Description and Variation

A number of milfoil species occur in the western United States and many of these species are very similar to each other in appearance. Eurasian watermilfoil looks so much like its native relative *Myriophyllum sibericum* that it was once thought to be a variety of that species. Often, even milfoil experts must rely on pigment or DNA analysis to distinguish milfoil species from each other. Like many milfoils, Eurasian watermilfoil is a submersed perennial plant with finely dissected feather-like leaves. The leaves are arranged in whorls of 4 (rarely 5) around the stem at each node. Each Eurasian watermilfoil leaflet generally has 14 or more paired divisions per leaflet and this feature can be used about 70 percent of the time to distinguish Eurasian watermilfoil from other milfoil species. However, the number of pairs of leaflet divisions is very variable and can range from 5 to 24. Young plants and free floating plant fragments often develop leaflets with fewer than 14 divisions. In the photo above, the leaflet on the left is Eurasian watermilfoil and the other leaflet is northern milfoil (*Myriophyllum sibericum*). Note the difference in leaflet shape, number of divisions, and spacing of the divisions between the two species. Although the two species appear quite easy to distinguish in this photograph, many times these characteristics are not so distinctive.

The growing stem tips of Eurasian watermilfoil (and other milfoil species) are tassel-like and often red; especially early in the growing season. Tiny pinkish flowers occur on reddish spikes that stand several inches above the water and submerge when pollination is complete. The stem width of Eurasian watermilfoil almost doubles below the inflorescence. Lower flowers are pistillate, upper flowers staminate. Seeds are produced, but seedlings are rare in nature. In situations where water evaporates slowly and the plants gradually become stranded, Eurasian watermilfoil can develop into a land form. The leaves of the land form are smaller, stiffer, and have fewer divisions. If such plants are submerged, new growth with aquatic leaves develops in 7-10 days, but the first leaves formed have relatively few divisions and only later does the number of divisions increase to more than 12 leaflet pairs.

Economic Importance

Eurasian watermilfoil adversely impacts aquatic ecosystems by forming dense canopies that often shade out native vegetation. Monospecific stands of Eurasian watermilfoil provide poor habitat for waterfowl, fish, and other wildlife. Significant rates of plant sloughing and leaf turnover, as well as the decomposition of high
biomass at the end of the growing season, increase the internal loading of phosphorus and nitrogen to the water column. Dense Eurasian watermilfoil mats alter water quality by raising pH, decreasing oxygen under the mats, and increasing temperature. Eurasian watermilfoil impacts power generation and irrigation by clogging dam trash racks and intake pipes. Stagnant water created by Eurasian watermilfoil mats provides good breeding grounds for mosquitoes. Eurasian watermilfoil interferes with recreational activities such as swimming, boating, fishing and water skiing. In Washington State, private and government sources spend about $1,000,000 per year on Eurasian watermilfoil control. Other states and provinces (Minnesota, Wisconsin, Vermont, New York, and British Columbia) spend similar amounts per year to control Eurasian watermilfoil infestations.

**Geographic Distribution**

Eurasian watermilfoil is native to Europe, Asia, northern Africa and also occurs in Greenland. Eurasian watermilfoil is mainly a problem plant in North America, but it has been reported from Australia. In North America, Eurasian watermilfoil is found from Florida to Quebec in the east, and California to British Columbia in the west. It appears to be primarily spread from waterbody to waterbody through boating activity, although anglers have been known to deliberately plant this species in lakes. A number of populations found in Oklahoma were introduced by earthworm farmers who packed their product in Eurasian watermilfoil.

**Habitat**

Eurasian watermilfoil is an extremely adaptable plant, able to tolerate and even thrive in a variety of environmental conditions. It grows in still to flowing waters, can tolerate salinity's of up to 15 parts per thousand (half the salinity of Puget Sound in Washington), grows rooted in water depths from 1 to 10 meters (regularly reaching the surface while growing in water 3 to 5 meters deep), and can survive under ice. It is able to tolerate pHs from 5.4-11. Relative to other submersed plants, Eurasian watermilfoil requires high light, has a high photosynthetic rate, and can grow over a broad temperature range. Eurasian watermilfoil grows best on fine-textured, inorganic sediments and relatively poorly on highly organic sediments. Over the spectrum of infertile to enriched aquatic systems, Eurasian watermilfoil appears to prefer an approximate mid-point, although it occurs in ultra-oligotrophic lakes like Lake Tahoe in California and Lake Chelan in Washington and in hyper-eutrophic lakes.

