Damage to Eurasian watermilfoil (*Myriophyllum spicatum)* due to herbivory by *Euhrychiopsis lecontei, Acentria ephmerella,* and *Cricotopus myriophylli* in Otsego Lake, summer 2005

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INTRODUCTION

Eurasian Watermilfoil (*Myriophyllum spicatum)* is a submerged vascular plant in the family Haloragaceae (Johnson et al. 1998) that is native to northern Europe and Asia and arrived in North America sometime between the late 1800s and the early 1940s (Reed 1977). Eurasian watermilfoil can quickly invade lakes, rivers, irrigation canals, farm ponds and other watery habitats (Wood 1999). It spreads very rapidly due to the ability to reproduce through its own fragments. It is also well adapted to many climates and conditions, and it can grow to the surface of lakes in depths up to 5 meters. Once on the surface it continues to grow forming thick mats, often shading out native macrophyte species. This can lead to a decline in species richness (Coffey 1974), whereas mixed native macrophyte beds support a diverse community of invertebrates (Campbell and Clark 1983). From an economical standpoint this nuisance macrophyte impedes recreational uses of lakes such as boating, fishing and swimming. It also negatively influences commercial navigation, flood control, power generation from hydroelectric dams, water supplies and regional development. Eurasian milfoil was first documented in Otsego Lake in 1986 (Dayton and Swift 1987). It is now the most abundant macrophyte present in the lake; however, it has not caused economic and recreational activities to suffer to the extent that often occur in infested lakes (Harman et al. 1997).

Many lake users in U.S. and Canada are challenged with Eurasian milfoil management (Couch and Nelson 1986). Physical and chemical methods have been applied, including plant harvesting and herbicide use. Harvesters cut plants and have a large conveyor where plants are collected. This method has a tendency to broadcast fragments of milfoil which may enhance growth due to its reproductive nature. Harvesting is non-specific, with desirable species being removed with milfoil. Because 90% of what is harvested is water by weight, a lot of time and money is required to harvest milfoil (Livemore and Koegel 1979).

Eurasian milfoil can also be controlled chemically (Harman et al. 2005). Different chemicals have different modes of action on plants. Most are toxic and damage plants by disrupting cell membrane integrity or change plant growth regulators (Langeland 1997). The chemicals also require some means of dispersal or degradation in the environment. A sudden die off of underwater plants can change water chemistry as well. A large amount of oxygen is used in the decaying process, nutrients are released, and bottom detritus is added in a relatively short period of time. This ecosystem alteration can include changes in community structure and food webs (Cooke et al. 2005).

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Such means of milfoil control can provide some short term relief, but neither is permanent or particularly specific to *M. Spicatum* (though more recently, chemicals have become available that offer some target specificity with greater than one season of control (Harman et al. 2005). Each year millions of dollars are spent on herbicides and harvesting without a long term solution to manage *M. spicatum*.

A potentially more ecological alternative in the management of *M. spicatum* is biological control (Sheldon and Creed 1995). Biological control differs substantially from mechanical and chemical techniques. The objective is to find a biological agent that is specific to a target pest and, through some mechanism, controls its growth to acceptable levels. The aquatic moth *Acentria ephemerella,* the aquatic weevil *Eurychiopsis lecontei*, and the midge *Cricotopus myriophyll* all have been noted as herbivores that feed on Eurasian milfoil (Lord 2004).

The milfoil weevil *E. lecontei* is native to the U.S. and Canada. The adult lays eggs on the growing tips of milfoil. These eggs hatch within a week and the larvae begin to feed on the plant boring through the stem near the plant's tip, inhibiting vertical growth. Eventually the larvae pupate in the lower stem of the plant. The new adult emerges and swims to the top of the plants and begins the life cycle again. In autumn, the adult weevils move to plant litter at the lake margin where they over-winter. The following spring the adults move back to the plants in the lake.

