WEED CONTROL IN PASTURES - THE POTENTIAL FOR BIOLOGICAL CONTROL

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POTENTIAL FOR BIOLOGICAL CONTROL OF PASTURE WEEDS

Combellack (1987) estimated that weeds cost Australia more than $2500 million p.a. (in 1985/86 dollars).

There are many important pasture weeds which are poisonous, competitive and/or cause vegetable fault (Combellack 1987). These include skeleton weed (*Chondrilla juncea*), thistles (*Carduus*, *Carthamus*, *Cirsium*, *Onopordum* and *Silybum*), Paterson's curse (*Echium plantagineum*), common heliotrope (*Heliotropium europaeum*), blackberry (*Rubus fruticosus aggr.*), grasses (*Avena*, *Brachiaria*, *Digitaria*, *Echinochloa*, *Hordeum*. *Lolium*, *Nasella*, *Phalaris*, *Setaria*, *Sorghum*, *Urochloa*, *Vulpia*, etc.) and many others. All of these genera except the grasses are current or likely future targets for biological control, and are discussed below.

CURRENT BIOLOGICAL CONTROL PROGRAMS FOR PASTURE WEEDS

St. John's wort (*Hypericum perforatum*)

This is the second oldest biological control program in Australia, having been initiated in 1917. Twelve agent species were imported 1919-53; eight species were released from 1930-53; four of these became established, but only one species (the leaf-feeding beetle, *Chrysolina quardrigemina*) has a major effect on the weed (Delfosse and Cullen, 1982). This species, often in combination with pasture improvement, controls St. John's wort in much of the area of Australia with a Mediterranean - like climate. However, other species are needed which could thrive in the more unpredictable climate of the Great Dividing Range, where St. John's wort is still a problem.

A moth, *Anaitis efformata*, was released in 1982-4, but its establishment was prevented by predation (Briese, 1987; Briese and Pullen, 1987). An aphid, *Aphis chloris*, released in New South Wales, Victoria and the A.C.T. in 1986, has become established and has already spread quite widely. Localized damage to St. John's wort by the aphid has been noted at two sites. Another moth, *Actinotia hyperici*, larvae of which feed on foliage of St. John's wort, has been released in the field, but no recoveries have yet been made. Evaluation of *A. chloris* and *A. hyperici* will continue for several years.

The most promising agent for St. John's wort is a mite, *Aculus hyperici*, which deforms the growing tips of the weed. This species has been introduced into quarantine in Canberra, where the final host-specifity tests are being conducted.

Another potential agent species is a stem-mining moth, *Aristotelia morphochroma*. Most of the host-specificity testing has been completed, and the species may be considered for introduction in the future.

Common heliotrope (Heliotropium europaeum)

Lengthy and difficult host-specificity testing and problems in mass-rearing have delayed this program, but several aspects have recently been completed.

An improved mass-rearing technique for the flea beetle Longitarsus albineus enabled 30 000 individuals to be released at sites in New South Wales and Victoria in 1986-87 (Delfosse et al., 1988). Adults feed on foliage, making "shot holes", and larvae feed on rootlets. Small numbers of adults were recovered at release sites in the 1987-88 summer, and establishment seems likely. Evaluation of this species will continue for several years.

Very difficult and time-consuming host-specificity tests for the weevil Pachycerus cordiger (also with foliage-feeding adults and root-feeding larvae), which had to be done in the field in Greece, have been completed, and the species is being mass-reared in quarantine in Canberra while an application for its field release is being made.

The most promising agent for common heliotrope is a rust fungus, Uromyces heliotropii. Lengthy host-specificity testing for this species was completed in mid-1988, and an application for its field release will be made soon. This species attacks plants at all stages of growth, and has been very effective in controlling common heliotrope in field experiments in France.

The next two agents for common heliotrope are a moth, Ethmia distigmatella, which has larvae which kill developing seeds, and a fungus, Cercospora heliotropii-bocconi, which causes leaf spot. Host-specificity testing for these species will begin in 1988.

