Resume Of Studies And Control Of Eurasian Watermilfoil (Myriophllum Spicatum L.) In The Tennessee Valley From 1960 Through 1969[1]

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INTRODUCTIOON

From its inception, TVA has been concerned about the control of marginal and submersed aquatic plants which break the water surface and provide suitable breeding places for the mosquito vector of malaria, *Anopheles quadrimaculatus.* The structure of dams was modified to allow for special water level fluctuation and seasonal recession to help control plants and mosquitoes.

Many biological changes and adjustments have taken place in TVA's reservoirs over a period of years. The lakes have become increasingly clear, and nutrients have been added from changing agricultural practices, new industries, and increased population centers along the river. A variety of ecological factors, some known and some unknown, has resulted in an increase in the growth of submersed aquatic plants.

In 1960 Eurasian watermilfoil (*Myriophyllum spicatum* L.) was identified for the first time from the Piney River embayment of Watts Bar Reservoir. At that time its known distribution in the Tennessee Valley was confined to the lower end of this one reservoir. By 1969, there were over 25,000 acres in eight reservoirs.

This old-world, rooted, submersed plant has become the most troublesome aquatic weed in TVA reservoirs. Due to its rapid rates of growth, fragmentation, migration, and establishment, milfoil is a serious threat to several uses of the Valley's water resources. For example, in some reservoir areas, heavy infestations have (a) depressed real estate values, (b) stopped recreational activities such as boating, fishing, skiing, and swimming, (c) clogged municipal and industrial water supply intakes, and (d) provided extensive new breeding areas for mosquitoes in surface mats from July to midwinted (1).

BIONOMICS

The most efficient method of reproduction and spread of milfoil is by fragamentation. Either large, mature plant parts break off and float to new areas, or very small portions (2 to 6 in) of the plant tips are abscised, float for a period of time, and then lose their buoyancy and settle to the lake bottom. The abscised tips develop roots which anchor the plant to the soil, and under favorable conditions start new colonies (Figure 1). A single, 2-inch fragment may take root and grow 4 feet or more in one season. During the second year, multiple stems arise from the rooted base and may achieve lengths of 8 to 15 feet, and their fragmentation continues the spread of the plant. Some floating plant parts may be seen throughout the year, but observations suggest that peak releases of abscission fragments occur in the spring and fall.

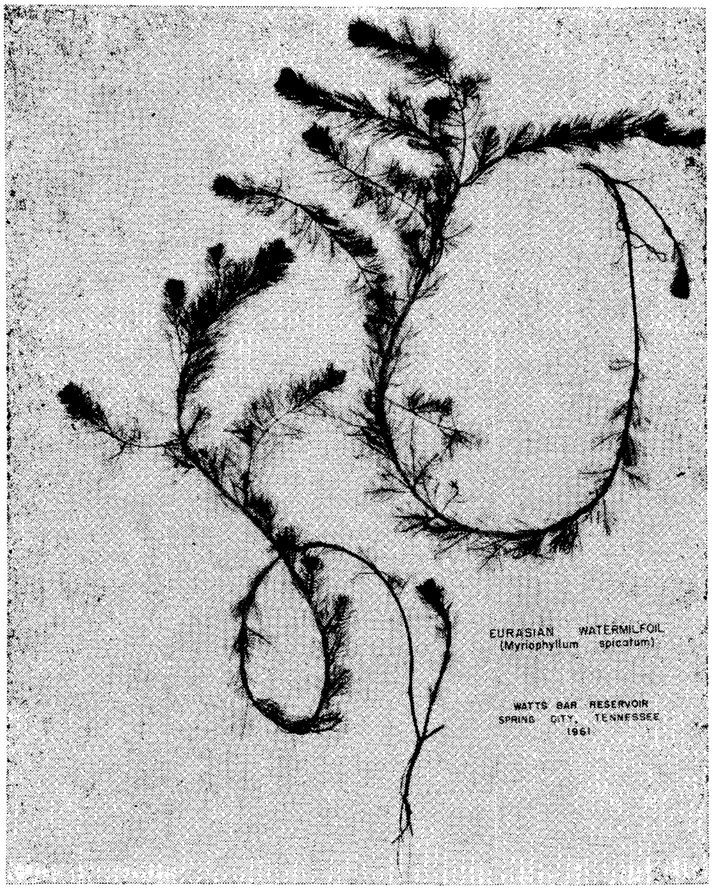

Figure 1. Left (inset) - Roots (shown against black) develop from tips of broken plant fragments to start new milfoil colonies. Right - A two months' growth from plant fragments (½ natural size).

