Validating the New Zealand Biocontrol Risk Model for Australia: Systematic surveys for non-target host use

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Summary This research aims to determine whether weed biological control agents attack non-target plants that supported some development in host specificity testing. Field surveys were conducted for agents released to control six major Australian weeds: ragwort (*Jacobaea vulgaris* Gaertn.) English broom (*Cytisus scoparius* (L.) Link), gorse (*Ulex europaeus* L.), alligator weed (*Alternanthera philoxeroides* (Mart.) Griseb.), Montpellier broom (*Genista monspessulana* (L.) L.A.S.Johnson), and St John's wort (*Hypericum perforatum* L.). A total of 10 agents, including mites and insects, previously released for biological control were examined, and host specificity checks were conducted. Overall, 15 potential alternative host plants were examined for agent attack as well as the target plants. All agents are well established in Australia and had been released from 12 to 44 years earlier. There was no evidence that the non-target species included in this survey were able to support full development of the agents, although an incidental finding of non-target host use requires further survey effort.

Keywords biological control, non-target, host specificity testing, systematic surveys.

INTRODUCTION

The biggest risk from introducing a weed biocontrol agent from one country to another is that the agent could damage non-target plants, especially crops or native species. Globally, of the 332 weed biocontrol agents that have established, 60 (18 %) were recorded causing non-target attack (Schwarzländer *et al.* 2018, Hinz *et al.* 2019). In Australia the incidence is lower with 11 agents recorded causing non-target damage of the 142 that have established (8 %) (Hinz *et al.* 2019, Winston *et al.* 2021).

Despite this concern, non-target surveys are rarely carried out and are usually reactive; in response to a recorded attack, opportunistic establishment, or incidental finds (Hinz *et al.* 2014, 2019). The literature generally agrees that major non-target impacts would already have been observed and reported if they had occurred. Systematic surveys for non-target damage in New Zealand did not discover any further agents causing major damage to valued species than those already recorded in the literature (Fowler *et al.* 2000, 2004, Paynter *et al.* 2004, 2015, 2018).

Whilst the risk of non-target attack is real, biocontrol is a useful tool that has a proven track record of reducing the impact of some of the most intractable weed problems (Schwarzländer *et al.* 2018). A better understanding of the circumstances under which biocontrol agents cause non-target damage will improve the risk analysis process that underpins the approval of biocontrol releases (Paynter *et al.* 2015). To this end we used a literature survey to develop a list of non-target plant species on which certain biocontrol agents were able to develop under laboratory conditions. We then used field surveys to determine if they were attacked by the agent after release.

MATERIALS AND METHODS

Surveys were conducted during 2020-2022 in Tasmania, Victoria, and Queensland in areas where each of the agents were known to have become widely established on the target weed. The target weed was first examined for the presence of the agent and, if present, the nearest non-target plant located was examined. Methods used to detect the presence of agents on both the target and non-target plants included field and laboratory examination of invertebrates collected using a pooter after beating the target plant over collection trays, the presence of webbing, frass, larvae, pupae and associated stem damage, galls, or webbed larval shelters.

Some non-target plants were also returned to the laboratory, cut into sections, and placed in Tullgren funnels (width 30 cm diameter; depth to grid 10 cm; distance from grid to 2.5 cm opening, 50 cm; 60 W incandescent light source 25 cm from grid) for 3-4 days and any extracted invertebrates examined under a compound microscope.

Non-target plants included in the survey list were both native: *Dillwynia glaberrima* Sm., *Hypericum* *gramineum* G.Forst., *Oxylobium ellipticum* (Labill.) R.Br., *Pultenaea juniperina* Labill., *Senecio quadridentatus* Labill., *S. linearifolius* A.Rich., *S. pinnatifolius* var. *alpinus* (Ali) I.Thomps., *S. pinnatifolius* var. *maritimus* (Ali) I.Thomps.; and naturalised: *Alternanthera sessilis* (L.) R.Br. ex DC., *Cytisus proliferus* L.f., *Genista monspessulana*, *Lupinus angustifolius* L., *L. arboreus* Sims, and *Spartium junceum* L.

RESULTS

Surveys were conducted for 29 combinations of biocontrol agents and the non-target plants they were able to develop on under laboratory conditions. For 24 agent/non-target combinations no non-target plant use was observed (Table 1). Biocontrol agents were observed on five non-target plant species (Table 2). *Sericothrips staphylinus* was located on *P. juniperina* during spring 2020 but not during follow up surveys in early and late autumn 2021 when the agent was still active on the target weed. *Arytinnis hakani* was located on *C. scoparius* and *S. junceum* in Victoria. Surveys in Tasmania did not find *A. hakani* present on *S. junceum* whilst the agent was active on the target weed within 20 m of the non-target. One *B. villosus* was netted from *C. palmensis*. In Queensland, surveys for *A. hygrophila* on *A. sessilis* resulted in observations of the agent on *A. denticulata* R. Br. at one site.

DISCUSSION

All the biological control agents included in the survey were well established in each state and are widespread, having been released from 12 to 44 years earlier. The biological control agents released on *S. jacobaea* have had a highly significant impact on their target plants (Ireson *et al*. 2007). For instance, in southern Tasmania, *S. jacobaea* was once a major problem in pastures throughout the Huon Valley and is now confined to a few minor infestations as well as in orchards where insecticides are used. Densities of the biological control agents have declined accordingly, but the agents are still active and usually present where ragwort can be located. Given the decline in *S. jacobaea* densities, alternative hosts would have been open to agent exploitation if the agents were not host specific to ragwort. However, there was no evidence that any of the biocontrol agents targeted in the survey could complete their life cycle on any of the potential alternative hosts examined during the survey.