**History**

Eurasian watermilfoil may have been introduced to the North American continent at Chesapeake Bay in the 1880s, although Couch and Nelson present evidence that the first collection of Eurasian watermilfoil was made from a pond in the District of Columbia during the fall of 1942. By 1985, Eurasian watermilfoil had been found in 33 states, the District of Columbia, and the Canadian provinces of British Columbia, Ontario, and Quebec.

**Growth and Development**

Eurasian watermilfoil exhibits an annual pattern of growth. In the spring, shoots begin to grow rapidly as water temperatures approach 15 degrees centigrade. When they near the surface, shoots branch profusely,
forming a dense canopy. The leaves below 1 meter senesce in response to self-shading. Typically, plants flower upon reaching the surface (usually in mid to late July). After flowering, plant biomass declines as the result of the fragmentation of stems. Where flowering occurs early, plant biomass may increase again later in the growing season and a second flowering may occur. During fall, plants die back to the root crowns, which sprout again in the spring. In areas with mild winters, like western Washington and Oregon Eurasian watermilfoil frequently overwinters in an evergreen form and may maintain considerable winter biomass. Eurasian watermilfoil plants do not form specialized overwintering structures such as turions. Carbohydrate storage occurs throughout overwintering shoots and roots.

Reproduction

Although Eurasian watermilfoil can potentially spread by both sexual and vegetative means, vegetative spread is considered the major method of reproduction. In Lake George, New York a young population of Eurasian watermilfoil averaged a seed set of 112 seeds per stalk. Eurasian watermilfoil seeds readily germinate in the laboratory and also germinated in situ in a study conducted in Lake George. Despite the high seed production, it is thought that germination of seed is not a significant factor in Eurasian watermilfoil reproduction. Seedlings have never been observed occurring naturally in situ, therefore colonization of new sites is mainly by vegetative fragments. During the growing season, the plant undergoes autofragmentation. The abscising fragments often develop roots at the nodes before separation from the parent plants. Fragments are also produced by wind and wave action and boating activities, with each fragment having the potential to develop into a new plant. Once introduced, Eurasian watermilfoil also may spread rapidly. In Currituck Sound, North Carolina, Eurasian watermilfoil was first reported in 1965 when approximately 40 hectares were densely infested and 200 to 400 hectares were lightly infested. A year later 3,200 hectares were heavily infested and 26,800 hectares had some milfoil plants. Nine years later, over 32,000 hectares were infested with Eurasian watermilfoil.

Response to Herbicides

Westerdahl and Getsinger report excellent control with 2,4-D, diquat, diquat and complexed copper, endothall dipotassium salt, and endothall and complexed copper. They report good control with fluridone. In Washington, fluridone (brand name Sonar®) has been successfully used to eradicate Eurasian watermilfoil in Long Lake, Thurston County and in other western Washington lakes. To be effective, fluridone concentrations of 10-15 ppb must be maintained in the water column for 10 to 12 weeks. Follow-up diver surveillance and hand-pulling of surviving plants is essential to the success of this technique. Some eradication attempts with fluridone have had mixed success in Washington. Factors such as surface and ground water inflows and development of land forms of Eurasian watermilfoil all affect the success rate. The herbicide triclopyr is undergoing federal aquatic registration and holds great promise for Eurasian watermilfoil control. Unlike fluridone, triclopyr requires a short contact time (18 to 48 hours) and will selectively control Eurasian watermilfoil while leaving many native aquatic plants relatively unaffected.

