The distribution and spread of salvinia in Australia

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SUMMARY

Salvinia molesta is a sterile, pentaploid, aquatic fern which originated in South America but is now widely distributed in the tropics and sub-tropics. In Australia, it is widespread on the east coast and is also found in a number of other places as far apart as Perth, Darwin and Mount Isa. The main agent for its dispersal is man. The plant is capable of rapid vegetative growth and interferes with utilization of water resources. The cost of the plant to Australia is difficult to estimate but, in Lake Moondarra (Mount Isa) alone, $126000 has been spent on its control in 1976 and 1977. It is felt that current infestations should be diminished wherever possible and every attempt must be made to prevent further spread of the plant. Any new outbreaks should be controlled chemically and monitored for at least 5 years thereafter. Research on the ecology of salvinia and possibilities for its biological control should continue.

INTRODUCTION

Salvinia (*Salvinia molesta* D.S. Mitchell) is an aquatic fern belonging to the family, Salviniaceae. There are at least 10 species in the genus, and 7 of these are neotropical in origin. None is native to Australia. Among the neotropical species are 4, *S. auriculata, S. herzogii, S. biloba,* and *S. molesta*, which Herzog (1935) considered as one species, *S. auriculata*, on the basis of the nature of the upper surface of the leaf. This is covered with rows of multicellular papillae, each of which is surmounted by four hairs joined together at their tips in a birdcage-like arrangement. Subsequently, de la Sota (1962) and Mitchell (1972) showed that the reproductive structures (sporocarps) were different within this group and separated *S. herzogii* and *S. molesta*, respectively. All the plants so far collected in Australia belong to *S. molesta*, though they had previously been called *S. auriculata.*

Salvinia molesta is a sterile pentaploid in which spore production is largely abortive and germination does not occur (Loyal and Grewal, 1966; Mitchell, 1970). Although it is clearly South American in origin, it has not been recorded growing in natural conditions there. However, herbarium specimens of the species were collected from the Rio de Janiero Botanic Garden and it has been suggested that the species arose as an accidental horticultural hybrid (Mitchell, 1972).

Salvinia is a free floating plant with horizontal rhizomes. At each node there is a pair of floating leaves and a submerged root-like organ, which bears the sporocarps when these are present and which is regarded as a modified leaf or a dissected axis. Vegetative growth is rapid in suitable conditions (calm water, high

nutrient status, water temperatures between 20 and 30°C) and the plant can double in 8 days in the field and in 3 to 4 days in the laboratory (Mitchell and Tur, 1975). Growth rates are greatly reduced at low temperatures but stable mats of salvinia are resistant to frost although individual plants may be damaged.

The plant causes a variety of problems. It impedes flow in channels and drains, devalues recreational use of water by preventing boat movement and making fishing difficult, interferes with engineering structures such as floodgates, causes small water bodies to become stagnant, decreases rice yields in infested paddies, and alters ecosystems by eliminating native aquatic plants and their associated biota.

Salvinia was first recorded as a weed in Sri Lanka (Senaratna, 1943) where it was apparently introduced in 1939 (Williams, 1956). Since then it has become successfully naturalized in a number of tropical and sub-tropical countries as a result of introductions by botanists and through the aquarium trade. It now occurs in Africa, India, Sri Lanka, Malaysia, Singapore, Indonesia, New Guinea, New Zealand, Fiji and Australia.

DISTRIBUTION AND SPREAD

Salvinia was first recorded in Australia in 1953 when it was found in Bulimba Creek near Brisbane. Since then it has spread up and down the eastern seaboard and is now distributed quite widely between Cooktown and Nowra. In addition, the weed occurs in a number of localities in the vicinity of Perth, causes a major problem in Lake Moondarra at Mount Isa, has proven difficult to eradicate from a farm dam near Deniliquin, and has been found in garden ponds or aquaria in Melbourne, Adelaide, Griffith, Darwin and Derby (Figure 1). It is almost certainly growing in garden ponds and aquaria in other places in Australia.

Within a particular system salvinia is spread by wind, currents and boats. Between systems the principal agent for its dispersal is man. There is considerable circumstantial evidence to show that it is not distributed by birds though it can be spread short distances by animals carrying it on their bodies after wallowing in infested waters (Mitchell, 1970). The main avenues of dispersal are through the aquarium and horticultural trade, and by exchanges of material between aquarists and gardeners. Despite several warnings of the potential threat of this plant to Australian aquatic ecosystems (Usher, 1971; Morschel, 1972; Beck and Nagle, 1973; Kleinschmidt, 1973), it has continued to spread by these means since its introduction into the country.

