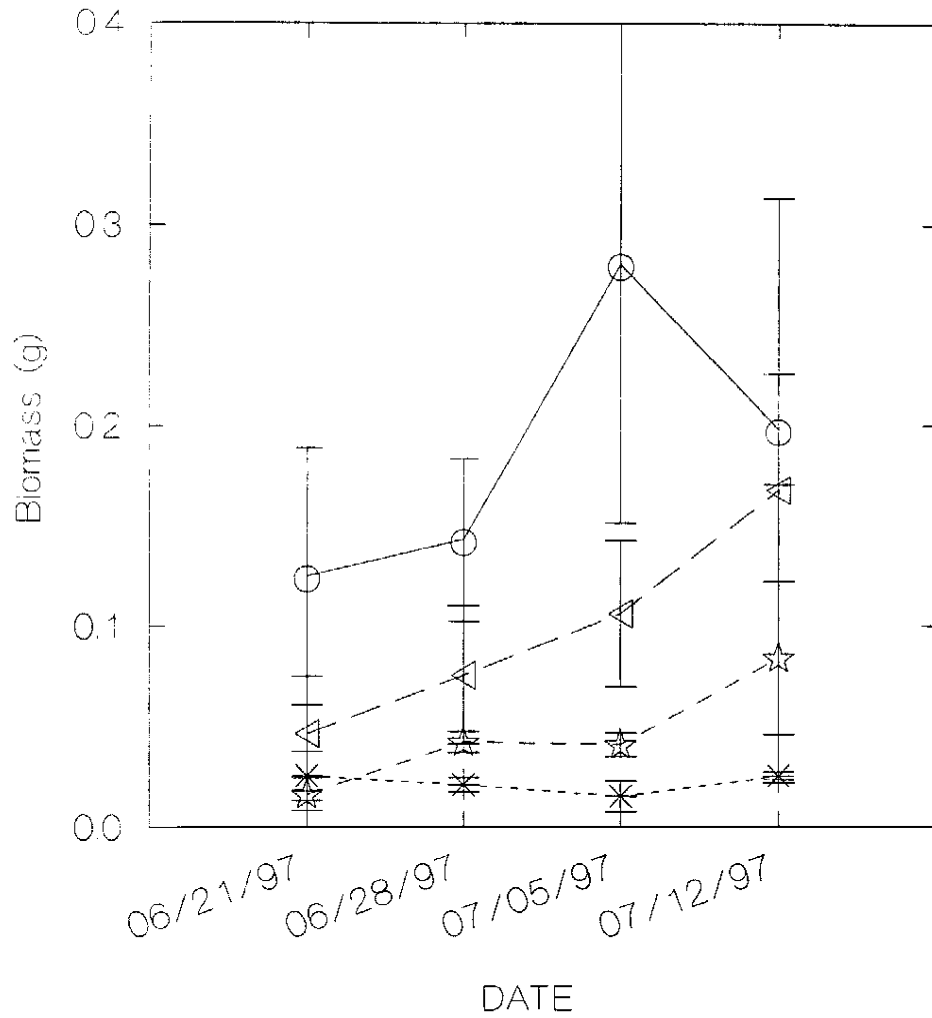


Figure 1: Changes in algal biomass (grams) collected from tiles in experimental streams from June 21, 1997 to July 12, 1997

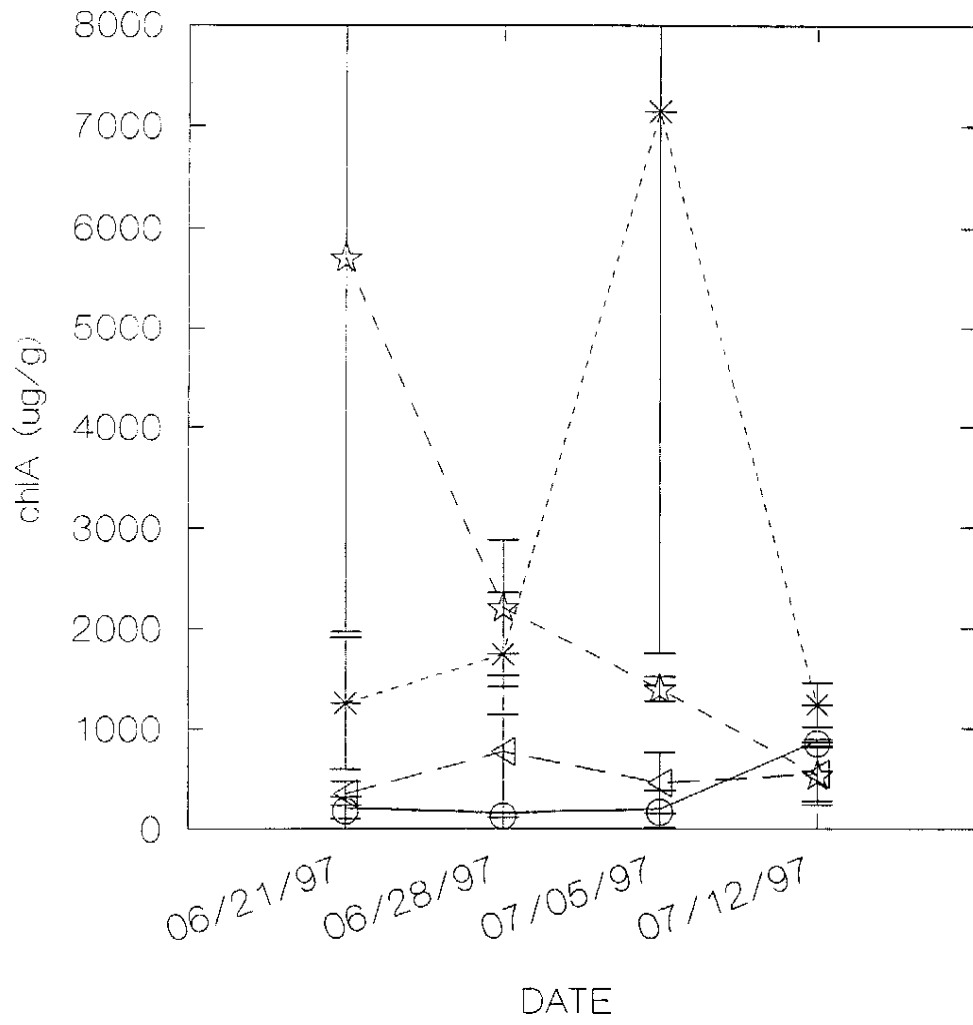


Figure 2: Changes in chlorophyll A (micrograms/ gram) production by the algal populations in the experimental streams from June 21, 1997 to July 12, 1997