Protocols for biological control of weeds and current Victorian priorities

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Summary

The scientific and administrative protocols governing biological control of weeds are outlined, using three-cornered jack and caltrop as examples of target weeds. The prospects for projects on *Emex* and *Tribulus* are discussed in relation to priorities and resources.

Introduction

Biological control of weeds is a science which has evolved in the twentieth century. The first attempt at controlling weeds with insects occurred in Hawaii in 1902 and a few years later in Australia.

In the early days, programs were initiated on weeds when they were thought of being of national importance. Then, as now, the main concern of scientists was the relative safety of introducing an organism from one part of the world to control its host plant which had become weedy in another part of the world. Slowly, protocols evolved for the introduction and testing under quarantine of candidate insects.

During the last 50 years these scientific protocols have evolved considerably and in Australia they are now backed by administrative protocols and legislation controlling the biological control of pests.

This paper outlines the current scientific and administrative protocols governing the biological control of weeds in Australia, with reference to three-cornered jack (*Emex australis*) and caltrop (*Tribulus terrestris*). The current priorities for biological control of weeds in Victoria are also outlined.

Scientific protocol for biological control of weeds

The first question which should be asked when considering biological control of a weed is: 'Why biological control?' To answer this, a number of criteria for the target weed, should be satisfied. These are:

a. The weed should be widespread and dense. This is the case for both three-cornered jack and caltrop.
b. The recommended control methods for the weed may be controversial. This is the case for control of weeds with herbicides due to concerns with effects to non target vegetation, herbicide drift and contamination of soil and water.
c. Biological control may be the only control method of use in inaccessible areas. This is not the case for three-cornered jack and caltrop control in vineyards and cereals but may be the case in pastures and conservation areas.
d. The weed may be difficult to control by other means. There are herbicide recommendations for both three-cornered jack and caltrop control in vineyards and on drying greens, however, repeated treatment is necessary with caltrop due to continuous germinations in summer.
e. The weed should not be closely related to desirable plants to increase the number of potential biological control agents. Both three-cornered jack and caltrop are closely related to a number of desirable plants.
f. The weed has been controlled successfully by biological means in other parts of the world. This is the case with three-cornered jack in Hawaii and partial control of caltrop has been achieved in California.

A number of scientific steps are recognized as part of a biological control program:

1. Carry out cost/benefit analysis of control. This is desirable as it provides a quantitative value of the problem on which decisions can be based. Current cost/benefit data are not available for three-cornered jack and caltrop.
2. Study taxonomy, biology and ecology of target weed. This is necessary to determine why a plant is a weed, and to find the vulnerable stages in its life-cycle. Ideally, studies should be carried out both in the area of origin of the plant and the area where it is considered a weed, to determine any differences between the two situations. The taxonomy, biology and ecology of three-cornered jack is well known, however caltrop's taxonomy and aspects of its biology and ecology are not clear.
3. Survey area of origin of weed for natural enemies. Most of the area of origin of *Emex australis* and *E. spinosa* have been surveyed but only small areas of the distribution of *Tribulus* spp. have been surveyed.
4. Select most damaging natural enemies and study their biology. A number of natural enemies of three-cornered jack and caltrop have been studied by different countries.
5. Determine safety (host specificity) of selected natural enemies. The host specificity of four candidate insects for three-cornered jack has been determined and two were sufficiently specific to release in Australia. The host specificity of candidate agents for caltrop has not yet been studied in Australia.
6. Mandatory quarantine rearing of imported natural enemies. This is carried out for one generation and ensures that agents are free of diseases and parasites.
7. Mass rear and release host specific natural enemies. The weevils *Perapion antiquum* and *Lixus cribricollis* have been released in Australia for three-cornered jack.
8. Evaluate the effect of natural enemies on weed population. The two weevils released on three-cornered jack are having little effect on the weed.

Administrative protocol for biological control of weeds in Australia

Early in the development of biological control as a science, researchers began to solicit guide-lines on the importation, testing and release of biological control agents as well as the selection of target weeds. Later, the resolution of conflicts of interest which arose out of biological control programs, had to be addressed. In Australia, the issues of candidate agents and candidate target weeds are treated separately.

The importation, testing and release of biological control agents has been regulated under provisions of the Quarantine Act 1908 and more recently the Wildlife Protection (Regulation of Exports and Imports) Act 1982. The former is administered by the Australian Quarantine and Inspection Service (AQIS). The latter is administered by the Australian National Parks and Wildlife Service (ANPWS). Each agent requires a joint application to AQIS and ANPWS, who co-operate in the issuing of importation and release permits. AQIS co-ordinates the applications review by committees of experts in each State (entomologists, botanists, mycologists or nematologists). After consideration of the committees' advice, AQIS and ANPWS decide on the merit of importation/release and issue separate permits if applicable.

