

Classical biological control of Californian thistle: the New Zealand story

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Summary Californian thistle (*Cirsium arvense* (L.) Scop.) is ranked as one of the world's 80 worst weeds and costs the Southland region of the South Island, New Zealand, NZ\$27 million annually. A group of farmers and farming-associated organisations in Otago and Southland formed a trust called the Californian Thistle Action Group (CalTAG) and applied for community funds to 'improve the control of Californian thistle using natural enemies'. This group funded CABI Bioscience in Europe to survey for potential new biocontrol agents. Its aims also included assessing the current status of biocontrol agents in New Zealand, and evaluating the effectiveness of current control methods (mowing, spraying and grazing).

Three agents (*Altica carduorum* Guerin-Meneville 1858, *Lema cyanella* Linnaeus 1758, and *Urophora cardui* Linnaeus 1758) have been released into New Zealand for the biological control of Californian thistle but they either failed to establish or had little impact on populations of this thistle. For example, after four years of caged rearing and farmer involvement from the Otago and Southland regions, the gall-forming fly *U. cardui* has failed to establish in large numbers.

Through additional community funding a new agent (*Apion onopordi* Kirby 1808) was imported and tested for host specificity in 2002/03. This root- and stem-feeding weevil is a vector for the *C. arvense* rust, *Puccinia punctiformis* (Str.) Rohl. Host testing has shown that the weevil can attack plant species within the tribe Cardueae, potentially including the minor crop species safflower (*Carthamus tinctorius* L.) and globe artichoke (*Cynara scolymus* L.).

This paper outlines the process of forming and funding a community group project in New Zealand, and the ups and downs of the biological control of this major pasture weed.

Keywords *Apion onopordi*, *Puccinia punctiformis*, biological control, Californian thistle, community.

INTRODUCTION

Holm *et al.* (1977) rated Californian thistle (*Cirsium arvense* (L.) Scop.) 30th out of 80 of the world's worst weeds. It was first recorded in New Zealand in 1878 (Kirk 1878) and is a serious weed of pastures and arable land throughout both islands.

Californian thistle is recognised as the most economically important weed of intensively grazed

pastureland in southern Otago and Southland with an estimated annual cost of control in these regions of NZ\$21 million in 1993 (Mitchell and Abernethy 1993) and \$27 million in 2001 (J. Labes 2000, unpublished report to the Californian Thistle Action Group).

A biological control program against Californian thistle in New Zealand was started in the 1970s and the first insect biocontrol agent, *Urophora cardui* Linnaeus 1758 (a stem-galling fly), was released in 1975. Further releases of *U. cardui* were made in 1994 and 1996. Two other insects have been released in New Zealand, *Lema cyanella* Linnaeus 1758 (a leaf-feeding chrysomelid) in 1983 and 1990 and *Altica carduorum* Guerin-Meneville 1858 (a leaf-feeding chrysomelid flea beetle) in 1990.

Recently the biological control program has been led by the Californian Thistle Action Group (CalTAG), which was formed in 1998. Towards the end of the project CalTAG used surplus funds to import for initial host testing an insect discovered during the European survey. The stem- and root-feeding weevil *Apion onopordi* Kirby 1808 was imported into New Zealand in 2003 and initial host tests were conducted in containment. This weevil was considered the most promising biocontrol agent that the surveys had found because of its mutualistic relationship with the thistle rust (*Puccinia punctiformis* (Str.) Rohl), which is already present in New Zealand, and attacks roots of Californian thistle.

This paper describes how the community group was formed, how well it achieved its objectives, the current status of the Californian thistle biocontrol program in New Zealand, and plans for future control.

