A REVIEW OF QUEENSLAND DEPARTMENT OF LANDS RESEARCH ON BIOLOGICAL CONTROL OF WEEDS

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Summary. Queensland Department of Lands has imported and released potential biological control agents on twelve weeds. We review these projects and highlight some critical issues including relative success of collections from the same versus related plant taxa, host specificity criteria, number of agents required and assessment of efficacy of control agents. Control of the harrisia cactus complex, *Eriocereus spp.*, by a mealybug has been clearly successful. Results of insect releases on herbaceous and woody weeds are less clear. Partial control of seven weed species has been achieved, with effects ranging from major reductions in density over the range of the weed to temporally or spatially scattered damage. Projects on four weeds have achieved no significant control to date.

INTRODUCTION

The highly successful biological control campaign against prickly pear, *Opuntia stricta*, involving *Cactoblastis cactorum* set the stage in Queensland for continuing research into this method of weed control. When the Commonwealth Prickly Pear Board was terminated in 1939, Queensland Department of Lands took over responsibility for control of exotic weeds. Research into biological control, and other methods of weed control, is carried out at the Alan Fletcher Research Station in Brisbane and at the Tropical Weeds Research Centre at Charters Towers in north Queensland.

The current status of Department of Lands biological control projects is reviewed in this paper. The relevance of these projects to the debate of some critical issues in biological control is discussed.

STATUS OF PROJECTS

The success of biological control projects was assessed by the extent to which previously used control measures, such as herbicides or mechanical control, have been replaced or reduced following the release of biological control agents. The status of projects on twelve weeds for which agents have been released is summarised in Table 1.

Harrisia cactus is a weed of grazing lands in central Queensland. The mealybug has greatly reduced density of the cactus, but the insect has limited powers of dispersal. Control by government and landholders by mechanical clearing and herbicide application has been replaced by distribution of the mealybug (12).

Noogoora burr is a weed of grazing lands throughout much of Queensland, reducing pasture growth, impeding access to water, and contaminating wool with burrs. Following the apparently accidental introduction of a rust fungus, noogoora burr is no longer considered a serious weed by many graziers and the cost of removal of vegetable matter from wool has been greatly reduced (2).

Table 1. Current status of Queensland Department of Lands biological control projects against weeds

Weed	Degree of control	Effective agents
Eriocereus spp harrisia cactus	acceptable	*Hypogeococcus pungens* mealybug
Xanthium strumarium noogoora burr	acceptable, many areas and seasons	*Puccinia xanthii* rust fungus
Mimosa invisa giant sensitive plant	acceptable, many areas and seasons	*Heteropsylla spinulosa* sap-sucking bug
Baccharis halimifolia groundsel bush	partial, inadequate	*Oidaematophorus balanotes* stem-boring moth *Megacyllene mellyi* stem-boring beetle
Lantana camara lantana	partial, some areas and seasons, inadequate	*Teleonemia scrupulosa* sap-sucking bug *Octotoma scabripennis, Uroplata girardi* leaf-mining beetles *Phenococcus parvus* mealybug
Parthenium hysterophorus parthenium	partial, inadequate	*Epiblema strenuana* stem-galling moth
Ambrosia artemisiifolia annual ragweed	partial, inadequate	*Epiblema strenuana* stem-galling moth
Ageratina adenophora crofton weed	partial, inadequate	*Cercospora eupatorii* leaf-spot fungus
Ageratina riparia mistflower	none	—
Cryptostegia grandiflora rubber vine	none	—
Acacia nilotica prickly acacia	none	—
Parkinsonia aculeata parkinsonia	none	—

Giant sensitive plant, *Mimosa invisa*, is a fast growing, prolific weed of pastures, crops, plantations and roadsides in the wet tropics. Thorny clumps prevent grazing and restrict access. Control with herbicides continues in crops. Herbicide use by graziers and government has been drastically reduced since introduction of the psyllid in 1988/89, except for areas and seasons that are too wet or too dry for the psyllid.

