Extension Bulletin WQ-61 • New • June 2009

Biological Control of Eurasian Watermilfoil: A Review of the Native Watermilfoil Weevil

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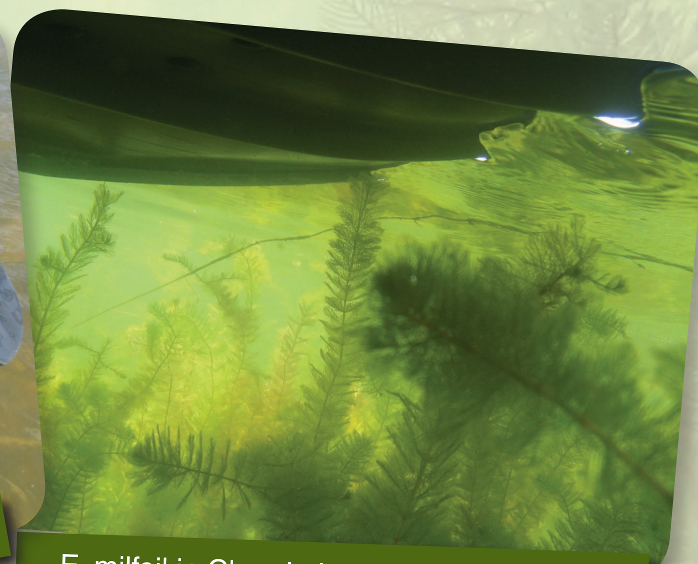
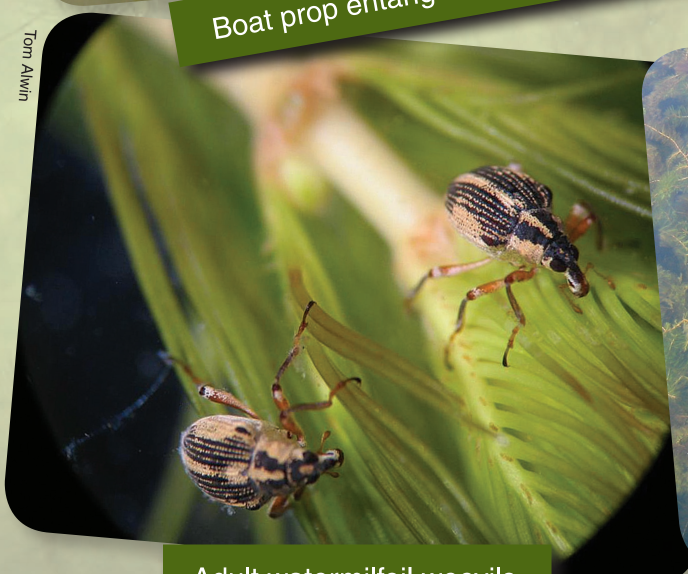
Boat prop entangled with E. milfoil.



Tom Alwin

E. milfoil in Clear Lake, Mecosta Co., Mich.



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Adult watermilfoil weevils.

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Looking down into a dense E. milfoil bed.

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Eurasian watermilfoil (*Myriophyllum spicatum*), hereafter referred to as "E. milfoil", is an invasive exotic aquatic plant that, once introduced, can reach nuisance levels in ponds, lakes, rivers and reservoirs. Dense E. milfoil growth can alter the physical and chemical conditions of water bodies and drastically change fish and wildlife habitat. Dense E. milfoil beds can also impede swimming, fishing and boating. Also, E. milfoil accumulating at the water surface or broken E. milfoil stems collecting on shore can reduce the aesthetic quality of the lake. Significant amounts of time and money are invested in E. milfoil management because of these potential impacts.