Nodding and slender thistles (Carduus spp.)

Carduus thistles have been managed by biological control agents plus cultural methods in several countries. The main agent that has been used is a seed head weevil, Rhinocyllus conicus (Kok and Pienkowski, .985). A colony of this species was imported from France in February 198., cleared of a potentially-damaging disease, and is being mass-reared in anticipation of receiving approval for field release by spring 1988. A second colony, from New Zealand, has also been imported, and is being mass-reared in quarantine. The CSIRO Divisions of Plant Industry and Entomology are conducting ecological studies of Carduus thistles at field sites in New South Wales.

Scotch and related thistles (Onopordum spp.)

These weeds are mainly problems in Australia, so unlike Carduus thistles, potential agents have not been tested by any other country. A new project has therefore been started, for which CSIRO is examining Onopordum thistles for their natural enemies in southern Europe. Host-specificity testing could be completed for the first potential agent by 1990-91.

Spiny emex (Emex spp.)

Officers at the CSIRO Biological Control Unit in Cape Town have discovered that the promising weevil, Rhytirrhinus inaequalis, was not specific to Emex australis, and work on this species was terminated. A brief survey of E. spinosa was conducted in Israel in 1988, and two or three promising species were located. This will be pursued as soon as resources permit.

Blackberry, (Rubus fruticosus aggr.)

Host-specificity testing for the rust fungus, Phragmidium violaceum, was conducted at the Montpellier Unit by the Keith Turnbull Research Institute (KTRI; Department of Conservation, Forests and Lands, Victoria), in cooperation with CSIRO. Fifteen strains of the rust have been multiplied every six months for several years to retain viability, while application for release was made. Unfortunately, because of objections about minor attack of the fungus on native Rubus spp., which is not considered to place the species at risk, release approval has not been given. Officials at the KTRI are considering their limited options at this time; it may require use of the Biological Control Act 1984.

Bitou bush/boneseed (Chrysanthemoides monilifera)

The Cape Town Unit is surveying C. monilifera for its natural enemies, and will send potential agents to the KTRI for host-specificity testing. Already, a foliage-feeding moth has been sent to the KTRI, and two foliage-feeding beetles are expected to be approved for importation shortly. This is a cooperative project, sponsored by the Council of Nature Conservation Ministers (CONCOM), State National Park Services, the Soil Conservation Service of New South Sales, KTRI and CSIRO.

Paterson's curse/salvation Jane (Echium plantagineum)

This program was halted by an injunction issued by the High Court in 1980 on behalf of two beekeepers and two apiarists; the conflict-of-interest was reviewed by Cullen and Delfosse, (1985) and Delfosse, (1988). An Industries Assistance Commission inquiry conducted under the auspices of the Biological Control Act 1984 found that the program would be in the nation's interest by at least 9:1. Approval to release the eight species which CSIRO proposed has been given by the Biological Control Authority, pending lifting of the injunction. A hearing was held in the Supreme Court of South Australia on 2 March 1988, at which CSIRO requested lifting of the injunction, among other matters. On 16 March, Justice Lunn ruled that the Biological Control Act 1984 was valid, but did not lift the injunction. CSIRO immediately appealed. Grant funds from the Australian Meat and Livestock Research and Development Corporation and the Australian Wool Corporation have enabled work to be restarted at the Unit in France, and officers will ship agents to Australia when the injunction is lifted.

Skeleton weed (Chondrilla juncea)

Skeleton weed is normally considered to be a crop weed, but can affect pastures as well, such as interfering with establishment of lucerne in the Mallee. The narrow-leaf form, formerly the most common form of skeleton weed, has been controlled since the early 1970s by a strain of a rust fungus, Puccinia chondrillina, and gall mite, Aceria chondrillae. Both of these agents attack only the narrow-leaf form of the weed in the field. This has resulted in a savings to the industry of some $26 m p.a. (Cullen, 1985).