THE COMMUNITY GROUP

In the mid to late 1990s a body of work by Landcare Research scientists promoted community-based adaptive management and the need for science to work with communities to develop new understanding among all participants in natural resource management. This required governing authorities to move away from centralised planning allowing science to help communities to deal with their own needs. In response, Landcare Research sought to identify community groups with a common weed problem, and encouraged each group to form a Landcare group trust and apply for funding to research and help solve their weed problem. One of

the first of these groups was the Californian Thistle Action Group (CaITAG) headed by Grant Catto, a sheep and wool farmer and ex Agricultural Research and Marketing Development Trust (AGMARDT) Young Farmer of the Year. With the assistance of Landcare Research, Grant gathered interested groups from around the region such as the Otago and Southland regional councils, Ravensdown Fertilisers, the Meat and Wool Innovation industry, the Clutha Agricultural Development Board, along with the Southern South Island Hill and High Country Farm Study Group and the Hawkdun Landcare Group. Representatives from these organisations formed a charitable trust and applied for funding from AGMARDT. Researchers at Landcare Research provided the science background for the project application and as a major subcontractor provided the majority of the research needed to complete the project. The Trust's committee funded its objectives through a combination of the sources listed above along with a major contribution from the AGMARDT Progressive Farming Grants scheme.

The objectives of CaITAG were to:

- assess the costs of control attributable to Californian thistle in Otago and Southland;
- survey the two regions for evidence of establishment of the two chrysomelid beetles released during the 1990s (*L. cyanella* and *A. carduorum*, Gourlay and Fowler 2000);
- establish, rear and redistribute the gall-forming fly *U. cardui* in the two regions;
- help educate farmers in the two regions about how to help reduce the abundance and impact of the thistle on their farms; and
- fund overseas surveys in Europe and Asia for new potential biocontrol agents.

COSTS OF THE WEED

An assessment of the costs of Californian thistle in Otago and Southland was made by John Labes of the Clutha Agricultural Development Board through a postal survey of farmers. A questionnaire was developed and tested on local farmers before being sent out to 167 farmers throughout the two regions. On average 30% of farmers replied to the questionnaire. The detailed results are yet to be published (J. Labes and G. Bourdôt in prep.) but all respondents said they had Californian thistle on their properties, 66% of respondents sprayed for the weed annually, 82% either mowed or topped their thistle paddocks, and 36% used a new method of control developed by AgResearch of mow/graze during December/January. From this survey the cost to farmers of control and treating scabby-mouth in sheep (a disease that arises when sheep graze on this weed) in the Otago and

Southland regions was estimated at NZ\$27 million per annum. These costs are similar to those estimated by the Ministry of Agriculture and Fisheries from a survey of 120 farms in 1989 (\$3500 per farm or \$21 million per annum).

CLASSICAL BIOCONTROL INTRODUCTIONS

Altica carduorum This leaf-feeding beetle was released in many areas of New Zealand during the 1990s. Evidence of larvae and larval damage to plants was recorded the following season. However, in the second season after release no evidence of damage, larvae or adults was found and no beetles have been seen since at any of the 27 release sites (L. Hayes pers. comm.).

Lema cyanella This leaf-feeding chrysomelid beetle was the second to be released throughout New Zealand during the 1990s. This beetle was recovered from many sites the following year and at one site for several years. However, at 97% (36 in 37) of release sites the beetle failed to establish and at the one site where the beetle was found, no significant impact has been recorded on Californian thistle plants (L. Hayes pers. comm.).

Urophora cardui This stem-galling fly was released at 23 sites throughout New Zealand. Releases into field cages were made over several years in the Otago and Southland regions. Field studies were conducted in these regions, through funding from CaITAG, on the methodology and success of various release strategies for this gallfly. In addition to studying caged release strategies, the impacts on thistle growth and flowering were measured at five sites (Fowler 2000). This study showed that stem terminal galls stunted thistle growth by 40% and reduced flowering by 80%. The studies conducted on developing protocols for caged releases of the gallflies showed that up to 35 galls were harvested per cage, on average four flies emerged from each gall (a fivefold increase in fly numbers), the timing of fly releases into the cages was critical, and the growth stage of the plants was important (Fowler and Gourlay 2000). Over the next four years more releases of flies were made in the region and caged rearing continued, but the fly did not establish in large enough numbers to cause an increase in population levels and therefore did not impact on plant growth and flowering. The galls formed in the thistle stems were very palatable to stock and so were gleefully eaten by sheep and cattle alike. For these reasons this agent was considered not worthy of further study.

OVERSEAS SURVEYS IN EUROPE AND ASIA

Research organisations in Canada, the USA and New Zealand contracted CABI Bioscience in Switzerland

to conduct surveys in central and northern China, Tibet, Southern Siberia, Uzbekistan, Armenia, Pakistan, Eastern Turkey and the Black Sea coast to look for potential biocontrol agents for Californian thistle.

