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The Effect of Herbivore Feeding on the Buoyancy of Eurasian Watermilfoil[1]

ROBERT P. CREED JR.,[2] S. P. SHELDON[2] AND D. M. CHEEK[3]

INTRODUCTION

Recent investigations examining the effects of herbivores on Eurasian watermilfoil (*Myriophyllum spicatum* L.), hereafter referred to as watermilfoil, have focused on the ability of these herbivores to remove leaf tissue and/or affect plant growth (Painter and McCabe 1988, MacRae et al. 1990, Creed and Sheldon 1991, 1992). We recently observed a collapse in a watermilfoil bed which suggests that some of these herbivores may have additional effects on watermilfoil. In late July of 1991, we noticed that watermilfoil plants in Browningtom Pond, Vt had sunk below the water surface. The top of the west bed (see Creed and Sheldon 1991) was at least one meter below the surface of the pond; earlier in the summer the plants almost reached the surface. Inspection of the plants showed that many of the stems had been bored by larvae of the weevil *Euhrychiopsis lecontei* (Dietz). Other plants which showed little or no weevil damage appeared to have been pulled down by adjacent, insect-damaged plants. This observation suggested that the herbivorous weevil *E. lecontei* and the caterpillar *Acentria nivea* (Olivier), which is also present in the pond, could have an additional, negative effect on watermilfoil by reducing the buoyancy of the plants.

MATERIALS AND METHODS

Adult weevils and undamaged, apical portions of watermilfoil stems were collected on 29 July 1991. The length of the stems was standardized and they were sorted into ten groups of six stems each. The blotted wet weight was determined for each of the groups. The mean initial wet weight (± 1 S.E.) of the groups of stems was 5.08 ± 0.15 g. On 30 July the watermilfoil stems were placed into ten, 38 l aquaria filled with well water. The aquaria were placed in a line (north to south) on the ground in an area where they received direct sunlight from mid-morning to mid-afternoon. Each aquarium was aerated with a single airstone. The weevils were sexed and sorted into five groups of four weevils (each with 3 females and 1 male). Weevils were added to five of the ten aquaria; the remaining five aquaria served as controls. Assignments of treatments to aquaria, and watermilfoil and weevils to aquaria were randomized. Water temperature was monitored using floating thermometers in three of the control aquaria. Temperatures were recorded in the morning and evening and ranged from 16 to 29C in the aquaria during the experiment (mean morning temperature was 18.7C; mean evening temperature was 23.8C). All aquaria were covered with a tight-fitting, translucent lid to prevent the escape of the weevils. The lids also contained a panel of 500 micron mesh Nitex to allow for air exchange and also aid in temperature regulation of the water.

After 21 days all watermilfoil that was not resting on the bottom was considered as floating. All watermilfoil settled to the bottom on cool, overcast days so the experiment was terminated on a sunny day. Floating watermilfoil was separated from that which had settled to the bottom of the aquaria. All herbivores were removed from the aquaria and from the plant material. While this experiment had initially been designed to examine the effects of weevils on buoyancy, we had contamination of 4 of the 5 weevil aquaria with *Acentria* larvae. Therefore we will refer to the effect on buoyancy as an herbivore effect and not simply a weevil effect. All watermilfoil was then weighed (blotted wet weight). Most of the watermilfoil in one of the control aquaria had settled to the bottom. The watermilfoil in this aquarium was encrusted with what appeared to be iron precipitation. Using Dixon's test (Sokal and Rohlf 1981) we determined that this replicate was a statistical outlier and removed it from the analysis. Treatment effects were compared using an ANOVA (Sokal and Rohlf 1981). The data used in the ANOVA were the weight of the floating watermilfoil. Weight data were log transformed prior to performing the analysis.

RESULTS AND DISCUSSION

Herbivores had a significant effect on watermilfoil buoyancy. Significantly more watermilfoil was floating in the control aquaria than in the aquaria with herbivores ($F = 19.97$, $p < 0.003$). Figure 1 shows the buoyancy data plotted as percent watermilfoil floating (mean ± 1 S.E.). Almost all of the watermilfoil (98.6 ± 1.3%) was floating in the controls but only 18.5 ± 7.5% was floating in the herbivore treatments.