Although adults of *S. staphylinus* were found on *P. juniperina* in spring, they were not found on samples taken the following autumn *when S. staphylinus* adults were still active on gorse (Ireson *et al.* 2008). This suggests that *S. staphylinus* had crossed over to *P. juniperina* from neighbouring gorse during spring dispersal (Ireson *et al.* 2008). Its absence from the later samples is indicative that it cannot complete its life cycle on this plant.

Table 1. Summary of surveys for biocontrol agents where non-target host use was not observed.

Non-target plant	No. survey sites	Distance from agent (km)
Agent: *Aceria genistae* Nalepa		
Cytisus proliferus	2	0-0.5
Lupinus angustifolius	1	0
Lupinus arboreus	4	0-2
Agent: *Bruchidius villosus* Fabricius		
Genista monspessulana	1	0
Agent: *Arytinnis hakani* Loginova		
Lupinus arboreus	3	0.5-2.8
Agent: *Chrysolina quadrigemmina* Suffrian		
Hypericum gramineum	1	0.01
Agent: *Cochylis atricapitana* Stephens		
Senecio quadridentatus	3	5-5.5
Agent: *Platyptilia isodactyla* (Zeller)		
S. pinnatifolius var. *alpinus*	1	22
S. pinnatifolius var. *maritimus*	1	24
S. linearifolius	3	0.5-1.9
Agent: *Agonopterix umbellana* (Fabricius)		
Cytisus proliferus	2	0.3-5
Genista monspessulana	4	0-1.7
Lupinus arboreus	1	1
Pultenaea juniperina	1	0.015
Agent: *Sericothrips staphylinus* Haliday		
Cytisus proliferus	2	0.5
Dillwynnia glaberrima	1*	0.2
Lupinus angustifolius	1	2
Lupinus arboreus	5	1-2
Oxylobium ellipticum	2	1
Agent: *Tetranychus lintearius* Dufour		
Cytisus proliferus	2	0.5
Lupinus angustifolius	1	1
Lupinus arboreus	5	1-2
Oxylobium ellipticum	2	1
Pultenaea juniperina	2	0-0.1

* Site surveyed twice, 9 months apart

Table 2. Detail of surveys where non-target host use was observed

Non-target plant	Survey site	Survey date	Distance from agent (approx.)	Agent present on non-target?
Agasicles hygrophila* Selman & Vogt targeting *Alternanthera philoxeroides				
Alternanthera denticulata	Coorparoo, Brisbane (Qld)	28/10/2020	8 km	N
	Cliveden Ave, Corinda, Brisbane (Qld)	13/01/2021	2 km	N
	Cliveden Ave, Corinda, Brisbane (Qld)	3&10/03/2021	2 km	Y
	Cliveden Ave, Corinda, Brisbane (Qld)	12/05/2021	2 km	Y
	Kendall St, Corinda, Brisbane (Qld)	10/03/2021	3 km	N
	Eddystone Rd, Oxley, Brisbane (Qld)	10/03/2021	4 km	N
	Bill Moore Park, Brisbane (Qld)	10/03/2021	2 km	N
Bruchidus villosus* Fabricius targeting *Cytisus scoparius				
Cytisus proliferus	Beechworth (Vic)	23/11/2021	0 km	Y*
Arytinnis hakani* Loginova targeting *Genista monspessulana				
Cytisus scoparius	Thomas's lookout, Daylesford (Vic)	10/02/2021	0 km	Y
Spartium junceum	Botanic Gardens, Daylesford (Vic)	25/12/2020	1 km	Y
	Botanic Gardens, Daylesford (Vic)	10/02/2021	1 km	N
	Reservoir, Melbourne (Vic)	5/10/2021	3 km	Y
	Dynnyrne (Tas)	13/02/2021	20 m	N
	Dynnyrne (Tas)`	12/02/2022	20 m	N
Sericothrips staphylinus* targeting *Ulex europaeus				
Pultenaea juniperina	Mount Nelson (Tas)	20/03/2020	100 m	N
	Mount Nelson (Tas)	30/11/2020	15 m	Y
	Mount Nelson (Tas)	15/03/2021	15 m	N
	Mount Nelson (Tas)	18/05/2021	15 m	N

*One beetle collected from non-target. Follow up survey required to confirm utilisation (or not).

Similarly, *A. hakani* was not found on *S. junceum* in Daylesford in a follow up survey. The non-target had finished flowering by that stage, and it is likely that the agent was dispersing. At the location where *A. hakani* was collected from *C. scoparius* the non-targets were interspersed with the target. Although the agent appeared less abundant on the non-target, follow up surveys at sites where the two species are more distant from each other would clarify whether the agent can fully utilise this non-target as a host.

The single *B. villosus* collected from *Cytisus proliferus* likely indicates that non-target host use is occurring on this species in Australia as it does in New Zealand but follow up surveys are required to confirm this (Syrett 1999).

The discovery of *A. hygrophila* on *A. denticulata* was incidental. This native non-target plant was not included in the survey list as host testing data for this species was not available. Native plants were not routinely included in host testing in the 1970s when this agent was introduced to Australia. This non-target host use was not unexpected, given *A. denticulata* is attacked in NZ, and unpublished post-release testing demonstrated it could be a host. Larvae feed on this species but are unable to pupate on *A. denticulata* as it lacks hollow stems.

Aside from this incidental discovery, none of the agents observed or collected from non-target plants was having a major impact on those species. This confirms the notion that surveying for non-target host use is unlikely to uncover major damage to valued plants. The damage to the native plant species *A. denticulata* has potentially been overlooked as being attack on the invasive look-a-like *A. sessilis* (Heenan and de Lange 2004).

The results of this survey will be included, alongside previously published survey data, in an analysis of the comparison between the host testing results for an agent and its ability to utilise non-target species as hosts.

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