Grazing by the snail Lymnaea stagnalis on the macrophyte Potamageton richardsonii and Periphyton

Thomas Stahl
UNDERC Research Project
Dr. David M. Lodge
December 1, 1989

Abstract

Many organisms, such as waterfowl, muskrats, fish (Lodge, in review) and crayfish (Lodge and Lorman, 1987) have an effect on the abundance and distribution of macrophytes, but grazing has usually been discounted as an important impact on macrophyte abundance (Lodge, in review). Sheldon (1987) stated that snails are also capable of affecting the abundance of macrophytes. In order to test this statement, Lymnaea stagnalis were placed with Potamageton richardsonii in the presence and absence of an alternate food source, periphyton, for a period of 11 days. The two different treatments (N=6) were conducted in containers in a lab with 10 L. stagnalis, 1 macrophyte shoot and a periphyton-covered rock (in one treatment) in each container.

Macrophytes were consumed to a much greater extent in the absence of periphyton. It can not be said that the snails with periphyton did not eat the macrophyte and therefore have no effect on macrophyte abundance, because there was no control to see the amount of decay and there was some biomass loss in this treatment. However, the facts that the snails ate far less macrophyte in the presence of periphyton and that there are always prefered food sources in natural aquatic bodies of water lead one to believe that snail herbivory does not play much of a role in macrophyte abundance and distribution. Previous reports on the diet of L. stagnalis seem to support the fact that they do not ordinarily eat live macrophytes and therefore have little effect on the macrophytes, although these studies are not in agreement about the actual diet of snails (Reavell, 1980; Scheerboom and Van Elk, 1978). The snail's effect of shredding the macrophyte was not taken into account either. The amount of shredding done by the snail would be good to know for the ecology of the snail, but it does not change the effect of the snail on the macrophyte's abundance because the macrophyte looses biomass whether it is eaten or shred.

Introduction

Macrophytes are a very important part of freshwater lakes. They have an effect on the physical environment, the chemical environment and the biota within a lake, and any changes taking place within the macrophyte assemblage may consequently affect the whole lake ecosystem (Carpenter and Lodge, 1986). Therefore, organisms that determine the distribution and abundances of macrophytes may indirectly be affecting the whole lake ecosystem. The crayfish Orconectes rusticus reduces macrophytes by grazing on and otherwise destroying them (Lodge and Lorman, 1987). There are also other organisms, including waterfowl, muskrats and fish, which graze on macrophytes (Lodge, in review). Recently it has been asserted that snails also eat live freshwater macrophytes and thereby determine the abundance of macrophytes (Sheldon, 1987).

Sheldon's (1987) work has very important implications. It is known that snails are part of the macrophyte-periphyton-grazer complex described in Carpenter and Lodge (1986). Snails are known to primarily graze periphyton (Lodge, 1986), and the grazing of macrophytes by snails has never been observed in freshwater lakes of Northern Wisconsin and Upper Michigan (Lodge, personal communication). Along with this observation, there are several problems with Sheldon's (1987) research that have been pointed out (Lodge, in review) that lead one to believe that the patterns of macrophyte occurrence in Sheldon's (1987) study may have been due to organisms other than snails (Lodge, in review). If snails do graze on macrophytes, the association of snails with macrophytes would be more complex than snails associating with certain macrophytes for their different periphyton assemblages (Lodge et al., 1987). Snail and macrophyte distributions would be affecting each other directly if snails graze on macrophytes.

The purpose of this research was to determine if snails actually do graze on macrophytes. The most preferred macrophyte by Physa gyrina in Sheldon's (1987) research, Potamageton richardsonii, was put in with a snail that does, at least sometimes, eat macrophytes, Lymnaea stagnalis (Reavell, 1980; Scheerboom and Van Elk, 1978;

Lodge, personal communication), although the reports conflict on the amount of macrophyte and other food sources which are eaten. Two different treatments, one including periphyton-covered rocks with the macrophyte and one without periphyton-covered rocks, were used to test the hypothesis that L. stagnalis only eat macrophytes in the absence of periphyton.

Materials and Methods

Lymnaea stagnalis to be used in this experiment were readilly collected from Mann Pond near the UW-Madison Trout Lake Station. They were then transported to the University of Notre Dame Environmental Research Center (UNDERC) located in the Upper Peninsula of Michigan, where the study was conducted. Potamageton richardsonii shoots were collected from Tenderfoot Lake (at UNDERC).

There were two different treatments (N=6) in the experiment which was run 11-22 July, 1989 in the basement of the UNDERC research laboratory where windows provided natural lighting. Each container (Nalgene, 25 cm by 18 cm by 14 cm deep) in treatment A contained 10 L. stagnalis (of similar size), a periphyton covered rock (about 6-10 cm in diameter) and a macrophyte shoot (approximate length 55 cm with approximately 40 leaves). The replicates in treatment B consisted of 10 L. stagnalis and a macrophyte shoot.

Prior to the experiment, all 12 P. richardsonii shoots were gently hand-rubbed under running tap water to remove any periphyton from them that could be used as an alternate food source for the L. stagnalis. Shoots were then individually spin-dried, weighed and photocopied. While this was taking place the L. stagnalis were left without food (for less than a day), so they would be hungry at the outset of the experiment.

The containers were cleared every other day to keep them free of periphyton. Clearing treatment A consisted of removing the snails and macrophyte, dumping out the water, feces and "used" rock, replacing the water, snails and macrophyte, and putting in a fresh periphyton-covered rock. Treatment B was cleared by removing the snails and the macrophyte shoot, dumping out the water and feces, scrubbing the sides of the container with a dish scrubber and replacing the water, snails and macrophyte. Treatment B's containers were scrubbed to prevent periphyton growth on the container walls, since these snails were only supposed to have macrophyte as a food source.Treatment A's sides were not scrubbed because these snails were supposed to have periphyton available as an alternate food source besides P. richardsonii.

At the end of the experiment, the P. richardsonii from each replicate was spin-dried, weighed and photocopied for comparison to the starting weights and photocopies.

Results

There were no problems with this experimental set-up other than a few (less than 10) L. stagnalis deaths. Dead L. stagnalis were replaced with a live one from a stock of L. stagnalis kept alive with relatively little food so they would be hungry when introduced into the experiment.

Macrophyte shoots in the absence of periphyton-covered rocks had a greater loss of macrophyte biomass than those with periphyton-covered rocks (Figure 1, $p<0.01$, t-test). Figure 2 also clearly illustrates this point with the initial and final photocopies of the macrophytes of the replicate in each treatment that had the greatest biomass loss.

Discussion

This experiment was designed to force L. stagnalis to eat the macrophyte. The macrophyte listed in Sheldon (1987) as being the most preferred macrophyte was used as the food source. This macrophyte, in the treatment without periphyton, was washed of periphyton prior to the start of the research in order that the macrophyte be the only food source in the container. The containers of the treament without periphyton were scrubbed every other day to keep any periphyton from developing on the container itself. Tap water was used also, so there would be no periphyton in the added water. The other treatment was given periphyton as a food source (from the rocks and the periphyton allowed to grow on the container walls). With this experimental design the snails without periphyton were almost forced to eat macrophytes, if they were part of their diet. The snails with periphyton were given a choice between an abundance of periphyton and macrophyte. In this way it was hoped to be seen if the L. stagnalis would eat a macrophyte preferred by snails when this macrophyte is the only food source, and if the macrophyte is eaten in the presence of another confirmed food source.