Biological control agents inflict damage that is believed to significantly reduce vigour of individual plants and, in some cases, populations of five of the weeds listed in Table 1, but without apparently reducing the need for alternative methods of control. This degree of control is listed as partial but unacceptable.

Four biological control targets for which only one or two agents have been released remain unaffected (Table 1).

CRITICAL ISSUES IN BIOLOGICAL CONTROL

Some theoretical aspects of biological control are raised in many of the forums in which biocontrol is discussed. The continuing discussion indicates that these issues are unresolved, and some perhaps cannot be resolved to the stage that useful generalisations can be made. Four of these issues are discussed below in the light of evidence provided by examples of weed biocontrol in Queensland.

<u>How many agents should be released</u>? Myers (9) has challenged the "conventional wisdom that more insect herbivory is better for weed control" to conclude that success is more frequently achieved by a single species.

In each of the cases of successful control listed in Table 1, success has been achieved by a single species following release of between two, for giant sensitive plant, and five, for noogoora burr, agents. Twenty five species have been released on lantana, with four inflicting some damage, and eight have been released on groundsel bush, with two inflicting some damage, and in both cases only partial, inadequate control has been achieved. These examples support Myers' (9) suggestion that each introduction is a lottery that may or may not achieve success, and that more established agents may not improve control.

<u>Efficacy of "old" versus "new" associations</u>. Hokkanen and Pimentel (8) concluded that biocontrol agents collected from species other than the target, thus a new association, have been more successful than agents collected from the target species, an old association. Goeden and Kok (6) refuted this claim for weed biocontrol, citing groundsel bush as an example but without access to complete data. Data for all species tested, presented in Table 2, provides further support for the conclusion of Goeden and Kok that new host-plant incompatability is a major obstacle for new associations in weed biocontrol.

<u>Assessment of efficacy of agents.</u> Harris (7) suggested that economic evaluation of weed biocontrol is necessary to ensure continued funding, and that scientific evaluation is necessary to develop concepts that will lead to increasing success in weed biocontrol.

The first of Harris' (7) points is increasingly important as funding for science in general and weed biocontrol in particular becomes more competitive. Evaluations of harrisia cactus (12) and noogoora burr (2) have clearly demonstrated the large benefits accruing from successful weed biocontrol. Evaluation of the partial control of parthenium attributed to the stem-galling moth would identify any economic advantage attributable to effects on parthenium that allow pastures to compete more successfully with the weed. However, the resources necessary to do the evaluation may be better directed towards introduction of further agents.

Table 2. Comparison of efficacy of old and new associations for biocontrol of *Baccharis halimifolia*

	Old associations	New associations
Collected from:	*Baccharis halimifolia*	Other *Baccharis sp.*
Number of species:		
tested	7	14
successfully reared on *B. halimifolia*	5	3
released in the field	5	3
established in the field	4	2
effective	1	1

Harris' (7) second point is appealing to scientists, but can it be supported? Evaluation has allowed modification of the weed-biocontrol agent system under study to increase success of that system (14), but most attempts at generalisation have failed (4). As Cullen (4) suggests, scientific evaluation must be directed towards consideration of the particular insect-plant interaction.

Host specificity criteria. The centrifugal phylogenetic method of host specificity testing (13) has been adopted in Australia. These tests have been successful in excluding potentially significant pests and identifying potential for attack on non-target native plants (10). However, these tests are time consuming and may indicate an artificially wide host range (5).

The rust on noogoora burr and the mealybug on lantana (Table 1) were apparently accidental introductions. Given the results of subsequent host testing of these agents (1, 11), formal approval for release probably would not have been granted. The host ranges of these agents in the field are largely restricted to the weed hosts, providing further evidence that decisions based on the usual tests may be too conservative.

Greater reliance should be placed on the host range of potential agents in the field in their country of origin, and Cullen's (3) suggestions for increasing realism of test procedures should be adopted.

CONCLUSIONS

This review of successes and failures in weed biological control by Queensland Department of Lands provides further data relevant to debates over some critical issues in the weed biocontrol process. Whether science can make major contributions to what is still essentially an empirical process remains to be seen.

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