Old plants in quiet embayments reach the water surface about the first of July, produce a flowering peak in mid-August, and subsequently form fruit with viable seed. Milfoil seedlings have been sought but have not been found in reservoirs in the Tennessee Valley.

This rooted, submersed aquatic plant will grow in

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water as deep as sufficient light will penetrate; in some reservoirs this is as much as 15 feet.

Apparently nutrients in soil or water are not limiting factors in the growth of watermilfoil in reservoirs in the Tennessee Valley, but other environmental factors such as low calcium content of the water may be. Trials indicate that milfoil will not grow or survive in a small pond where the alkalinity is less than 20 mg calcium carbonate per liter (11).

ECONOMIC VALUE

A considerable amount of work has been done by others to determine the nutritive value of watermilfoil. This weed was considered as a potential source of xanthophyll in chicken feed. In feeding tests, it was found that meal made from *Myriophyllum* pigmented broilers, and that xanthophyll derived from it was very unstable. Analysis indicates that watermilfoil is low in proteins and carbohydrates. Analyses for Ca, K, Na, N, P, and Mg have shown that it is not a good source of nutritive elements (2). Other studies determined that *M. spicatum* would not be an economically feasible substitute or supplement for commercial fertilizer due to a low N-P-K value of 3-2-5 (3). These facts are not surprising when one considers that over 90% of the fresh weight of the plant is water and that diatoms and quartz on the outside of the plant may contribute substantially to its weight and ash content. Grainy quartz was the only crystalline substance found to be common in the materials covering the plant surface (4).

Suggestions have been made that a way be found to use this plant as edible food, but nothing less than a culinary genius could make an appetizing dis from watermilfoil! Its greatests assets seem to be harboring great numbers of fish food organisms and furnishing coverts for fish.

RATES OF SPREAD

After watermilfoil escaped from the Piney River embayment to the main river portion of Watts Bar Lake, its spread to downstream areas was greatly enhanced by normal streamflow, and wind and boating activities carried it to upstream areas. The TVA dams serve as natural barriers to its downstream progress during periods of low streamflow, but floating plant fragments may move freely over the spillways when high flows occur during flood periods.

In spite of extensive control efforts, a substantial increase in milfoil infestations occurred from 1960 to 1969.

In 1960, milfoil was limited to the lower end of Watts Bar Reservoir. By the end of 1961, newly established colonies were found 40 miles downstream in the upper end of Chickamauga Reservoir. In September 1962, a single rooted fragment was found in Lake Wilson, 270 miles downstream from Piney River embayment. Careful surveys by boat and helicopter in 1963 confirmed the expected spread of the plant downstream; new, well-established colonies, were found along the main stream in Chickamauga, Hales Bar (Nickajack), and Guntersville. By 1965, an upstream tributary reservoir, Melton Hill, was found infested by unknown methods, and rooted colonies were also found in Wheeler Reservoir. The first rooted plants were found in Pickwick in 1969.

The explosive growth and spread of watermilfoil by fragmentation seem to be by geometric progression. Theoretical calculations have been made which indicate that in one year's time one fragment could propagate almost 250 million new fragments (5).

CHEMICAL CONTROL

Experimental chemical control tests were started in 1960 and continued through 1969. During this period numerous herbicides and chemical formulations with potential value for milfoil control were tested at various rates, combinations, and seasons of the year, and under various reservoir conditions. In these studies, TVA scientists have communicated and collaborated with colleagues throughout the United States and Europe.

Tests showed that watermilfoil is very susceptible to the 2,4-D herbicides and that it could be successfully controlled by these chemicals under certain conditions. Chemical control is more effective and practical in protected embayments but is usually ineffective along main river and lake shorelines where the chemicals are rapidly dissipated by dilution and water interchange. In most tests, spring applications proved more effective than at any other time of the year (6).