Another milfoil herbivore is the aquatic moth *Acentria ephemerella*. Although not a specialist feeder (Johnson et al. 1998) it can mainly be found feeding on milfoil, most likely due to the plant's abundance. Like *E. lecontei, Acentria* spend most of their life cycles among milfoil. The larvae stage of the moth will eat tips and glue them down to the stem to make retreats in which to pupate. Adult moths live for only a few days in order to reproduce and start the cycle over (Shledon 1995).

The third possible control agent is the milfoil midge (*Cricotopus myriophylli).* This is the smallest of the group and evidence supporting its ability to control milfoil is lacking. The midge's bodies appear green, leading to the belief that they are feeding on milfoil; however, no significant physical damage is evident (Cook et al. 2005).

These herbivores graze, live and reproduce among *M. spicatum*. Introductions of these invertebrates have taken place in lakes around the country. The results, however, are not as fast nor the control as complete as some would hope, suggesting that biological control of milfoil with these herbivores is not efficient. All three of these herbivores naturally occur in Otsego Lake. Studies and research done on Otsego Lake, dealing with biocontrolling herbivores, may further evaluate their effectiveness in controlling milfoil.

METHODS

In order to evaluate the extent of damage occurring due to herbivores, Eurasian milfoil was collected during the weeks of 11 July, 18 July, 1 August and 8 August 2005. Collection was done by boat at five different sites around the lake. Samples were collected from the south end of the lake (Site 1), Rat Cove (Site 2), Brookwood Point (Site 3), the north end of the lake (Site 4) and Hyde Bay (Site 5) (Figure 1).

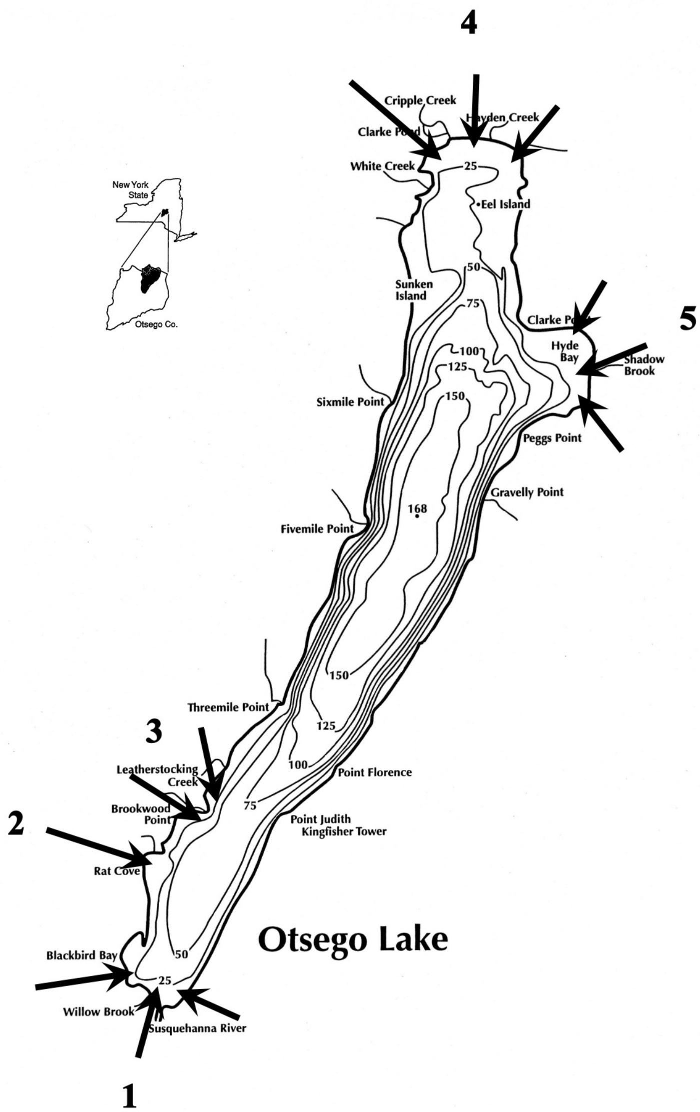

Figure 1. Sampling sites used for Eurasian milfoil collection, summer 2005. Multiple arrows indicate general areas for collection, allowing for some spatial distribution.

At each site a plant rake was thrown 5 separate times in order to collect 5 strands of milfoil each. Each of the 5 throws was done at different spots throughout the site, in order to get a greater distribution. If a throw did not produce five strands it was disregarded and a new throw was done. Strands of milfoil were then selected from the basal end to produce un-biased sampling. The first 25 cm of the terminal end of each strand was collected, bagged, and labeled. The labels consisted of site, date and the number of rake (1-5), collecting 5 tips per 5 rakes. This gave a total of 25 tips per site. The bags were put on ice and transported back to the lab and refrigerated until examined.

The methods employed for the tip evaluations follow those of (Johnson unpubl.). Each tip was examined with a stereo dissecting microscope, starting with the distal end of the tip. Each life stage of *Acentria* and *Euhrychiopsis* was enumerated and damage caused to stems, tips and leaflets by them was evaluated. Because of the difficulty in identifying the milfoil midge, no attempt was made to do so. All midges observed were recorded, so the reported data do not necessarily reflect those with the potential of controlling milfoil. Stem damage was evaluated and ranked as being healthy (no damage), minor, moderate, and extensive. In order to calculate the average extent of damage to tips and leaflets of each stem and site, a number was assigned to each category of damage, with “1” indicating a healthy stem , “2” being minor, “3” moderate and “4” extensive damage. The mean value for each date was calculated and the resultant value was re-assigned to its corresponding degree of damage, which was intended to semi-quantitatively describe mean damage at each site.

RESULTS AND DISCUSSION

A summary of the numbers of herbivores, per 25 stems, and the percent damage by those herbivores, for 12 July, 17 July, 1 August and 8 August 2005 are given in Tables 1-4, respectively. The mean lake wide numbers of herbivores and the mean extent of damage by them is also given for each date.

HERBIVORES	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Average**
Acentria adult (#)						
Acentria larvae (#)		1			2	2
Acentria cocoon (#)	3					3
Acentria retreat (#)						
Acentria eggs (#)						
***Acentria* total (#)**	**3**	**1**	**0**	**0**	**2**	**1**
Euhrychiopsis adult (#)						
Euhrychiopsis larvae (#)						
Euhrychiopsis pupa (#)						
Euhrychiopsis eggs (#)						
***Euhrychiopsis* total (#)**	**0**	**0**	**0**	**0**	**0**	0
Midges	111	24	33	12		45
Caddisflies (#)		1				1
STEM DAMAGE						
Healthy stem (%)	44	52	80	88	88	70
Acentria damage(%)	20	8	4	0	8	8
Euhrychiopsis damage (%)	16	36	12	12	0	15
Both types of damage (%)	16	4	4	0	4	6
TIP DAMAGE (average)	**HEALTHY**	**MINOR**	**HEALTHY**	**HEALTHY**	**MODERATE**	**MINOR**
LEAFLET DAMAGE (average)	**HEALTHY**	**MINOR**	**HEALTHY**	**HEALTHY**	**MODERATE**	**HEALTHY**

Table 1. Herbivore numbers and assocated milfoil damage per site (25 stems), 12 July 2005

HERBIVORES	Site 1	Site 2	Site 3	Site 4	Site 5	Average
Acentria adult (#)		1				1
Acentria larvae (#)	1	4	4			3
Acentria cocoon (#)		3			1	2
Acentria retreat (#)	20	5	4	3		8
Acentria eggs (#)		4	4			4
***Acentria* total (#)**	**21**	**15**	**12**	**3**	**1**	10
Euhrychiopsis adult (#)						
Euhrychiopsis larvae (#)		1				1
Euhrychiopsis pupa (#)						
Euhrychiopsis eggs (#)						
***Euhrychiopsis* total (#)**	**0**	**1**	**0**	**0**	**0**	0
Midges	111	21	19	19	14	37
Caddisflies (#)	0	1		1	0	1
STEM DAMAGE						
Healthy stem (%)	12	32	40	72	72	46
Acentria damage(%)	68	28	32	16	16	32
Euhrychiopsis damage (%)	16	24	12	8	4	13
Both types of damage (%)	4	12	16	16	8	11
TIP DAMAGE (average)	**MINOR**	**MINOR**	**MODERATE**	**MINOR**	**HEALTHY**	**MINOR**
LEAFLET DAMAGE (average)	**MINOR**	**MINOR**	**MINOR**	**MODERATE**	**MODERATE**	**MINOR**