Preventing E. milfoil introduction and early detection need to be the first lines of defense. However, if your water body is already infested with E. milfoil, then deciding on a control strategy may be the next step. Several methods are available for whole-lake E. milfoil control. Each method has pros and cons associated with it (see Table 1 for details). This publication focuses on one of these methods: biological control. Biological control is defined as the use of biological means (such as parasites, viruses or predators) to control a pest. The benefits of this approach are selectivity — the control affects only the target pest — and the potential for long-term control. Also, biological control is generally considered a natural and sustainable method of control. This bulletin provides general information on a native watermilfoil weevil, *Euhrychiopsis lecontei*, a commercially available beetle that has shown some promise as a biocontrol agent for E. milfoil.

Euhrychiopsis lecontei ("yoo-RICK-e-op-sis la-CON-tee-eye") – the Milfoil Weevil

The watermilfoil weevil, hereafter referred to as "the weevil", is an aquatic beetle native to North America. Adult weevils reach a length of 3 millimeters (about the size of a sesame seed) and are dark-colored with brown to yellow stripes on their backs[1]. They can be found from coast to coast in the northern United States and southern Canada[2]. The weevil's natural host plant is a native variety of milfoil[2], but once it's exposed to E. milfoil, the weevil prefers it over native plants[3]. This high affinity for E. milfoil means that weevils will have little impact on other aquatic plants. On E. milfoil, weevil survival and reproductive rates are high, and weevil populations can reach levels capable of controlling E. milfoil. On native milfoil plants, however, weevil numbers remain low, and they generally do not negatively affect the native milfoil population[4]. Weevil survival on hybrids of E. milfoil and native milfoil is intermediate, and weevils' impact on hybrids is likely somewhere between their impact on native and invasive milfoils[5]. In small-scale laboratory studies, milfoil weevils have been found to be effective at controlling E. milfoil. These results indicate that the watermilfoil weevil may be an ideal biological control agent for E. milfoil.

Life cycle of the weevil

The weevil life cycle — egg, larva, pupa, adult — is closely coupled to milfoil. Adults feed on the leaves and stems of milfoil, reducing the plants' ability to photosynthesize[6]. Females can lay an average of two eggs per day on the growing tips of milfoil, and a maximum of five generations can be completed each summer[7]. Of all stages of the weevil's life cycle, the larval stage has the largest impact on the plant[6]. After hatching, larvae tunnel into the stem and eat the inner tissue. Their feeding interrupts the flow of nutrients through the plant. Lower nutrient concentrations in the roots may reduce E. milfoil's overwinter survival[8]. Larval tunneling also creates holes in the stem walls, which release the gases that keep the plant upright[6,9]. This reduced buoyancy can cause the plant to sink out of the water column and cause entire E. milfoil beds to collapse. Individual larvae then hollow out a pupal chamber in the upper portion of the plant (2 to 3 feet from the tip of the plant) to complete development. Pupal chambers, as well as the larval stem mining, have been found to increase stem breakage[8], but stem fragments that result from weevil damage rarely succeed in developing into new plants[10].

When the adult beetle emerges from the pupal chamber, it moves back to the E. milfoil canopy to feed and reproduce. Each season, the last generation of adults foregoes reproduction and instead stores fat for overwintering, which occurs in nearshore soil and leaf litter[7,11]. During the spring, adults emerge from the soil and return to the water to reproduce. Because all weevil life stages feed exclusively on milfoil, the weevil may be particularly well-suited as an agent for E. milfoil biocontrol.

E. milfoil control, not eradication

Although the weevil can be an effective control agent for E. milfoil under some conditions, it will not completely eliminate E. milfoil from a lake. In fact, some remaining E. milfoil is an important component necessary for long-term E. milfoil suppression. If E. milfoil is completely removed from the lake, weevil populations will not persist, leaving the lake vulnerable to reinfestation. Therefore, some E. milfoil remaining provides resources to maintain a small weevil population that can keep the E. milfoil in check for years to come. As in most natural systems, the weevil-milfoil interactions can fluctuate from year to year. In years when conditions are particularly good for plant growth, the E. milfoil population may grow too fast for complete control. There may be a slight lag before the weevil population builds up in response and again suppresses the E. milfoil to a low level.