The other two (intermediate- and broad-leaf) forms of skeleton weed, are spreading into areas formerly cocupied by the narrow-leaf form. The new strains of the rust fungus specific to the intermediate-leaf form of the weed were released near Young, New South Wales (Delfosse et al., 1985), but are not effective. A new strain of the gall mite which is specific to the intermediate-leaf form was released at the Young site in 1987, and in other areas in southeastern Australia in 1988. These releases are currently being evaluated.

Effective strains of these and other agents are being sought by the CSIRO Biological Control Unit in Montpellier, France, using advanced electrophoretic and ecological techniques.

CONCLUSIONS

Safe and apparently-effective agents have been found for the pasture weeds discussed above, and potential for their control must be rated as high.

Grasses have not yet been targeted for biological control. It is often stated that the reason for this is the close relationship between weedy and crop grasses. However, certain types of agents are often very specific (for example, the restriction of the skeleton weed mite and rust fungus to one form of skeleton weed), and it is likely that the fears of lack of specificity are unfounded.

There are many other important pasture weeds, of course, some of which are suitable targets for biological control. For example, Parthenium weed, Parthenium hysterophorus, and Noogoora burr, Xanthium strumarium, are often considered to be mainly Queensland weeds, and the Queensland Department of Lands has had the responsibility for their biological control. However, they are also weeds in New South Wales.

For Parthenium weed, a stem-galling moth, Epiblemma strenuana, has been introduced, and is exerting significant control. This agent also attacks annual ragweed, Ambrosia artemisifolia, and Noogoora burr (McFadyen 1985). Another potential agent for Parthenium weed is a fungus, Puccinia abrupta, and is currently being tested by the Commonwealth Institute of Biological Control for the Queensland Department of Lands. Additionally, mycoherbicides are being investigated for biological control of Xanthium spp. by the New South Wales Department of Agriculture (Auld, 1988).

However, there are three very real impediments to expansion and efficient conduct of biological weed control in Australia: lack of adequate funding; threat of legal action; and delays in receiving approval to release agents under certain circumstances.

The main limiting factor to biological control research is adequate, long-term funding. Appropriate funding to CSIRO has been cut severely over the past few years, and no longer allows new projects to start without cutting current programs. Therefore, for any new projects to begin, the "user pays" system is encouraged; i.e., the rural sector which is predicted to benefit most from a successful program will have to fund it. This is sometimes justified, and, because Rural Industry Research Funds appreciate the value of weeds to their industries, they are often willing to fund biological control research (about 40% of the CSIRO Division of Entomology Section on Biological Control of Weeds is supported by external funds). However, there are weeds without an identifiable primary potential beneficiary, and there are weeds whose control would yield significant benefits Australia-wide. For these weeds funding arrangements are more complex, and increased Government support may be required.

The protracted Paterson's curse, (**Echium**),situation has placed a cloud over biological control of those weeds which have friends. There is no question that the nation as a whole would benefit from successful biological control of Echium. However, the eight-year delay in the program so far clearly indicates the problem of trying to solve complex scientific, social and economic questions in a court of law. During this period the direct damage due to Echium would be more than $240 m, while the direct benefits to the beekeeping industry would be less than $25 m. Additionally, the weed has spread significantly during that period, and existing infestations have become more dense.

Since most weeds of high priority for biological control in southern Australia have friends, the threat of an injunction being granted must influence the choice of targets. The Biological Control Act 1984 can theoretically be used to resolve conflicts-of-interest. However, the IAC Echium Inquiry and subsequent actions took two years, during which time the person responsible for the biological control program had time to do little else. No wonder there is a great deal of reluctance to use the Act.

The final impediment to implementing biological weed control programs involves delays in obtaining approval for release of agents. For example, for blackberry, an application to import and release the 15 strains of P. violaceum was made 18 July 1986; the application was rejected on 18 May 1988, after advertisement in newspapers, protracted discussions, extra information being submitted, etc. For other agent species, collection times overseas are often very limited, and if approval is not given in time, a year can be lost until the species can be collected again. In the case of blackberry, a year's delay in control costs approximately another $40 m. While the concern of authorities consulted over applications is recognized, perhaps a better mechanism is required to ensure that the information is assessed objectively and efficiently.

