Naturally Occurring Antagonistic Relationships Among Aquatic Plants That May Be Useful in Their Management[1]

by
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Aquatic vegetation causes serious problems in both natural and man-made bodies of water. It impedes the delivery of water in canals; plugs orifices of sprinkle-irrigation equipment; creates offensive tastes and odors in potable water; encourages breeding habitats of mosquitoes, midges, and snails; depreciates real estate values because of poor aesthetics; and decreases the usefulness of water used for recreational purposes.

Current methods of controlling aquatic weeds primarily include the use of herbicides and mechanical techniques. Both methods have some disadvantages. They are expensive, can greatly alter the aesthetics or harm fish and other fauna and flora, and usually control target vegetation for only short periods before it regrows or is replaced by other undesirable vegetation.

Biological control techniques offer safer and sometimes more enduring weed control than chemical or mechanical approaches. This method of controlling aquatic weeds involves the use of organisms to suppress or eliminate unwanted aquatic vegetation. This paper is concerned with naturally occurring antagonistic relationships among aquatic plants that may be useful in devising procedures for their management.

There are several bases for the antagonistic associations that cause aquatic plants to adversely influence the growth of other aquatic plants. These include competition for a critical growth factor, antipathic inhibitions, and variations in natural growth adaptations. Specific examples of these occur naturally and may be used to manage aquatic vegetation. Many of these natural occurrences cannot be effectively utilized, except in special situations, because they result in unwanted vegetation and it is this type of vegetation we wish to manage.

Competition for one or more of several critical growth factors can be used as a tool for managing aquatic vegetation. Light is a critical growth factor and shading by dense growth of aquatic plants can reduce the necessary amount of sunlight needed to sustain the normal growth of another plant. Dense canopies of the floating leaves of yellow pondlily (*Nuphar* sp.) and lotus (*Nymphaea* sp.) and thick mats of stoloniferous free-floating plants, such as waterlettuce (*Pistia stratiotes* L.) and waterhyacinth (*Eichhornia crassipes* (Mart.) Solms) severely curtail penetration of light through the surface, thereby inhibiting the growth of vascular plants and phytoplankton in the water beneath (Sakai, 1961). We have observed that watershield (*Brasenia schreberi* Gmel.), and the South American waterlily (*Victoria amazonica* Sow.) exert a similar influence. Van Zon (1973) found that duckweeds (*Lemna* sp.) and waterlilies (*Lotus* sp.) retard the growth of submersed aquatic weeds in ditches and canals by intercepting sunlight.

Dense algal blooms, produced by the addition of inorganic fertilizers to ponds, are used successfully in the southeastern United States to control rooted vascular weeds by shading (Swingle & Smith, 1947). Oborn (Oborn *et al.,* 1954) described another example of shading with algae. He found that the ephiphytic pond scum *Oedogonium* sp. and several species of diatoms coated the stems and leaves of leafy pondweed (*Potamogeton foliosus* Raf.) sufficently to reduce photosynthesis and kill the shoots.

Competition for nutrients is a critical factor in aquatic weed growth and the competition often results in the development of monocultures that dominate the habitat. Alikunhi and coworks (1952) found that when common duckweed (*Lemna minor* L.) was introduced into fish ponds containing planktonic algal blooms, the algae disappeared within 6 days. They implied that the dense layer of duckweed at the surface killed the algae by reducing available light and air. However, the findings of Silvey (1967) suggest that the disappearance

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of the algae was more apt to be due to the inability of the algae to compete with the duckweed for certain nutrients. He found that duckweed collected from the American River in California had a high affinity for iron and manganese. The duckweed contained 1,840 ppmw of iron and 922 ppmw of manganese in water containing 0.00057 and 0.002 ppmw of iron and manganese, respectively. Fitzgerald (1969) notes that antagonistic activity exists between populations of vascular aquatic weeds and filamentous green algae. When the nitrogen is limiting, the algae disappear. Aquatic bacteria of the genus *Pseudomonas* suppress the growth of the algae, *Scenedesmus* sp., by depriving the algae of phosphorus (Rhee, 1972).