In the spring of 1962, the first full-scale operational control program was initiated. Efforts were made to treat all known colonies of milfoil in both Watts Bar and Chickamauga Reservoirs, amounting to 2,075 acres. A granular preparation containing 20% 2,4-D acid equivalent (butoxyethanol ester) was dispersed by helicopter at a rate of 100 pounds of granules per acre (20 lb. acid equivalent). Approximately 1,160 surface acres of milfoil were treated in Piney River embayment, 475 acres along or near the main river of Watts Bar Reservoir, and 440 acres in the upper end of Chickamauga Reservoir. These treatments made in the same way, near the same time, and at the same application rate yielded (a) complete elimination of all milfoil from the 1,160-acre Piney River embayment which continues to remain free of the plant 8 years after treatment and (b) chemical mowing of the 915 acres along the main river where dilution impaired effectiveness.

In the years that followed this treatment, favorable water levels plus increased and repeated chemical pressures have drastically reduced milfoil infestations in both Watts Bar and Chickamauga Reservoirs.

From 1962 through June 30, 1969, a total of 35,636 accumulative acres of watermilfoil was treated in eight reservoirs with 1,441,385 pounds of 2,4-D acid equivalent in two formulations. One was a 20% granular formulation of butoxyethanol ester of 2,4-D on attaclay granules; the other was liquid dimethylamine salt of 2,4-D, which was not used in quantity until 1969. Both formulations were applied at rates of 20 and 40 pounds of 2,4-D acid equivalent per acre. Three hundred fifty acres were treated with Diquat at the rate of 1 gallon (2 lb. cation Diquat) per acre. The total cost for watermilfoil control operations in all reservoirs from 1962-1969 amounted to $1,588,264 (7).

Chemical control is very expensive but may bring temporary relief in some areas. Because watermilfoil can spread and grow so rapidly in flowing waters of main river reservoirs, "chemical mowing" or 99% control is not good enough to hold it in check. While milfoil may be essentially eliminated from some protected embayments by chemical applications, these areas may soon become reinfested by new fragments from outside areas or from a few surviving plants.

New methods for application of the herbicide are needed in the development of more effective and economical measures for milfoil control. These could take the form of new materials or different formulations of old materials to give controlled release of the herbicide; or possibly a combination of new and old formulations might give synergistic action.

Studies have been made and are continuing on the effects of these large-scale applications of herbicide on aquatic fauna and water quality. Data collected indicate that 2,4-D applied for watermilfoil control on TVA reservoirs has not produced adverse effects on aquatic fauna and water quality (8).

ENVIRONMENTAL CONTROL

Previous experience with water level manipulation in the control of plants led TVA to consider the possibility of controlling watermilfoil by this means. It has been determined that dewatering is the most effective method available for milfoil control. The normal 6-foot wintertime water level drawdown of Watts Bar and Chickamauga Reservoirs kills all of the plants on well drained shorelines in dewatered zones, but because of the depth to which the plant is able to survive and flourish, normal reservoir drawdown schedules are insufficient for complete control. Special dewatering operations must be limited because of complex multipurpose uses of water from TVA reservoirs. Guntersville Reservoir is normally limited to a 2-foot drawdown and has a number of poorly drained sites, resulting in a very serious milfoil control problem. In some temporarily dewatered areas, land forms of milfoil develop which revert to the aquatic forms when inundated (9).

The competitiveness between lotus (*Nelumbo lutea*) and watermilfoil is being studied. Evidence indicates that lotus will shade out and kill milfoil in selected areas. If it should become desirable to kill the lotus, this may be done with about 1/20 as much herbicide as normally required to kill milfoil (10).

Many biological-ecological studies have been made, but more research is needed to determine the significance of various aspects of water quality and the specific requirements or conditions necessary for the growth of watermilfoil. These are prerequisites to the development of more effective preventive or control measures. One may guess at some of the cause-and-effect relationships, but most of them are unknown and need to be carefully studied.

More sophisticated instrumentation is needed to provide continuous, accurate records of light energy and other environmental conditions. Such information would be integrated with sampling and observation by specialists in aquatic botany, plant physiology, limnology, and ecology.

All aspects of environmental and biological control need further investigation, especially pathogens, insect vectors of plant diseases, herbivorous fish, and aquatic plant competitiveness.

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