Despite these problems, biological weed control is the most economical, environmentally-safe, and permanent method known - in fact, the only option for some weeds - and is supported strongly by the rural community. Given adequate support, the potential for successful biological control of pasture weeds (as well as other weeds) is very high.

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REFERENCES

Auld, B.A. (1988). Mycoherbicides for Xanthium weed species. Proceedings of the VII International Symposium on Biological Control of Weeds, pp. 6-11 March 1988, Rome, Italy. Delfosse, E.S. (e.d.). Italian Ministry of Agriculture, Rome (in press).

Briese, D.T. (1987). Factors affecting the establishment and survival of Anaitis efformata (Lepidoptera:Geometridae) introduced into Australia for the biological control of St. John's wort, Hypericum perforatum. II. Field trials. Journal of Applied Ecology (in press).

Briese, D.T. and K.R. Pullen (1987). Factors affecting the establishment and survival of Anaitis efformata (Lepidoptera:Geometridae) introduced into Australia for the biological control of St.John's wort, Hypericum perforatum. I. Laboratory experiments. Journal of Applied Ecology (in press).

Combellack, H. (1987). Weed control pursuits in Australia. Chemistry and Industry, 20 April, pp. 273-80.

Cullen, J.M. (1985). Bringing the cost benefit analysis of biological control of Chondrilla juncea up to date. Proceedings of the VI International Symposium on Biological Control of Weeds, 19-25 August 1984, Vancouver, Canada. Delfosse, E.S. (ed.). Agriculture Canada, pp. 145-52.

Cullen, J.M. and E.S. Delfosse (1985). Echium plantagineum: catalyst for conflict and change in Australia. Proceedings of the VI International Symposium on Biological Control of Weeds, 19-25 August 1984, Vancouver, Canada. Delfosse, E.S. (ed.). Agriculture Canada, pp. 249-92.

Delfosse, E.S. (1988). Resolution of the Echium conflict-of-interest in Australia. Proceedings of the VII International Symposium on Biological Control of Weeds, 6-11 March 1988, Rome, Italy. Delfosse, E.S. (ed.). Italian Ministry of Agriculture, Rome (in press).

Delfosse, E.S. and J.M. Cullen (1982). Biological control of weeds of Mediterranean origin: a progress report. Australian Weeds 1,25-30.

Delfosse, E.S., S. Hasan, J.M. Cullen and A.J. Wapshere (1985). Beneficial use of an exotic phytopathogen: Puccinia chondrillina as a biological control agent for skeleton weed, Chondrilla juncea, in Australia. Proceedings ANZAAS - Australian Academy of Science Joint Exotic Disease Symposium, Canberra, 15-19 May, 1984, Australian Academy of Science pp. 171-177.

Delfosse, E.S., C.S. Smith and T.L. Woodburn (1988). Progress in biological control of Heliotropium europaeum in Australia since 1984. Proceedings of the VII International Symposium on Biological Control of Weeds, 6-11 March 1988, Rome, Italy. Delfosse, E.S. (ed.). Italian Ministry of Agriculture, Rome (in press).

Kok, L.T. and R.L. Pienkowski (1985). Biological control of musk thistle by Rhinocyllus conicus (Coleoptera:Curculionidae) in Virginia from 1969 to 1980. Proceedings of the VI International Symposium on Biological Control of Weeds, 19-25 August 1984, Vancouver, Canada. Delfosse, E.S. (ed.). Agriculture Canada, pp. 433-8.

McFadyen, R.E. (1985). The biological control programme against Parthenium hysterophorus in Queensland. Proceedings of the VI International Symposium on Biological Control of Weeds, 19-25 August 1984, Vancouver, Canada. Delfosse, E.S. (ed.). Agriculture Canada, pp. 789-96.