Table 2.Herbivore numbers and associated milfoil damage per site (25 stems) 17 July 2005

HERBIVORES	Site 1	Site 2	Site 3	Site 4	Site 5	Average
Acentria adult (#)	1	1	1			1
Acentria larvae (#)			1	5	1	2
Acentria cocoon (#)	2		1	2		2
Acentria retreat (#)	5	10	6	8	5	7
Acentria eggs (#)	6	3				5
***Acentria* total (#)**	**14**	**34**	**10**	**15**	**6**	16
Euhrychiopsis adult (#)					1	1
Euhrychiopsis larvae (#)				1		1
Euhrychiopsis pupa (#)						
Euhrychiopsis eggs (#)						
***Euhrychiopsis* total (#)**	**0**	**0**	**0**	**1**	**1**	0
Midges	20	8	12	19		15
Caddisflies (#)						
STEM DAMAGE						
Healthy stem (%)	76	36	40	64	68	57
Acentria damage(%)	8	28	40	24	32	26
Euhrychiopsis damage (%)	16	36	8	12	0	14
Both types of damage (%)	0	0	12	0	0	2
TIP DAMAGE (average)	**MINOR**	**MINOR**	**MINOR**	**HEALTHY**	**HEALTHY**	**MINOR**
LEAFLET DAMAGE (average)	**MINOR**	**MINOR**	**MINOR**	**HEALTHY**	**HEALTHY**	**MINOR**

Table 3. Herbivore numbers and associated milfoil damage per site (25 stems) 1 Aug. 2005.

HERBIVORES	Site 1	Site 2	Site 3	Site 4	Site 5	Average
Acentria adult (#)		1				1
Acentria larvae (#)		1	1	3	3	2
Acentria cocoon (#)	2			1		2
Acentria retreat (#)	9	9	14	7	17	11
Acentria eggs (#)	3				7	5
Acentria total (#)	**14**	**11**	**15**	**11**	**27**	16
Euhrychiopsis adult (#)						
Euhrychiopsis larvae (#)	2	1				2
Euhrychiopsis pupa (#)						
Euhrychiopsis eggs (#)						
Euhrychiopsis total (#)	**2**	**1**	**0**	**0**	**0**	1
Midges	16	8	9	5	2	8
Caddisflies (#)	0	2	1	0	0	1
STEM DAMAGE						
Healthy stem (%)	40	48	48	40	52	46
Acentria damage(%)	44	44	40	28	16	34
Euhrychiopsis damage (%)	16	8	12	24	24	17
Both types of damage (%)	0	0	0	8	8	3
TIP DAMAGE (average)	**MINOR**	**MODERATE**	**MINOR**	**MINOR**	**HEALTHY**	**MODERATE**
LEAFLET DAMAGE (average)	**MINOR**	**MINOR**	**MINOR**	**MINOR**	**MINOR**	**MINOR**

Table 4. Herbivore damage and associated milfoil damage per site (25 stems) 8 Aug 2005.

The total numbers of each herbivore encountered over the summer are given in Figure 2. The numbers of herbivores collected on 12 July were the lowest encountered. No adult weevils or any sign of their activity was recorded. *Acentria* numbers were low, but more evidence of their presence could be noticed. By 17 July, *Acentria* had increased from an average of 2 per stem to 13 per stem. On 1 August, the density had further increased to about 20 per stem, similar to that encountered on 8 August. *Eurhychiopsis* densities remained below 1 per stem throughout the study. Overall, damage to milfoil was minor. Densities of neither herbivore showed any spatial trends regarding sampling site.