Another critical factor influencing the dominance between competing plants is the competition for water by roots (Sakai, 1961). Certain plants persist in aquatic and semi-aquatic sites because their roots are positioned to the best advantage to utilize water. An extensive root system in close proximity to water gives a competing advantage to an establishing plant. We have observed cattails (*Typha* sp.), bulrushes (*Scripus* sp.) reed canarygrass (*Phalaris arundinacea* L.), Nebraska sedge (*Carex nebraskensis* Dewey), and saltcedar (*Tamarix pentandra* Pall.) as successful competitor species commonly occurring along waterlines of reservoirs and canals. These plants are usually considered undesirable. In contrast, some short-growing perennial grasses, saltgrass (*Distichlis spicata* (L.) Greene) and Kentucky bluegrass (*Poa pratense* L.), have dense fibrous root systems and thrive along the waterlines of some canals.

The integral part oxygen plays as a critical factor in the dominance of aquatic plants has not been fully explored. Sculthorpe (1967) reports that common reed (*Phragmites communis* Trin.) successfully excludes mannagrass (*Glyceria maxima* O. R. Holm) in marshes and that the competitive advantage of common reed is due to its roots having a higher proportion of lacunate air parenchyma than mannagrass. We believe that exploitation of the competition for substrate oxygen used in respiration by certain submersed aquatic plants may also be a possibility for retarding the growth of some rooted aquatic species.

Space is an important factor in preventing the invasion of a new species into an established growth. Johannes (1974) found that germinated seeds of burreed (*Sparaganium erectum* L. Curt.) and curlyleaf pondweed (*Potamogeton crispus* L.) placed over a dense lawn-like growth of slender spikerush (*Eleocharis acicularis* (L.) R. & S.) could not penetrate the growth. Roots of the seedlings became entangled and were held up by the stiff erect and dense culms of the slender spikerush. This has also been observed by the author to occur when rootstocks of American elodea (*Elodea canadensis* Michx.) and roots of newly germinated turions on curlyleaf pondweed are placed over an established stand of spikerush. Van Zon (1973) reports that in the autumn, some weeds cannot penetrate the dense spikerush sod to develop winterbuds, while in the spring, other plants cannot grow through it from their rootstocks. Some monocultures of aquatic plants become so dense that the physical aspect of space would not allow additional floating plants to penetrate the canopy, as exhibited by the South American aquatic-sensitive plant *Mimosa pigra* L.

Certain terrestrial plants develop toxins or inhibiting substances that are released from the plants while they are alive. Other plants develop precursors of substances that become toxic upon decomposition of the plant tissues. These have been discussed by Evanari (1961), Muller (1966), and Rice (1974). However, this discussion is limited to aquatic situations.

Sources of natural substances that cause inhibition of growth of plants include secretions from leaf surfaces or exudations from roots. They may be volatile or nonvolatile. Numberous algae release inhibitory substances. The alga, *Pandorina morum* (Mull.) Bory, produces an inhibitor that reduces the photosynthesis of several species of *Volvox,* but does not affect their respiration (Harris, 1975). Boyd (1973) reports that a *Chlamydomonas* species inhibits the growth of *Scenedesmus dimorphus* Kutz.,*Colastrum microporum* Naegeli, and *Chlorella pyrenoidosa* Chick. *Pithophora* sp. will keep fish aquaria clear of *Ankistrodesmus* sp. and *Scenedesmus* sp. Fresh filtrates of macerated *Scenedesmus quadricauda* (Turp.) Breb. inhibit the growth of other algae (Lefevre & Jacob, 1949).

Leachates from certain dead leaf tissues and decomposed plants contain growth retardants. Whittaker (Whittaker & Feeney, 1971) states that in both successional and climax communities strongly dominated by a single species, chemical effects of that species on the soil may limit the number of other species able to occupy the site. Aqueous extracts of cattail leaves inhibit the germination of *Typha* seeds and water squeezed from soil collected in a cattail marsh inhibits the growth of seedlings (McNaughton, 1968). Szczepanski (1971) reports that when cattails were cultivated together with common reed, the growth of common reed was reduced by 61 percent. He also states that substances leached from the dead leaves of *Glyceria aquatic* Walenb. inhibit the germination of other plants.

