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What's Bugging **Watermilfoil**

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What is Biocontrol?

Weeds thrive in part because insects and diseases that keep them in check in their native land are not introduced with them (by weed, I mean non-native plants that take over). Because they don't have to fight off pesky bugs, they are able to put all their energy into growth and reproduction. This isn't the only reason they dominate, but part of the picture. This is also the idea behind biological control (biocontrol). If the insects and diseases that keep the plant from being a problem in its native land can be introduced to its new range, the weed should lose at least some of its advantage over native plants.

In the early days of this practice some disasters took place that gave biocontrol a bad reputation – think cane toads in Australia. However, since then biocontrol has come under much tighter restrictions. In the U.S., insects or diseases must undergo stringent testing overseen by the U.S. Department of Agriculture to ensure they only survive and reproduce on the one weed that is being targeted. This ensures what is introduced will not then become a pest itself.

This practice of looking for biocontrol agents in the weed's native land, testing it to ensure it only eats the one plant, and eventually introducing it to the new range is known as *classical biocontrol*. There is another avenue that is sometimes followed, where insects or diseases already in the weed's new home find it appealing and start to eat it. These agents of control are then discovered when the weed starts to die back. At that point there is often an effort to learn about the "bug" causing the decline, and if it looks promising, to try increasing its population in new areas. This is called *augmentation*.

Biocontrol of Eurasian Watermilfoil

Eurasian watermilfoil is, of course, an invasive plant in many lakes and rivers across much of the United States and southern Canada. This has prompted searches in its native land for classical biocontrol agents, but so far none have made it through the process for release.

While Eurasian watermilfoil is certainly a problem in many waterbodies in Washington, there are also many where it doesn't take over the plant community, and doesn't grow to the surface to cause problems for recreational users. This phenomenon was first noticed in the northwest in the Okanogan Lakes of British Columbia in about 1980. Studies showed several insect herbivores were causing the Eurasian watermilfoil declines, and results were presented at the 2nd Annual NALMS conference in 1982 (Kangasniemi 1983). This was a long time ago! Unfortunately, the good work in British Columbia lost traction when their Eurasian watermilfoil program lost funding. A decade later a Eurasian watermilfoil decline in Vermont was investigated by Creed and Sheldon (1991). They found that a native aquatic weevil, the milfoil weevil (*Euhrychiopsis lecontei*), caused the extensive plant damage (Figures 1 and 2). Since then, much additional research has been done on this insect (Newman 2004). This weevil has been the primary focus of Eurasian watermilfoil biocontrol, with many augmentation projects having taken place, both experimentally and commercially.

Figure 1. Milfoil weevil adult on milfoil, stem damage typically resulting from larval mining can be seen on the upper portion of the plant. Photo by Kyle Borrowman.

Figure 2. Milfoil weevil adult on milfoil growing tip. Photo by Kyle Borrowman.

Because the milfoil weevil is already well known, I will spend a little time going over the other, less well-known insect herbivores implicated in causing Eurasian watermilfoil declines. Most of these were noted by Kangasniemi (1983). One such insect is the milfoil midge, *Cricotopus myriophylli* (Figures 3 and 4). This tiny fly is native to North America, and like the milfoil weevil, evolved with northern milfoil and feeds on it as well as Eurasian watermilfoil. The milfoil midge lives on milfoil as larvae, eating the growing tips. This is similar to the milfoil weevil, and I suspect there may be some competition between the two species if their populations are high. They were observed to be the primary insect causing Eurasian watermilfoil declines in the Okanagan Lakes in the 1980s, and they have been found in many other states and provinces. Early attempts to rear the milfoil midge and augment natural populations were largely unsuccessful; so much less research has been done on this insect than the milfoil weevil. In Washington we have found the milfoil midge associated with Eurasian watermilfoil in several lakes, and healthy populations are still in the Okanogan area on the Washington side of the border.

Other midge larvae can also cause Eurasian watermilfoil damage. Several studies have identified midge larvae that utilize Eurasian watermilfoil to various degrees, for example as a substrate to graze algae or filter water, or to graze on the plant itself. Unfortunately, this is a difficult group of insects to identify, so in the studies we have conducted, we aren't always sure which species cause the damage. However, we have seen relatives of the milfoil midge, in the *Cricotopus* group, which also damage the milfoil growing tips to the point that plant growth slows or stops. Also, a *Glyptotendipes* species will tunnel into the stems, often causing the upper part of the plant to die.

Figure 3. Milfoil midge case.

Figure 4. Midge larvae out of its case.