The results from this experiment were very clear and simple. The L. stagnalis ate the P.richardsonii, but not nearly as much when an alternate food source was present. This leads one to believe that, contrary to Sheldon (1987), the snails probably do not have much of an effect on macrophyte distribution within bodies of water. Periphyton is usually present where macrophytes are present, therefore the snails will choose the periphyton and not graze upon the macrophytes. The statement that snails do not have an effect on macrophyte abundance is only an hypothesis, however, because there was no control in this research. Included in the experimental design should have been a treatment with lone macrophyte shoots in containers. These would have served to show how much of the macrophyte biomass loss was due to decay alone. Since there was no control it can not be seen how much of the little biomass loss (~ 15%) in treatment A (with periphyton) was actually due to the snails and how much was due to the decay of the macrophyte. Whether or not any macrophyte is eaten in the presence of periphyton can not be known from this study. However, the conclusions which were taken from the results are still valid, and it is significant that the snails ate little macrophyte when periphyton was present, and much more when periphyton was not present. Another hypothesis from the results is that only if there is no periphyton present in a lake will snails have any affect on that lake's macrophyte distribution. This may not even be the case since snails are known to eat other food sources such as detritus (Reavell, 1980; Scheerboom and Van Elk, 1978), which is almost always present in lakes.

Several papers have stated that snails eat macrophytes. Scheerboom and Van Elk (1978) assert that L. stagnalis eat decaying macrophytes preferentially to all other food sources besides algae (periphyton). However, macrophytes are not eaten in early summer when the plants are in good condition since the macrophytes' protection mechanism against molluscs has not broken down yet due to decay of the macrophyte (Scheerboom and Van Elk, 1978). This means that, according to Scheerboom and Van Elk (1978), only decaying macrophytes are eaten. This statement is in contrast to Reavell (1980) who claims that L. stagnalis do not eat macrophytes. Reavell (1980) does claim that detritus is the main diet of the many snails he studied and there is no evidence for snails, including L. stagnalis, selecting macrophytes as part of their diet. Reavell (1980) also states that L. stagnalis does not change its diet except for an increase in dead invertebrates in midsummer. Both of these statements conflict with Scheerboom and Van Elk (1978). Scheerboom and Van Elk (1978) state that detritus is third in preference for L. stagnalis, behind algae and macrophytes. They also state that L. stagnalis start eating decaying (not dead) macrophytes after early summer, and this is a diet change. The discrepancies between these papers may be due to the fact that the L. stagnalis eat decaying macrophytes, and this is taken to be detritus by Reavell (1980). If this is the case, then the L. stagnalis studied by Reavell (1980) may have actually eaten macrophytes starting at midsummer, but they were taken to be detritus and no change in diet was seen.

Since the P. richardsonii used in this experiment was fresh and non-decaying, it may not have been preferred by the L. stagnalis due to a defense mechanism on the part of the macrophyte, as suggested in Scheerboom and Van Elk (1978); but it can not be said that they do not eat fresh macrophytes because they did (though this does not mean, as was seen, they will choose fresh macrophytes when other food sources are present). Anyways, in none of the above mentioned studies, or in this study, does it seem that L. stagnalis eat fresh macrophytes under ordinary circumstances. Even if the L. stagnalis do eat decaying macrophytes, which is not certain as is seen in the conflicting research, this should not have an effect on the distribution of the macrophytes because they are already in the process of death and the L. stagnalis only hastens this process. The macrophytes have already reproduced and eating the senescing macrophytes will not affect their distribution. This means that Sheldon (1987) may be incorrect in her assertion that snails affect macrophyte distribution to a great (or any) extent in lakes.

Another problem, other than the lack of a control, with this research was that shredding was not quantified. It has been noted that L. stagnalis do shred macrophytes, which adds to the detritus (Pieczynska, 1986), and in their association with P. richardsonii cause grazing damage (Pip and Stewart, 1976). It does not matter whether or not the macrophytes were shred from a standpoint of effect on macrophyte population, because eating and shredding has the same effect on the macrophyte. Shredding is only important in relation to the ecology of the snail. If they shred, then they are not actually eating the macrophyte and it is not a food source for them. The snail might shred the macrophyte as it forages for periphyton. The phenomenon of shredding, if indeed it occurs, should be further studied to see its significance to the snail. In this experiment, there were some fragments seen in the water, so shredding probably occurred to some degree; but as stated earlier this effect was not recorded in any way.