Cost of salvinia - It is difficult to estimate the cost of salvinia to Australia. Detailed accounts of expenditure on the control of salvinia apart from other aquatic weeds are generally not available. However the incidence of the plant in Lake Moondarra, Mount Isa, gives an indication, as costs of control since the plant was first reported there in October 1975 are available (T. Farrell, personal communication). Control was instituted early in 1976 as the weed was considered a threat to recreational use of the lake and possibly to water intakes and similar structures. It was also considered desirable to try and prevent the spread of the weed

Figure 1. Localities from which salvinia has been recorded in Australia

Herbarium records are indicated by a circle, visual records by an oblique stroke through a circle, and reports of the plant in garden ponds by a triangle.

further into the Leichhardt River system. A sum of $30000 was initially set aside but this proved inadequate and a further $60000 was eventually expended before attempts at control with paraquat were abandoned. In addition a further $12000 to $14000 was spent on booms which were used to confine the weed to certain areas of the lake. Recently the weed has been sprayed at a cost of about $23000 with a herbicide mixture developed by G. Diatloff of the Sir Alan Fletcher Research Station, Brisbane. The salvinia infestation of Lake Moondarra illustrates the nature of the economic and environmental costs of salvinia in Australia. So far it has not invaded irrigation systems and rice fields but it has been reported to have caused heavy losses to rice yields in Kerala State, India (Varshney and Singh, 1976) and the potential for the weed to have the same effect in Australia must exist.

Management of salvinia in Australia - Because *Salvinia molesta* is sexually sterile, it can be eliminated if all the plants in an infestation are killed or removed. This can be achieved in rivers liable to extensive flooding and in small ponds and dams. However there are no known cases of it being eliminated permanently from a large water body. This is largely because the plant exhibits remarkable powers of regeneration and because it can remain viable as small pieces consisting of a node with leaves no more than 3 to 5 mm wide. These small plants are extremely difficult to find and are likely to survive, providing sufficient moisture is present to prevent desiccation.

Several herbicides are effective against salvinia, the most widely used up to now being paraquat, diquat and diuron (Sainty, 1973; Swarbrick, 1976; O. Pastego, personal communication). However, in addition to Diatloff's mixture, salvinia is particularly sensitive to a recently developed herbicide*. It is also controlled by ametryn (Soerjani, 1977); niclosomide, a molluscicide used against bilharzial snails, (Wild and Mitchell, 1970); ammonia (Aryaratne, 1977); formalin (Begg, 1971); and thiram, a fungicide (Webster, 1977). In most cases it is important for a wetting agent to be mixed with the herbicide. In large water bodies non-target organisms are not usually affected because of the considerable dilution of the chemical in the main body of water under the salvinia.

Mechanical control provides only temporary relief as fragmentation can not be avoided. This favours the spread of the plant and encourages vegetative reproduction (Mitchell, 1970).

Investigations into the possibilities of biological control are at an interesting stage. Four insects show considerable promise, namely *Paulinia acuminata* (an acridid grasshopper), *Cyrtobagous singularis* (a curculionid weevil), *Samea multiplicalis* (a pyralid moth), all from South America (Bennett, 1974), and *Nymphula responsalis* (a pyralid moth) which is native to South East Asia and Australia (G.E. Allen, personal communication). Large

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* hexazinone

numbers of *Paulinia* were introduced to Lake Kariba in 1969 and are considered by Mitchell and Rose(in preparation) to have been a major factor in the marked decrease in extent of the infestation which occurred during 1973. However Australian requirements for meeting food specificity criteria are likely to prevent the introduction of this insect to the country. Recently the C.S.I.R.O. Division of Entomology expanded its investigations of biological control of water weeds to include salvinia and further developments can be expected.

Management policies for salvinia in Australia should not only aim at reducing current infestations but should also emphasize the prevention of further spread of the plant and the elimination of new outbreaks as soon as they are reported. At present, in comparison with water hyacinth, its potential to cause problems is insufficiently realized. More publicity on a national scale should be given to the threat posed by salvinia and vigorous, active steps should be taken to prevent trade in the plant by sensible enforcement of noxious weed legislation. Initial infestations should be treated with herbicides and steps taken to guard against reinvasion. The infested site, together with areas which the plant could have invaded from it, should be regularly inspected for at least 5 years after it is thought the plant has been eliminated. Research into biological control and ecology of the weed should continue in order that information be provided that could lead to its more effective management.

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