These surveys found the following.

- *Altica carduorum*. A population was found in China that is capable of outbreaking during the summer season, inflicting considerable damage on Californian thistle plants in the field.
- *Cleonus piger* Scop. Larvae were found as deep as 15 cm below ground level in the vertical roots of Californian thistle and at one site in the horizontal root system. *Cleonus piger* is likely to be oligophagus, and is capable of completing larval development on globe artichoke (*Cynara scolymus* L.) and New Zealand native puha (*Sonchus kirkii* L.) in no-choice feeding tests.
- *Luperus* sp. near *altaicus*. This chrysomelid galerucine defoliator, collected in Europe, also appeared to be oligophagus, with adult feeding damage observed on plants in the tribe *Cardueae*. (Further studies assessing the level of damage to safflower (*Carthamus tinctorius* L.), globe artichoke (*Cynara scolymus*), and both the native and exotic puha (*Sonchus kirkii* and *S. oleraceus*) in the field by *Cleonus piger* and *Luperus* sp. are planned to confirm their specificity.)
- *Aceria anthocoptes* Nalepa. This gall-forming mite is highly host specific and has been recorded damaging Californian thistle populations in the Balkans.
- *Cheilosia* sp. This stem- and root-boring fly is difficult to rear and may not be especially damaging.
- *Dyaphis lappae* Koch 1854. A root aphid from Denmark.
- *Lixus elongatus* Goeze. A stem-boring weevil.
- *Thamnargus* sp. A root-boring beetle not yet identified to species.
- *Apion onopordi*. This root-feeding weevil has a mutualistic relationship with the Californian thistle rust *Puccinia punctiformis*. The female weevils vector the rust from plant to plant when either boring an egg chamber in the stem or when ovipositing. Female weevils actively seek rust-infected plants. Adults emerging from rust infected plants are more fecund and longer-lived (Friedli and Bacher 2001a,b).

A population of *A. onopordi* weevils was introduced from Switzerland into containment in New Zealand in 2003. Initial host testing was conducted on plants of significance to New Zealand in the tribe *Cardueae*. There are no native thistle species present in New Zealand so an oligophagus insect is considered

to be advantageous. There are, however, two related species of native or cultural significance (native and exotic puha). The results of these initial tests suggest that *A. onopordi* is capable of feeding and developing on safflower and globe artichoke in the laboratory but not on either of the puha species. Field records from Europe suggest that *A. onopordi* has not been recorded from either safflower or globe artichoke.

NEW CLASSICAL BIOCONTROL POSSIBILITIES

***Phoma exigua* var. *exigua* Desm.** This disease was recently discovered causing severe yellowing of leaves, stunting growth and killing Californian thistle plants in the North Island of New Zealand. Field trials evaluating the efficacy of this naturally occurring disease have proven inconclusive showing a lack of consistent plant infection and damage. Further studies on this fungus are on hold until consistently virulent strains are isolated.

FUTURE WORK ON *C. ARVENSE*

A collaborative project between AgResearch and Landcare Research funded by central government with contributions from Meat and Wool Innovation and CalTAG, labelled 'Outsmarting Weeds', has been started in New Zealand. A major aim is to develop population models as tools for understanding how *A. onopordi* and other biological, physical and chemical control methods can be integrated into a sustainable management strategy for Californian thistle in New Zealand. Ultimately, New Zealand farmers affected by this weed will have to help develop an integrated weed management toolkit on how to improve the control and reduce the costs of *C. arvensis* on their farms.

The CalTAG part of this project is to find funding to import *A. onopordi*, complete its host range testing, conduct field studies in Europe to determine if it attacks safflower and globe artichoke, and conduct field cage tests inundating cages planted in the two species with field-collected weevils. If these studies show the weevil to be host specific to thistles with no attack on the native and exotic puha and little or no attack on safflower and globe artichoke, then CalTAG and Landcare Research will apply to the Environmental Risk Management Authority in New Zealand to release and begin to mass-rear and distribute the weevils to sites throughout Otago and Southland.

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