In summary, it can be said that snails eat macrophytes, although to a far less degree when another food source is present. It can not be said for sure that L. stagnalis do not eat

P. richardsonii when periphyton is present because there was no control in this experiment. Therefore, it can not be concluded that snails have no effect on macrophyte populations and distributions, but this is highly reasonable from the result that L. stagnalis prefers periphyton. This inconclusiveness in snail diet and preference, and the effect of shredding should be resolved in further research.

Acknowledgements

First of all, I would like to thank Mr. Bernard J. Hank for endowing the UNDERC course which this research was a part. Dr. David M. Lodge, my faculty advisor, deserves thanks for all of his help in this research. All of the staff and students at UNDERC, foremost Kurt Shubert for helping in the collection of L. stagnalis at Mann Pond, also get thanks for their roles in this research.

Literature Cited

Carpenter, S.R. and D.M. Lodge. 1986. Effects of submersed macrophytes on ecosystem processes. Aquatic Botany 1986: 341-370.

Lodge, D.M. 1986. Selective grazing on periphyton: a determinant of freshwater gastropod microdistributions. Freshwater Biology 16:831-841.

Lodge, D.M. In review. Herbivory on freshwater macrophytes. In: M.S. Adams and K. Sand-Jensen, eds. Ecology of freshwater submersed macrophytes. Elsevier Press.

Lodge, D.M., K.M. Brown, S.P. Klosiewski, R.A. Stein, A.P. Covich, and C. Bronmark. 1987. Distribution of freshwater snails: spatial scale and the relative importance of physicochemical and biotic factors. Am. Malacol. Bull. 5(1): 73-84.

Lodge, D.M., and J.G. Lorman. 1987. Reductions in submersed macrophyte biomass and species richness by the crayfish Orconectes rusticus. Can. J. Fish. Aquat. Sci. 44: 591-597.

Lodge, D.M., J.W. Barko, D, Strayer, J.M. Melack, G.G. Mittelbach, R.W. Howarth,B. Menge, and J.E. Titus. 1988. Spatial heterogeneity and habitat interactions in lake communities. In: S.R. Carpenter, ed. Complex interactions in lake communities. Springer-Verlag. New York. pp. 181-208.

Pieczynska, E. 1986. Sources and fate of detritus in the shore zone of lakes. Aquatic Botany 25:153-166.

Pip, E. and J.M. Stewart. 1976. The dynamics of two aquatic plant-snail associations. Can. J. Zool. 54:1192-1205.

Reavell, P.E. 1980. A study of the diets of some British freshwater gastropods. J. Conch. 30:253-271.

Scheerboom, J.E.M. and R. Van Elk. 1978. Field observations on the seasonal variations in the natural diet and the haemolymph-glucose concentration of the snail Lymnaea stagnalis (L.). Zoology May 1978:365-376.

Sheldon, S.P. 1987. The effects of herbivorous snails on submerged macrophyte communities in Minnesota lakes. Ecology 68:1920-1931.

Figures

Figure 1. Histogram of mean weight loss (g) ±2 SE (standard errors) in the treatments with and without periphyton ($p<0.01$).

Figure 2. Photocopies before and after of replicates in each treatment with the most macrophyte biomass loss. (a) Replicate 3 of treatment A (with periphyton) at start of research, (b) Replicate 3 of treatrment A at end of research, (c) Replicate 3 of treatment B (without periphyton) at start of research, and (d) Replicate 3 of treatment B at end of research.