While limited in scope, past research on herbivory on milfoil in Otsego Lake has been consistent with the data presented in this report. *Euhrychiopsis* was recorded in low numbers (<1 per 25 stems), while *Acentria* is more widespread and common (Miner 1998, Ward 2000). Additionally, findings by Miner (1998) show temporal variations in *Acentria* densities similar to those reported here, with numbers being lowest early in the summer and increasing through August (though she reported densities and numbers per kg milfoil, wet weight). She suggested that this trend was a function of successive generations over the course of the summer.

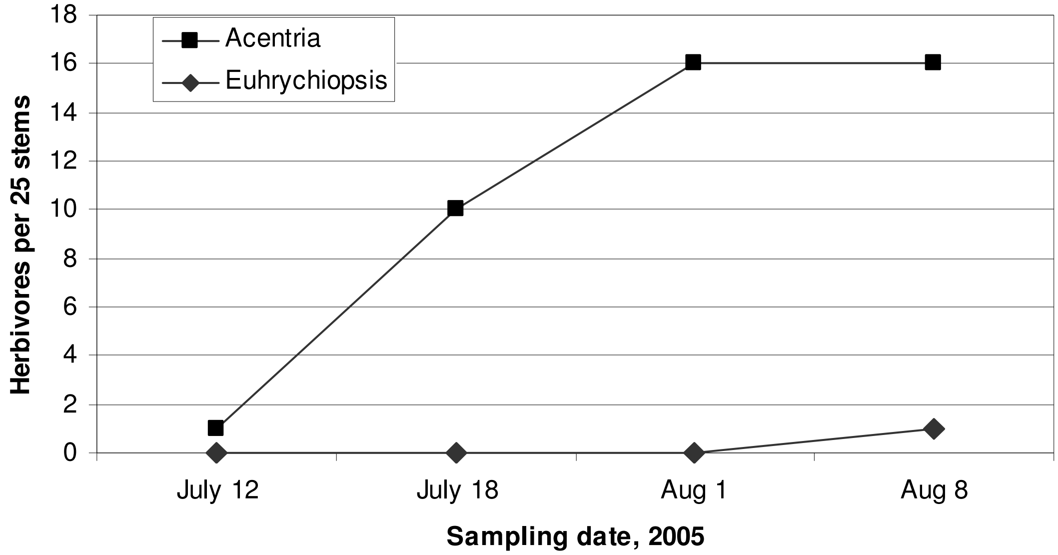

Figure 2. Mean number of *Acentria* and *Euhrychiopsis* per 25 stems thorugh July and Aug. summer 2005.

Lord (2004) reported that research by Painter and McCabe (1988) indicated that *Acentria* would severely impact milfoil, and effectively control it, when present at a density of .8 larvae per stem. Densities exceeding that rate were regularly observed during the month of August. However, it should be noted that total counts included refuges encountered, even when they were not occupied (see Tables 1-4). This was done, in part, to make the data comparable with those collected in the past (i.e., Harman et al. 2002). Additionally, Lord (2004) suggests that refuge construction contributes to the damage imparted by *Acentria* larvae. However, since a single larvae can build multiple refuges, this undoubtedly overestimates the actual number of *Acentria* reported.

On average, the damage by herbivory to milfoil tips and leaflets was considered "minor" on every date examined, implying a lack of effective control. However, it is possible that stems appearing relatively healthy do not necessarily indicate a lack of control of milfoil on a broader scale. Chronic, low level herbivory may not be obviously evident, though it might decrease the vigor of milfoil beds and/or favor lateral rather than vertical growth, resulting in a decreased canopy height, minimizing negative stakeholder impacts. This thesis could be evaluated only be incorporating an experimental design that somehow excluded the presence of herbivores in control sites without otherwise exerting other variables on milfoil growth.

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