Guide-lines on the selection of a target weed were developed under the auspices of the Australian Agricultural Council (AAC). One of the Council's technical committees, the Australian Weeds Committee (AQC), co-ordinates Australian weed policy and has been the forum used for the proposal and subsequent discussion of issues relating to candidate target weeds. Recently, conflicts of interest over the biological control of some weeds, resulted in legislation which facilitates the resolution of such conflicts. This Federal legislation is the Biological Control Act 1984 and it is backed by complementary legislation in all Australian States. If conflicts of interest cannot be resolved through AAC, the proposing organisation can submit the weed through the Biological Control Act, resulting in a public inquiry on the merits of biological control of the candidate weed. A positive response results in the declaration of the weed under the Act as a target for biological control.

The current administrative protocol for biological control of weeds in Australia can be summarized as:

1. Submit weed as a target for biological con-

trol through AWC/SCA to identify possible conflicts of interest. Both three-cornered jack and caltrop are agreed targets for biological control in Australia.
2. Resolution of conflicts of interest on target weed through SCA and/or Biological Control Act.
3. Weed declared/not declared a target for biological control.
4. Apply to AQIS and ANPWS for permit to import natural enemies into quarantine. Four species of candidate insects for three-cornered jack have received permits for importation into quarantine.
5. Apply to AQIS and ANPWS for permit to release "safe" natural enemies form quarantine.
6. Resolution of conflicts of interest on biological control agents through SCA and/or Biological Control Act.
7. Natural enemy declared/not declared an agent for biological control.
8. Permission obtained/not obtained to release natural enemy into weed infestation from AQIS and ANPWS. Permits have been obtained to release two insects for three-cornered jack control.

The elaborate nature of scientific studies and administrative protocols required during a biological control program, means that they are usually of long duration and therefore costly to implement. Depending on the level of funding, many of the stages can be carried out simultaneously to reduce the time frame of a program.

Victorian priorities on the biological control of weeds

In Victoria, biological control of weeds is implemented by the Department of Conservation and Environment (DCE). The selection of weeds for biological control is based upon an assessment of the economic, agricultural and environmental impact of the weed species and the feasibility of successful biological control. DCE resources for biological control research are deployed primarily for priority projects within the Department. Other projects require whole or part funding from an appropriate external source. Current Victorian programs and their priorities are listed in Table 1. Weeds listed as priority one in Table 1 are priority projects for DCE and weeds placed as priority two are those which have part funding from external sources. No research is currently being conducted by DCE on weeds listed as priority three due to lack of funding from external sources, however, other organisations in Australia may have current programs on these weeds.

Cost of a biological control program on three-cornered jack and caltrop in Australia

The requirements for full external funding of a biological control program on three-cornered jack and caltrop in Australia are listed in Table 2. Year 1 requires the salary and running costs of a scientist based in Australia to evaluate past releases of three-cornered jack insects and clarify the taxonomy of caltrop. Year 2 requires the salary and running costs of two scientists and one technician. One team would be based in Australia to carry out quarantine studies of candidate three-cornered jack agents recently proposed by the CSIRO Division of Entomology while a scientist would be based overseas to survey for candidate agents in the area of origin of caltrop. The overseas team also requires a technician in year 3. The outline is for an initial three year program which would cost approximately $350,500. This would ensure that additional three-cornered jack agents are imported and released (if safe) into Australia and that the first caltrop agents are imported for quarantine studies. It is likely that a full program on these two weeds, which includes mass-rearing and widespread releases of proven biological control agents, would extend to at least six years and perhaps nine.

Three-cornered jack and caltrop are a problem to a number of agricultural industries and it seems appropriate that the initial cost of implementing a biological control program should be shared by the industries which will reap the benefits. Biological control programs against weeds are costly to implement, however, if successful, the initial expense is quickly recovered and savings in control costs accumulate with time.

Table 1. Current biological control programs on weeds in Victoria

Weed	Priority	Funds DCE $	Other Funds $	Total $
Blackberry	1	41,000	-	41,000
Ragwort	1	119,000	-	119,000
Paterson's curse	2	90,000	(Wool) 45,000	135,000
Thistles	2	36,000	(Wool) 43,000	79,000
Boneseed	2	54,000	(CONCOM) 60,000	114,000
Horehound	2	46,000	(Wool) 113,000	159,000
St. John's wort	3	-	-	-
Skeleton weed	3	-	-	-
Three-cornered jack	3	-	-	-
Caltrop	3	-	-	-
TOTAL		386,000	261,000	647,000

Table 2. Requirements and costs of a biological control program on three-cornered jack and caltrop in Australia

Requirements	Cost ($)	
Year 1		
Scientist in Australia for three-cornered jack and to study caltrop taxonomy	27,500	
Running costs in Australia	15,000	
		42,500
Year 2		
Scientist in Australia for three-cornered jack	29,000	
Technician in Australia for three-cornered jack	25,000	
Running costs in Australia	15,000	
Scientist based overseas for caltrop	44,000	
Running costs overseas	20,000	
		133,000
Year 3		
Scientist in Australia for three-cornered jack and caltrop	30,500	
Technician in Australia for three-cornered jack and caltrop	26,500	
Running costs in Australia	15,000	
Scientist based overseas for caltrop	46,000	
Technician based overseas for caltrop	37,000	
Running costs overseas	20,000	
		175,000
	TOTAL	350,500