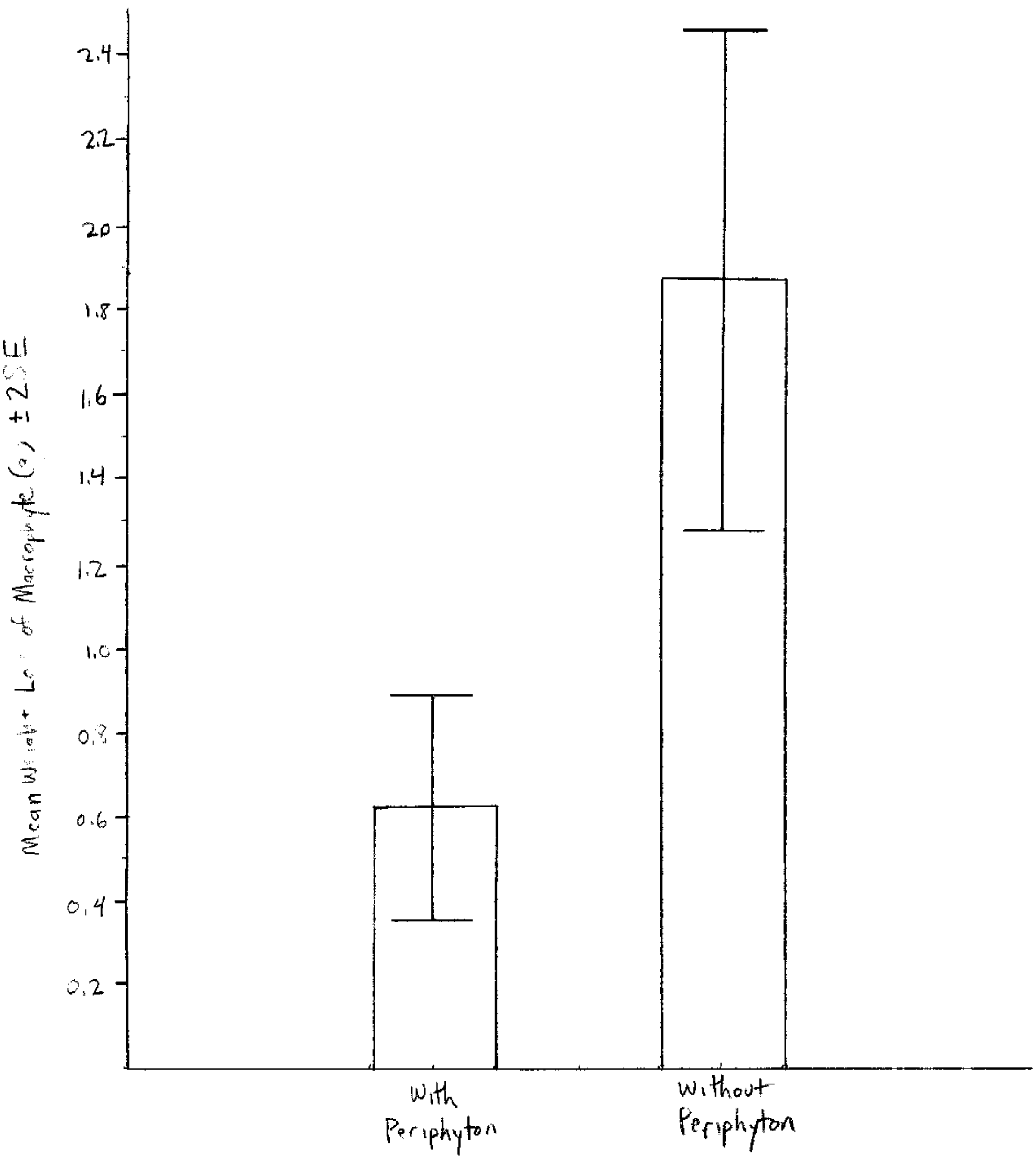
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
± 2SE
With
Periphyton
Without
Periphyton

Figure 1.

Figure 2.

Appendix 1. Data on macrophyte weights.

Replicate	Weight Before (g)	Weight After (g)	Difference (g)	% Weight Loss
1A	3.92	3.10	−0.82	21
2A	4.76	4.11	−0.65	14
3A	4.32	3.23	−1.09	25
4A	3.58	3.42	−0.16	4
5A	3.38	2.98	−0.40	12
6A	3.77	3.22	−0.55	15
$\bar{X}$	3.96	3.34	−0.61	15
1B	4.03	2.94	−1.09	27
2B	4.82	2.60	−2.22	46
3B	4.29	1.72	−2.57	60
4B	3.63	2.78	−0.85	23
5B	3.42	1.05	−2.37	69
6B	3.99	1.78	−2.21	55
$\bar{X}$	4.03	2.15	−1.89	47