Not all of the weevil adults were recovered from the aquaria at the end of the experiment. All four adults were recovered from two of the aquaria but only two were found in each of the remaining three aquaria with weevils. An average of 26.4 weevil larvae were removed from the five aquaria with weevils (range 11 to 43). Three dead weevil pupae and one *Acentria* larva were found in the control aquaria. The numbers of *Acentria* found in the weevil treatment aquaria were 0, 1, 2, 3, and 18.

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[2]Department of Biology, Middlebury College, Middlebury, Vermont 05753 USA.

[3]Department of Biological Sciences, Wellesley College, Wellesley, Massachusetts 02181 USA.

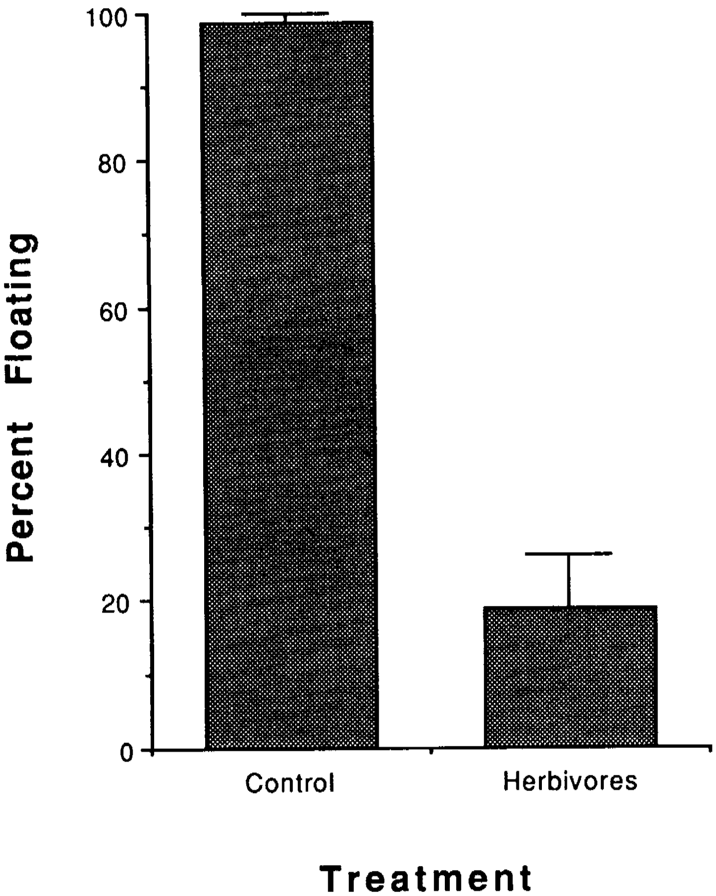

Figure 1. The effect of herbivores on watermilfoil buoyancy in the aquarium experiment. The bars in the histogram represent the mean (± 1 S.E.) percent of total watermilfoil weight found floating in each of the two treatments.

Herbivores clearly had a strong effect on watermilfoil buoyancy, which is not surprising as both *Acentria* larvae and *Euhrychiopsis* (both adults and larvae) expose stem vascular tissue while feeding. We have observed adult and larval weevils feeding and it is not unusual to see a stream of bubbles emerging from the damaged portion of the stem. It is significant that this small scale effect could result in the collapse of the upper portion of a watermilfoil bed. The implication is that this suite of herbivores does not have to remove considerable amounts of stem and leaf tissue to have a strong negative effect on watermilfoil. The consequences of leaf removal by herbivores may actually be minor compared to loss of buoyancy. For example, herbivore feeding could cause plants to sink out of well lit surface waters. If the plants are unable to get sufficient light for photosynthesis then energy will not be available for growth or even maintenence. The effect becomes even more pronounced if damaged plants can entangle and sink undamaged ones. Another possible negative effect related to loss of buoyancy includes disruption of the movement of oxygen from sites of oxygen production to the roots where respiratory demand is high (Wetzel 1983). The above examples suggest that loss of buoyancy could have a variety of consequences for watermilfoil physiology which may prove to be the major mechanisms of watermilfoil bed destruction by herbivores. These preliminary results suggest that these herbivores have a greater potential for biological control of Eurasian watermilfoil than is indicated by feeding and growth studies.

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