Another insect that can cause Eurasian watermilfoil declines in the northwest is the larvae of the caddisfly *Triaenodes tardus* (Figures 5 and 6). This insect grazes on milfoil and builds its case from leaf fragments. It is sometimes found on other plant species, but prefers milfoil, and will shred Eurasian watermilfoil to the point that only bare stems are left if the *Triaenodes* population is high enough. We raised some of these larvae in aquaria to adulthood in order to have them identified with confidence, and during that experiment we noted the tanks were littered with leaf fragments. This led us to suspect the insects are choosey when selecting pieces for their case, discarding many in the process. In Washington and British Columbia, high numbers of this caddisfly have done extensive damage to Eurasian watermilfoil in several lakes, but it is more typically found in lower numbers. In one study where we looked at fish diet, stocked trout in particular ate them and may play a role in keeping caddisfly numbers low.

A moth larvae, *Acentria ephemerella*, and possibly a different caddisfly larvae, cause Eurasian watermilfoil declines in the eastern U.S., but are not known from the northwest yet. Other beetles, caddisflies (including other *Triaenodes* spp), moth, and midge larvae have been noted as herbivores on native milfoil species (Harms and Grodowitz 2009), and may have potential in biocontrol of Eurasian watermilfoil if they will feed on it as well as the native species.

Of course, one wonders, if all these "bugs" are eating milfoil and other aquatic plants, why is plant growth sometimes so dense? That is the million-dollar question. Fish predation has been implicated in keeping herbivorous insect populations low, but may be more a matter of how many and what type of fish rather than absolute fish presence. Panfish such as pumpkinseed and bluegill have been particular suspects as predators on herbivorous insects. Weather also may play a part; last year's cold spring in Washington coincided with unusually low herbivorous insect numbers. Water quality, plant quality, and overwintering habitat are also likely to have an impact.

Investigations We Have Done

In Washington, we have investigated the relationship between invertebrates and Eurasian watermilfoil density in three lakes. We started with a milfoil weevil rearing and stocking trial in one small lake, Mattoon Lake. The results were recently published separately, but to summarize, in addition to weevils, we found the milfoil midge, *Triaenodes* caddisfly, as well as another unknown midge larvae damaging the Eurasian watermilfoil. In fact, the Eurasian watermilfoil decline was greatest prior to milfoil weevil establishment. From that experience, we learned that we should look comprehensively at invertebrates found on the plants, rather than focusing on one or two. During the study we also looked at fish predation, which correlated with changes in plant and invertebrate herbivore density. Initially the fish community was "out of balance" with many stunted pumpkinseed and few large predatory fish – typical for shallow lakes with dense, topped-out plant communities. By the study conclusion the fish community was more balanced and the plant community was more diverse with no topped out Eurasian watermilfoil beds and plentiful insect herbivores.

We also started monitoring plants and invertebrates in nearby Lavender Lake when we noticed Eurasian watermilfoil looked very scraggly. We found a natural population of milfoil weevils and also abundant *Triaenodes* caddisfly. Since then we have seen the Eurasian watermilfoil steadily decline, while the associated herbivores peaked and then also declined with the Eurasian watermilfoil. We only have fish data on this lake from the start of the study, and at that time there were high numbers of large picivorous (fish-eating) fish and few panfish.

The third lake, Stan Coffin Lake in central Washington, also has a natural population of milfoil weevils. In fact, the weevils were so abundant in 2002 that

Figure 5. Triaenodes larvae and case.

Figure 6. "Ratty"-looking milfoil with two Triaenodes caddisfly larvae and a swimming milfoil weevil from Lavender Lake.

it was used as our collection site during the Mattoon Lake augmentation project. The years for which we have plant and invertebrate data show that since then the milfoil population has varied, along with the associated invertebrates. (Note: the milfoil hybrid, a cross between Eurasian watermilfoil and the native northern milfoil, is present in this lake. So the term milfoil here means all three species combined). Fish have also been studied, and between 2003 and 2005, 400 largemouth bass were stocked annually to control panfish. Fish population data were collected between 2001 and 2005, and numbers of panfish increased over the study period, while yellow perch decreased. Our observations then show that while the milfoil weevil population was high, the panfish numbers were relatively low and the milfoil growth was also low. Then the two started to reverse, with dense milfoil growth, high panfish numbers, and low milfoil weevil numbers. A confounding factor may have been a prolonged dense algae bloom in 2003 that seemed to knock back the milfoil weevil population as well as reducing plant growth (Figure 7). In this lake we again noticed other midge species damaging the milfoil growing tips, including the milfoil midge and the stem mining midge *Glyptotendipes* sp. Lakes are complicated, and clearly much more could be learned about these relationships.