Factors that may limit weevil density

Although the weevil's life history and host specificity suggest that it may be a promising biocontrol agent, effective E. milfoil suppression depends on weevil grazing rates, which, in turn, are influenced by the total number of weevils present. Weevils can be found in many lakes at low densities, but they are rarely found in high enough numbers to control E. milfoil[12]. So, if weevils are already present in a lake at low levels and there are abundant food resources (E. milfoil), why are populations not naturally increasing to a level that can control E. milfoil? Several explanations for this have been proposed, and research into these areas is ongoing. The following are possibilities.

Overwintering habitat

A lack of suitable overwintering sites has been suggested as a factor limiting weevil densities from one summer to the next. One study suggested that natural shoreline may be needed to maintain weevil populations through the winter months. However, overwintering was not the focus of the study, and the impact of shoreline type on overwintering could not be tested because each lake was sampled only once. In fact, several lines of evidence suggest that overwintering conditions may not affect weevil densities. First, 10 years of commercial weevil stocking efforts have not seen any sizeable differences in weevil population densities between lakes having natural shorelines versus lakes with developed shorelines (Hilovsky, EnviroScience Inc., personal comment). Second, the weevils' high reproductive rate should allow small spring populations to reach high levels within a single season[13]. Third, a study of two Minnesota lakes with natural shoreline determined that weevil densities were not limited by overwintering habitat[14].

The amount and type of habitat necessary for successful weevil overwintering are poorly understood. Additional scientific study on overwintering survival success in landscaped habitat (maintained lawn, flower beds, mulch, etc.) is necessary. Maintaining a wide buffer zone (25+ feet deep) of natural vegetation along the shore, where possible, may help weevil populations and may indirectly improve E. milfoil management by taking up incoming nutrients from the surrounding landscape and reducing nutrient availability for E. milfoil growth.

Predation

Predation by fish is another potential explanation for naturally low weevil populations and may also limit the effectiveness of weevil stocking efforts. Because larvae and pupae spend the majority of their time inside E. milfoil stems, they are protected from predation. Larvae are susceptible when they occasionally leave the stem, and within E. milfoil beds, adult weevils are exposed to predation[12].

Several studies have investigated the effects of fish predation on weevil populations. Neither black crappie nor yellow perch consumes weevils, but sunfish larger than 2 inches will eat the weevils[15]. In fact, lower sunfish densities have been associated with higher weevil densities[15], and in Cenailko Lake, Minnesota, during the early 1990s, an unexplained decrease in sunfish density coincided with the weevil population reaching densities high enough to control E. milfoil[16]. These studies provide evidence that sunfish consume weevils and may negatively affect weevil densities. Dense and complex E. milfoil beds, however, may limit predator success, provide a refuge for weevils and positively affect weevil densities. Computer modeling found that both the sunfish and E. milfoil density affect weevil density[13]. No field studies to date have addressed the interactions between fish predation, E. milfoil stem density and weevil density, which may be an important factor in the weevils' ability to suppress E. milfoil.

Reproduction rate

Another potential explanation for small naturally occurring weevil populations is difficulty finding mates. At naturally low densities, weevils may have difficulty locating mates and reproducing, especially in dense E. milfoil beds. This situation is an area of weevil research that has not been investigated but may be important.

Milfoil hybrids

Hybridization between E. milfoil and native milfoil species can occur. In fact, reports of lakes infested with milfoil hybrids are increasing. These hybrid plants can possess the qualities of both species and pose a serious threat to the effectiveness of both weevil control and current herbicide treatments.

Improving biocontrol efforts: integrated pest management

Although natural weevil populations rarely reach the numbers necessary to control E. milfoil infestations without artificial augmentation, several approaches can be implemented to improve E. milfoil control using weevils. The following three management approaches can be applied to either increase weevil densities or reduce E. milfoil growth rates:

1. **Conservation biocontrol** modifies the existing habitat or management practices to conserve or enhance existing biocontrol agent populations. For weevils, three strategies discussed in detail below are reducing nutrient inputs that promote E. milfoil growth, practicing integrated pest management and reducing predation pressure.
   - ***Reducing nutrient inputs:*** Reducing nutrient inputs to a lake will not directly benefit weevil populations but may be an important step in reducing E. milfoil growth over time. Nutrients entering a lake from the surrounding landscape act as fertilizer and encourage vigorous E. milfoil growth. Actions by the surrounding landowners to reduce nutrient input include applying lawn fertilizer as per manufacturer directions, not washing cars on the driveway or street, maintaining a buffer of "wild" vegetation at the water's edge and properly maintaining septic systems. For more information on these and other steps to reduce nutrient loading to your lake, check out Extension bulletin WQ57, "Lakescaping for Wildlife and Water Quality," published through the Minnesota Department of Natural Resources and available through the Michigan State University Extension Bulletin Office.
   - ***Practicing integrated pest management:*** Biocontrol can be part of a strategy that also includes any combination of physical, mechanical or chemical control methods. Lake-wide herbicide application and harvesting are likely counterproductive to weevil populations because, in the short term, they eliminate E. milfoil and leave no food for the weevil. However, strategies such as targeted herbicide application or benthic barriers (light-blocking material anchored to the lake bottom) can be incorporated with biocontrol management

practices. These applications can be beneficial in high-traffic areas (e.g., boat launches) or other areas not suitable for weevils and may lead to more rapid lake-wide E. milfoil control.

- ***Reducing weevil predation:*** Although it's often impractical at best, reducing the densities of predator sunfish may help increase weevil populations. Approaches that could be taken to decrease sunfish numbers include increasing the population of large fish (greater than 12 inches) that prey on sunfish (e.g., largemouth bass), either by reducing fishing pressure and/or stocking, or increasing fishing pressure on sunfish. More practically, a lake with high sunfish density may require a different stocking strategy or may not be suitable for use of weevils for E. milfoil control.

Additional strategies that may be beneficial are limiting the production and spread of E. milfoil fragments (keeping boat traffic out of E. milfoil beds) and improving weevil overwintering habitat.

2. **Inoculative biocontrol** is intentional release of an organism as a biocontrol agent with the intent that it will multiply and control the pest for an extended period[17]. Weevil stocking has been applied to many lakes, including 70 Michigan lakes during 1998-2006 (EnviroScience, Inc.), with varying degrees of success. Enhancing natural weevil populations is likely necessary in most lakes to achieve weevil densities high enough to control E. milfoil.
3. **Combining the two strategies** above will likely improve the success rates of E. milfoil biocontrol.

Conclusion

Evidence from laboratory research, 10 years of commercial stocking in Michigan lakes and multiple examples of E. milfoil declines attributed to weevils all suggest that weevils can be an effective biological control agent. However, the results of stocking efforts have been variable. In most cases, some decline in E. milfoil can be seen within one to four years, but in other cases, stocking efforts appear to be ineffective. More research on what limits weevil populations is necessary to improve control efforts using the watermilfoil weevil, and to determine where and under what circumstances weevils are most suitable for E. milfoil control.

Frequently asked questions about weevil stocking

Q: ***How many weevils are needed per acre of E. milfoil?***

A: This question is difficult to answer because each lake has a unique set of conditions. Even under controlled laboratory conditions, there is no consensus on the minimum number of weevils necessary to control E. milfoil. Therefore, the goal of stocking has not been to attain a specific density but rather to establish areas of the lake with permanent and ecologically significant subpopulations. The subpopulations can then spread and increase over time to achieve lake-wide suppression of E. milfoil. Establishing significant subpopulations typically requires several thousand weevils to be stocked in close proximity.

Q: ***How long will it take to achieve lake-wide E. milfoil control?***

A: This is another tough question to answer. Many factors play a role in determining the time needed for control, including lake size, quantity and density of the E. milfoil, and the number of weevils stocked. However, in most stocked Michigan lakes, lake-wide control (not eradication) has been achieved in one to four years.

Q: ***Will the weevils become a nuisance? Specifically, do they bite or swarm homes in the fall?***

A: The answer to these questions is no. Typically, the only sign indicating that weevils are present in a lake is the impact they have on E. milfoil. Early indicators of weevil activity include brown or blackened stems and stems that are collapsing or "candy-caning" in the water column.

Q: ***What does it cost to stock the weevil?***

A: Weevils are stocked in increments of 1,000 individuals. The current market price is $1,200 per thousand. Stocking is often done over the course of several years, with the number stocked per year determined on a case-by-case basis. Making a direct comparison between weevil stocking and herbicide treatment is difficult. Herbicide treatment, determined by lake area and volume, has been estimated to average $80 to $350 per acre of E. milfoil (http://www.co.midland.mi.us/departments/extra.php?id=9&pid=513).

Q: ***What time of the year is best for stocking?***

A: Mid-May through early August is best. Stocking weevils by midsummer allows several generations to be completed before overwintering.

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Table 1. Methods for E. milfoil control.

Method	Effectiveness	Advantages	Disadvantages	Costs	Additional comments
Mechanical harvesting	Not effective	• Rapid results • Boat lane creation	• High cost to purchase harvester • Short-term relief, may need multiple applications per year • Generally not selective • Not useful in shallow areas • Cuttings need land disposal site • Resulting fragments may promote spread of milfoil	• High initial investment • Significant ongoing costs: equipment maintenance, labor, transport/disposal of cuttings	No permitting required
Herbicides	Highly effective	• Rapid control • Selective control • Some can be spot applied	• Reapplication required every 1-3 years • Certified applicator required • Restrictions may be associated with waters used for drinking and irrigation • Some milfoil populations are showing signs of herbicide resistance • Some non-target impacts are possible • Avoiding skin contact (swimming) for 1-2 days after application may be advisable	• High ongoing costs: chemicals, permitting, applicator fees	MDEQ permit required
Weevils	Effective, but some lake-to-lake variability	• Has the potential to provide long-term, sustainable control • Very selective, no non-target impacts • Environmentally friendly, uses native North American insect • High degree of flexibility in application and cost	• Not a quick fix – time lag of 1-4 years from stocking to control • May have limited usefulness in very high traffic areas • May not be appropriate for all lakes	• Variable cost, depending on number of weevils stocked • Generally less expensive than other methods over 3- to 5-year period	No permitting required in Michigan

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Adult watermilfoil weevils.

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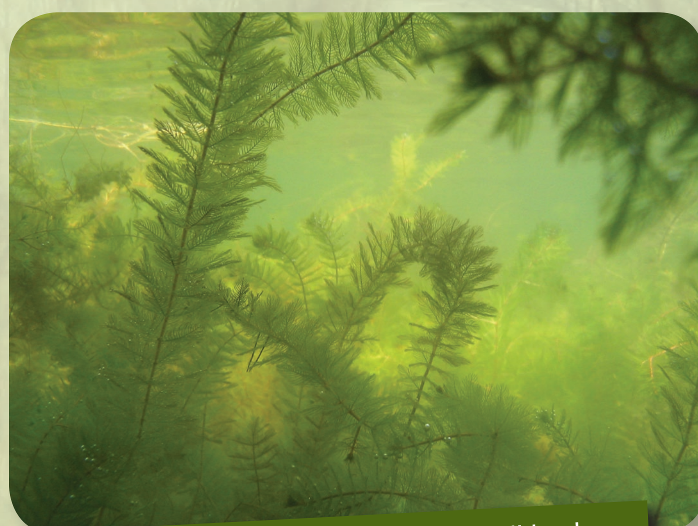
Looking down into a dense E. milfoil bed.

Tom Alwin

Collecting samples in an E. milfoil bed.

Tom Alwin



Underwater view of an E. milfoil bed.

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