Diseases and parasites exert antagonisms that weaken a species and may allow other plants resistant to the pathogens to successfully displace them. However, most reports discuss only *cause* and *effect* by these vectors with no consideration given to final management of the affected site. Various ascomycetes, basidiomycetes, and other fungal parasites infect the vegetative organs of emersed aquatic plants such as mannagrass, cattails, common reed, and bulrushes (Szczpanski, 1971). Parasitic fungi will significantly decrease transpiration in common reed, and *Puccinia phragmitis* (Schum.) Koern will reduce the nitrogen content in the leaves of this plant. Both effects seriously stress the plant. The fungus, *Phaetrichoconis crotalaria* Sal & Rao, will kill waterclover (*Marsilea quadrifolia* L.) (Ponnappa, 1967).Vibrolike bacteria cause lysis in *Chlorella vulgaris* Beij. (Mamkaeva, 1966).

Growth adaptations of plants that adversely influence the growth of other plants include a) seasonal variations of different growth stages and b) population potentials that vary between plant species. Knowledge of these variations and potentials can be used to manage aquatic vegetation.

We have observed some plants, particularly *Carex* sp. and *Eleocharis* sp., that emerge and flower early in the season and grow vegetatively the remainder of the year. When a neighbor plant emerges and flowers later in the season, it consumes large amounts of stored food reserves in the process and the overall net food reserves in the plant are depleted, slowing its rate of growth. It may then lack the aggressiveness to successfully compete with the other actively growing plants. Another seasonal variation we have observed occurs when curlyleaf pondweed (*Potamogeton crispus* L.) and sago pondweed (*Potamogeton pectinatus* L.) complete their active growth in the fall and the foliage dies back. If slender spikerush (*Eleocharis acicularis*) or dwarf spikerush (*Eleocharis coloradoensis* (Britt.) Gilly) occurs on the site, they continue growing and encroach upon the area previously occupied by the pondweeds, preventing their regrowth in this area the following spring. The replacement of the pondweeds by short-growing plants such as these spikerushes is coveted as they continue to encroach on the weeds and eventually displace them. Short-growing plants that develop monocultures that dominate aquatic sites early in the season include: pigmyweed (*Tilleae aquatica* L.), quillwort (*Isoetes Bolanderi* Englm.), and mudwort (*Limnosella acaulis* Sesse & Macino) (Yeo & Fisher, 1970).

Certain annual aquatic and semi-aquatic plants attain a seasonal predominance if they emerge early in the season by rapid germination of large numbers of seed, tubers, or other propagules. This is evidenced by the prolific seed-producer, horned pondweed (*Zannichellia palustris* L.), capable of producing in excess of 2,000,000 seeds a year from a single plant (Yeo, 1966). It frequently dominates the aquatic vegetation in channels early in the spring. Also, certain marsh plants such as cattails (*Typha* sp.) have specialized adaptations for disseminating large number of seeds and frequently dominate newly flooded areas (Yeo, 1964).

Many natural occurrences of antagonistic associations among plants have been referred to for displacing one aquatic plant with another. Only a few situations remedy the original weed problem by replacing the unwanted vegetation with an acceptable type. The method used to alter the unwanted vegetation should be carefully selected. Several methods that consider plant replacement include: a) Encourage the natural influx of a replacement plant by manipulating the environment in a manner that will accomodate its establishment and growth. Such manipulation may include fluctuating the water level, increasing fertility, or removing the existing vegetation by mechanical or chemical means. b) Introduce large numbers of propagules of the replacement plant into the weed-infested area, preferably when the weed is dormant. c) Remove the existing weed growth with a herbicide to facilitate sowing of abundant propagules of the replacement plant. The reduced competition from the weed during the early stages of growth of the replacement plant will enhance its establishment. d) In newly constructed water systems that are devoid of aquatic vegetation, weed problems can be prevented from occurring by careful preparation to establish a desirable vegetation on the bottom soil and along the waterline before the final filling of the system with water.

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