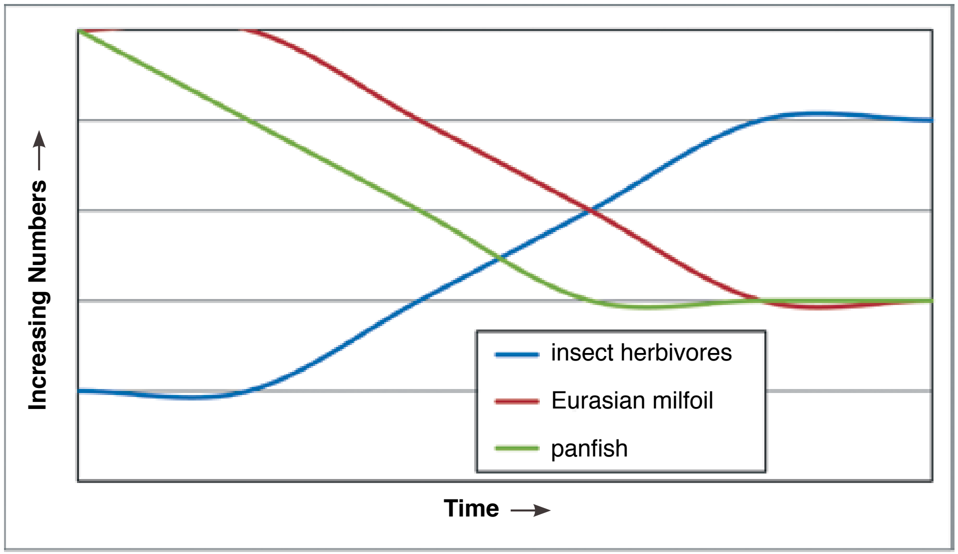

Figure 7. A general scheme showing a pattern observed in weedy lakes, where high panfish numbers correlate with low herbivorous insect numbers and dense Eurasian watermilfoil growth.

Summary and Conclusions

In Washington's lakes, native insect herbivores can control Eurasian watermilfoil in some lakes, particularly in the central part of the state. However, as would be expected, there can be periods when the herbivores will not thrive and the milfoil will resurge. What is behind this pattern is difficult to say. While predators on insect herbivores play a part, other factors such as severe weather events, water quality conditions, and plant quality also may play a role.

These correlations between insect herbivore abundance, plant density and fish community composition also have been observed by other investigators (Lord et al. 2003; Ward and Newman 2006). The studies support the idea that fish can have an important influence on the lake food chain where aquatic plants are the bottom of that chain, and insect herbivores are eating those plants. Aquatic plants have largely been overlooked as an important link in aquatic food webs – most studies focus instead on free floating and bottom-dwelling algae that are then grazed by invertebrates (Figure 8). This ties into the idea that promoting healthy populations of predators at the top of the food chain (typically, big fish that eat little fish, but fish-eating birds can also be important) can keep the little fish from becoming too abundant, that will in turn give the things those little fish are eating – the invertebrates that graze submersed plants and algae – a chance to thrive. (Note: birds such as swans and geese that directly eat aquatic plants can also have a strong influence on aquatic plant communities.)

More research on this aspect of aquatic food webs, especially in the northwest, would be valuable to lake managers. Perhaps herbivorous insects and other invertebrates could be enlisted in our efforts to sustain healthy lakes, along with nutrient reduction and other lake restoration techniques.

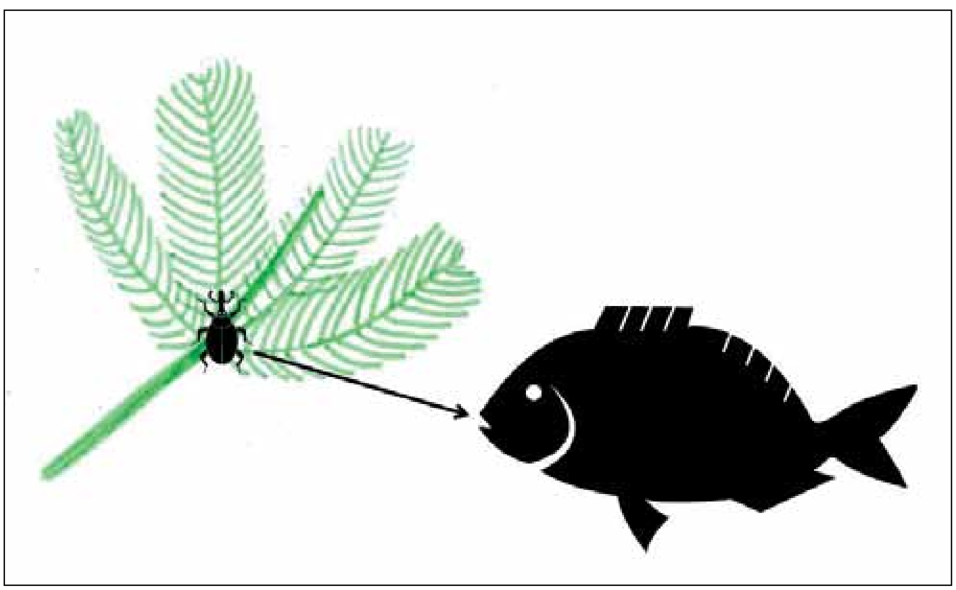

Figure 8. Crude illustration of the link between milfoil, herbivorous insects and a small fish. This is part of the lake food web, where the base of the food chain includes aquatic plants as well as algae. See LakeLine *from summer 2011 for more discussion on lake food webs.*

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