Response to Cultural Methods

Localized control (in swimming areas and around docks) can be achieved by covering the sediment with an opaque fabric which blocks light from the plants (bottom barriers or screens). Managers of reservoirs and some lake systems may have the ability to lower the water level as a method of managing aquatic plants. The Tennessee Valley Authority (TVA) uses both winter and summer water level drawdowns as effective way of reducing Eurasian watermilfoil biomass. They find that a drawdown of about 2 meters is effective in reducing excessive populations. Short-term dewatering for 2-3 days during period of freezing temperatures has been effective, but multiple exposures may improve control. A 1-week drawdown of a large TVA
Impoundment in July 1983 desiccated about 810 hectares of Eurasian watermilfoil. A narrow, relatively weed-free band occurred after refilling and control effects extended into the following two growing seasons. In Washington, the Bureau of Reclamation lowered the water level of Banks Lake in 1994 in an effort to manage Eurasian watermilfoil populations. The success of a drawdown on Eurasian watermilfoil is dependent on several factors such as degree of desiccation (drawdowns in rainy western Washington and Oregon are often ineffective), the composition of substrate (sand vs. clay), air temperature (the exposed sediments need to freeze down to 8-12 inches), and presence of snow.

Response to Mechanical Methods

Because this plant spreads readily through fragmentation, mechanical controls such as cutting, harvesting, and rotovation (underwater rototilling) should be used only when the extent of the infestation is such that all available niches have been filled. Using mechanical controls while the plant is still invading, will tend to enhance its rate of spread.

Rotovation: The British Columbia Ministry of Environment developed a barge mounted rototilling machine called a rotovator to remove Eurasian watermilfoil roots. Underwater tiller blades churn up to 8 inches into the sediment and dislodge buoyant Eurasian watermilfoil roots. Floating roots may then be collected from the water. Control with rotovation, generally extends 2 or more growing seasons.

Harvesting: Harvesting can be compared to underwater lawn mowing. Plants are cut generally 5 feet below the water's surface, collected by conveyer, and stored until disposal on land. Harvesting removes surfacing mats and creates open areas of water. However because of its rapid growth rate Eurasian watermilfoil generally needs to be harvested twice during the growing season.

Cutting: Cutting is similar to harvesting except cut plants are not picked up from the water by the cutting machine. Washington requires that cut plants be removed from the water.

Biocontrol Potentials

Insects: The United States Department of Agriculture in conjunction with the Army Corps of Engineers have carried out searches for Eurasian watermilfoil biological control agents in Pakistan, Bangladesh, China, Korea, and Yugoslavia. Several insects have been evaluated, including a number of pyralid moths and several stem-boring weevils. However, many of these insects were found to be non-specific to Eurasian watermilfoil or to offer little potential as effective biological control agents. In British Columbia, several insects were associated with Eurasian watermilfoil and a midge was investigated as a potential control agent. However, the midge proved to be extremely difficult to rear in the laboratory. The North American weevil, *Euhrychiopsis lecontei* (Dietz) has been found associated with declining populations of Eurasian watermilfoil in northeastern North America. *Euhrychiopsis lecontei* has been found in Washington state feeding on both Eurasian watermilfoil and northern milfoil (*Myriophyllum sibericum*) plants. Studies have shown that this native weevil appears to be a milfoil specialist and will not feed on other macrophyte species. It can be easily raised in the laboratory and laboratory-reared weevils could be used to augment natural populations, as is being tried in Vermont and Wisconsin.

Grass Carp: Although triploid grass carp will eat Eurasian watermilfoil, it is not a highly palatable or preferred species. To achieve control of Eurasian watermilfoil generally means the total removal of more palatable native aquatic species before the grass carp will consume Eurasian watermilfoil. In situations where Eurasian watermilfoil is the only aquatic plant species in the lake, this may be acceptable. However, generally grass carp are not recommended for Eurasian watermilfoil control.
Plant Pathogens: Interest in pathogens of Eurasian watermilfoil was stimulated by extensive mortality of Eurasian watermilfoil in Lake Venice and the Northeast River, Maryland in the late 1960s. At that time, the declines (called Northeast Disease) were suspected to be caused by a pathogen, although no pathogens were ever isolated. However Northeast Disease stimulated research into the use of plant pathogens for biological control. The plant pathogenic fungus *Mycoleptodiscus terrestris* has been shown to significantly reduce Eurasian watermilfoil biomass in laboratory studies. A commercial biotechnology firm spent several years developing this fungus as a biological tool to control Eurasian watermilfoil, but was unable to achieve control of the plant in field settings. The US Army Corps of Engineers is continuing research on plant pathogens.

References:


