# Progress on the biological control of gorse (*Ulex europaeus*) in Australia

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*Summary*

Gorse, *Ulex europaeus*, occurs in all Australian states, but principally in Tasmania and Victoria. An early attempt at biological control in Australia resulted in the establishment of the gorse seed weevil, *Exapion ulicis*, in 1939. *E. ulicis* is now widespread in Tasmania and Victoria, but its impact has been limited. In Tasmania, the number of pods attacked annually ranges from 15–44%. Gorse was declared a target for biological control in Australia in 1995. Since then, two foliage-feeding agents, the gorse spider mite, *Tetranychus lintearius* (of mixed European origin via New Zealand), and the gorse thrips, *Sericothrips staphylinus* (of English origin via New Zealand), have been released. *T. lintearius* was first released in Tasmania and Victoria in December 1998. By spring 2001, it had become widely established throughout most of the major gorse infestations in Tasmania and over large areas in Victoria. However, predation by the introduced Chilean predatory mite, *Phytoseiulus persimilis*, and the native coccinellid, *Stethorus histrio*, is already widespread. *P. persimilis* has been associated with the destruction of entire *T. lintearius* colonies in both Tasmania and Victoria, and it is expected that both predators will significantly restrict its impact. *S. staphylinus* was first released in Tasmania and Victoria in January and March 2001, respectively. Post-release surveys in Tasmania show that the agent has successfully established but dispersal is slow. Acceleration of its dispersal will need to rely on planned redistribution programs. However, *S. staphylinus* of Portuguese origin (via Hawaii via New Zealand) is now being reared for field release in Tasmania and Victoria to determine whether it spreads more rapidly than *S. staphylinus* of English origin. Planned releases of two additional European agents established in New Zealand, the gorse pod moth, *Cydia succedana* (a seed feeder), and the oecophorid moth, *Agonopterix ulicetella* (a foliage feeder), will be dependent on the outcome of investigations into their host specificity that are now being conducted. In the long term it is hoped that the combined effect of the biological control agents can reduce the spread, vigour and longevity of gorse and become useful components of area-based integrated management strategies.

**Keywords:** *Agonopterix ulicetella*, *Cydia succedana*, *Exapion ulicis*, gorse, *Tetranychus lintearius*, *Sericothrips staphylinus*.

## Introduction

*Ulex europaeus* L. (Fabaceae), gorse, was introduced to Australia from Europe during the early 1800s, primarily as a hedge plant, though there was also interest in its potential use as a fodder crop (Parsons and Cuthbertson 2001). It occurs in all Australian states, but the main problem areas are principally in Tasmania and Victoria, where it has invaded pastoral land, significantly reducing pasture and animal productivity. It is also a significant problem along roadsides, forest plantations and bushland margins. In 1999, gorse was listed as a Weed of National Significance.

An early attempt at biological control resulted in the establishment of the gorse seed weevil, *Exapion ulicis*

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(Forster) (Coleoptera: Brentidae). Originally from Europe, *E. ulicis* was introduced from New Zealand to Tasmania in 1939 (Evans 1942). Gorse was declared a target for biological control in 1995 by the Standing Committee of Agriculture and Resource Management following increasing concerns about the extent of the problem and the difficulty and expense of control. Since 1995, four additional European biological control agents established in New Zealand, have been investigated. These are: the gorse spider mite, *Tetranychus lintearius* Dufour (Acari: Tetranychidae), the gorse thrips, *Sericothrips staphylinus* Haliday (Thysanoptera: Thripidae), the gorse pod moth, *Cydia succedana* Denis & Schiffermüller (Lepidoptera: Tortricidae) and the oecophorid moth, *Agonopterix ulicetella* (Stainton) (Lepidoptera: Oecophoridae). This paper reviews the progress of work relevant to Australia carried out to autumn 2003, discusses future directions and the prospects for biological control.

## Agents released

### *Exapion ulicis* (gorse seed weevil)

*Exapion ulicis* is now widespread in Tasmania and Victoria, but its distribution in other states is unknown. In New Zealand, gorse produces seed in both spring and autumn, but *E. ulicis* was found to damage only *ca.* 36% of the annual seed pods (Cowley 1983), as only those produced in spring were attacked (Hill *et al*. 1991). In Australia, it was suspected that similar restrictions on the efficacy of *E. ulicis* applied (Ireson *et. al.* 1999) and a recent study by J.T. Davies (unpublished data) has now confirmed this. The study was conducted at two Tasmanian sites at altitudes of 30 m and 300 m. *E. ulicis* was univoltine at both sites. Larvae fed on seeds only during spring and early summer and were not present during the second period of seed production during autumn/winter. The number of pods produced annually that were attacked ranged from 15–44%.

### *Tetranychus lintearius* (gorse spider mite)

*Tetranychus lintearius* forms large colonies that prefer to feed on mature gorse foliage and are capable of causing severe damage. The suitability of *T. lintearius* for release in Australia was based on host-specificity tests conducted on over 130 plant species (Hill and O'Donnell 1991, Ireson *et al.* 2003). *T. lintearius* was first released in Tasmania and Victoria in December 1998. Rearing and release techniques that resulted in the subsequent establishment in Tasmania and Victoria were detailed by Ireson *et al.* (1999).

By spring 2001, widespread releases (over 200 sites in Tasmania and *ca*. 100 in Victoria), community redistribution programs and windborne dispersal had resulted in *T. lintearius* becoming widely established throughout most of the major gorse infestations in Tasmania and over large areas in Victoria. *T. lintearius*, was also established at a site in southern NSW following releases there in 2000 (A.E. Swirepik pers. comm.).

Two predators, the introduced Chilean mite, *Phytoseiulus persimilis* and the native coccinellid, *Stethorus histrio*, are already widespread amongst *T. lintearius* populations in Tasmania and Victoria, and both have the potential to significantly restrict the usefulness of *T. lintearius* as a biological control agent (Ireson *et al.* 2003). *Phytoseiulus persimilis* has been associated with the destruction of entire colonies of *T. lintearius* in both Tasmania and Victoria (Ireson *et al*. 2003) as well as in Oregon, USA (Pratt *et al*. 2003).

In Tasmania, *T. lintearius* has dispersed more rapidly in the warmer drier regions of the state compared to cooler, wetter regions (Ireson *et al*. 2003). Preliminary results from a Tasmanian field study on the impact of *T. lintearius* have shown significant reductions in gorse biomass 12 months after infestation (J.T. Davies, unpublished data).

### *Sericothrips staphylinus* (gorse thrips)

*Sericothrips staphylinus* can feed on all green gorse foliage (Hill *et al.* 2001), including newly germinated seedlings. Host testing on *ca*.120 plant species or cultivars enabled approval to be obtained for the release of *S. staphylinus* in Australia (Hill *et al*. 2001, J.E. Ireson and A.H. Gourlay unpublished data). *Sericothrips staphylinus* of English origin (via New Zealand) were first released in Tasmania and Victoria in January and March 2001, respectively.

By autumn 2003, *S. staphylinus* had been released at 103 sites in Tasmania and at 21 sites in Victoria. Establishment assessments at 23 Tasmanian release sites one and two years post-release resulted in recovery from 19 (83%) of the release sites. However, dispersal has been slow, with *S. staphylinus* still mostly confined to the bushes on which it was released. Poor dispersal of *S. staphylinus* of English origin has also been recorded in New Zealand and Hawaii, but *S. staphylinus* originating from Portugal was also released in Hawaii where it is reported to have dispersed rapidly (Hill *et al*. 2001). *Sericothrips staphylinus* of Portuguese origin (via Hawaii) are now established in New Zealand and were imported to Australia (via New Zealand) in October 2002. They are now being mass reared for field release in Victoria and Tasmania and will be monitored in both states to determine whether they spread more rapidly than *S. staphylinus* of English origin.

A glasshouse study was conducted in Tasmania during 2002 to assess the impact of *S. staphylinus* (English origin), ryegrass competition and grazing on the growth and survival of gorse seedlings. All three treatments combined reduced seedling survival to 7%. In addition, the study found that the presence of *S. staphylinus* alone reduced shoot dry weight of gorse by a mean of *ca.* 57% (J.T. Davies unpublished data).

## Agents under investigation

### *Agonopterix ulicetella* (oecophorid moth)

*Agonopterix ulicetella* is a potentially important control agent for gorse because the larvae damage new growth during late spring and summer (Hill *et al*. 1995). This agent has established well in Hawaii where it has caused extensive feeding damage (Markin *et al.*1996). However, in New Zealand, where it was first released in 1990, it has performed poorly. Populations are still surviving in the field, but only small numbers of adults have been recovered and no larval populations have been observed (A.H. Gourlay unpublished data).

Planned importations of *A. ulicetella* to Australia will be dependent on the approval of host-specificity tests which have been conducted on over 100 plant species or cultivars (Hill *et al.* 1995, J.E. Ireson and A.H Gourlay unpublished data). These results are scheduled for review in Australia during 2003.

### *Cydia succedana* (gorse pod moth)

In contrast to *E. ulicis*, *C. succedana* is a bivoltine species whose larvae are active during autumn as well as spring (Suckling *et al*. 1999, T.R. Partridge personal communication). Studies at a site in Canterbury, New Zealand (T.R. Partridge personal communication) showed that *E. ulicis* and *C. succedana* together reduced the annual seed crop of gorse at this site by *ca*. 56%. The proportion of the autumn seed crop reduced by *C. succedana* was *ca*. 10%.

Host-specificity tests conducted by Hill and Gourlay (2002) enabled the release of *C. succedana* in New Zealand in 1992. The release of *C. succedana* in Australia is still pending the outcome of ongoing host specificity tests.

## Prospects for control

Long-term control of gorse will be reliant on the development of integrated management strategies (Richardson and Hill 1998), in which a suite of complementary biological control agents will be useful components.

In Australia, although predators may significantly reduce the impact of *T. lintearius* (Ireson *et al.* 2003), studies in Tasmania (J.T. Davies unpublished data) have indicated that populations can still reach high densities. These populations can cause severe damage to gorse in localised areas, after which numbers start to decline; probably as a result of predation or migration triggered by the presence of predators, colony size and the decline in food quality.

Although a combination of *S. staphylinus*, simulated grazing and ryegrass competition significantly reduced gorse biomass under glasshouse conditions (J.T. Davies unpublished data), confirmation of these results under field conditions will be required to provide a useful basis for the development of an integrated control strategy involving this species. It is possible that *S. staphylinus* of Portuguese origin may spread more rapidly than *S. staphylinus* of English origin. However, the role of *S. staphylinus* in any integrated control program in the short term will depend on acceleration of its dispersal, either by artificial means through direct releases from culture, or local redistribution programs.

In New Zealand, establishment of *A. ulicetella* has been sporadic, and then at low densities (Richardson and Hill 1998). In Hawaii, *A. ulicetella* has established and spread widely (Markin *et al*. 1996), and this suggests it could be a useful biological control agent in Australia. However, in south-eastern Australia, foliage feeding biological control agents that spend most of their life cycle exposed on their host plant seem vulnerable to natural enemies (Briese 1986, McLaren *et al*. 2000, Ireson *et al*. 2002).

Simulation and analytical modelling by Rees and Hill (2001) showed that seed feeders were important in gorse control providing they were used in conjunction with other management practices that reduce seed recruitment and seedling survival. Control of gorse using seed-feeding agents alone would be difficult because of the need to consistently destroy a high proportion of the annual seed crop to achieve significant results (Rees and Hill 2001).

In Australia, as in New Zealand (Hill *et al.* 1991), studies in Tasmania (J.T. Davies unpublished data) have shown considerable variation in seasonal seed production on bushes within and between sites. Some sites produce seed during both late spring/summer and late autumn/winter and, at other sites, seed is produced only during the spring/summer period. New Zealand impact studies (T.R. Partridge personal communication) and modelling simulations (Rees and Hill 2001) show that the proportion of autumn produced seed that is reduced by the feeding of *C. succedana* will be insufficient to control gorse. The suite of biological agents needed to reduce gorse vigour and seed output should therefore include additional European agents (either biotypes of known species or different species) that may significantly reduce autumn seed production.

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## References

Briese, D.T. (1986). 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* **23**, 821–839.

Cowley, J.M. (1983). Lifecycle of *Apion ulicis* (Coleoptera: Apionidae), and gorse seed attack around Auckland, New Zealand. *New Zealand Journal of Zoology* **10**, 83–86.

Evans, J.W. (1942). The gorse weevil. *Tasmanian Journal of Agriculture* **13**, 15–18.

Hill, R.L. and Gourlay, A.H. (2002). Host-range testing, introduction, and establishment of *Cydia succedana* (Lepidoptera: Tortricidae) for biological control of gorse, *Ulex europaeus* L., in New Zealand. *Biological Control* **25**, 173–186.

Hill, R.L., Gourlay, A.H., and Martin, L. 1991. Seasonal and geographic variation in the predation of gorse seed, *Ulex europaeus* L., by the seed weevil *Apion ulicis* Forst. *New Zealand Journal of Zoology* **18**, 37–43.

Hill, R.L., Markin, G.P., Gourlay, A.H., Fowler, S.V. and Yoshioka, E. (2001). Host range, release and establishment of *Sericothrips staphylinus* Haliday (Thysanoptera: Thripidae) as a biological control agent for gorse, *Ulex europaeus* L. (Fabaceae), in New Zealand and Hawaii. *Biological Control* **21**, 63–74.

Hill, R.L. and O'Donnell, D.J. (1991). The host range of *Tetranychus lintearius* (Acarina: Tetranychidae). *Experimental and Applied Acarology* **11**, 253–269.

Hill, R.L., O'Donnell, D.J., Gourlay, A.H., and Speed, C.B. (1995). Suitability of *Agonopterx ulicetella* (Lepidoptera: Oecophoridae) as a control for *Ulex europaeus* (Fabaceae: Genisteae) in New Zealand. *Biocontrol Science and Technology* **5**, 3–10.

Ireson, J.E., Davies, J. T., Holloway, R.J. and Chatterton, W.S. (2002) Attempts to establish biological control agents for boneseed in Tasmania. *Proceedings of the 13th Australian Weeds Conference Proceedings* (eds H. Spafford Jacob, J. Dodd & J.H. Moore), pp. 407–411. Plant Protection Society of Western Australia, Perth.Ireson, J.E., Gourlay, A.H., Kwong, R.M., Holloway, R.J. and Chatterton, W.S. (1999) Progress on the rearing, release and establishment of the gorse spider mite, *Tetranychus lintearius* Dufour, for the biological control of gorse in Australia. *Proceedings of the 12th Australian Weeds Conference Proceedings* (eds A.C. Bishop, M. Boersma & C.D. Barnes), pp. 320–324. Tasmanian Weed Society, Hobart.

Ireson, J.E., Gourlay A.H., Kwong, R.M., Holloway, R.J. and Chatterton, W.S. (2003) Host specificity, release and establishment of the gorse spider mite, *Tetranychus lintearius* Dufour (Acarina: Tetranychidae), for the biological control of gorse, *Ulex europaeus* L. (Fabaceae), in Australia. *Biological Control* **26**, 117–127.

Mclaren, D.A., Ireson, J.E. and Kwong, R.M. (2000) Biological control of ragwort in Australia. *Proceedings of the X International Symposium on Biological Control of Weeds* (ed N.R. Spencer), pp. 67–79. United States Department of Agriculture, Agricultural Research Services, Sidney, MT and Montana State University, Bozeman, MT.

Markin, G.P., Yoshioka, E.R. and Conant, P. (1996) Biological control of gorse in Hawaii. *Proceedings of the IX International Symposium on the Biological Control of Weeds* (eds V.C. Moran & J.H. Hoffmann), pp. 371–375. University of Cape Town, South Africa.

Parsons, W.T. and Cuthbertson, E.G. (2001) *Noxious Weeds of Australia* (second edition), pp. 480–484. Inkata Press, Melbourne, Australia.

Pratt, P.D., Coombs, E.M. and Croft, B.A. (2003) Predation by Phytoseiid mites on *Tetranychus lintearius* (Acari: Tetranychidae), an established weed biological control agent of gorse (*Ulex europaeus*). *Biological Control* **26**, 40–47.

Rees, M. and Hill R. L. (2001) Large-scale disturbances, biological control and the dynamics of gorse populations. *Journal of Applied Ecology* **38**, 364–377.

Richardson, R.G. and Hill, R.L. (1998) The biology of Australian Weeds 34. *Ulex europaeus* L. *Plant Protection Quarterly* **13**, 46–58.

Suckling, D.M., Hill, R.L., Gourlay A.H. and Witzgal, P. (1999) Sex attractant-based monitoring of a biological control agent of gorse. *Biocontrol Science and Technology* **9**, 99–104.