Senecio madagascariensis Poir. – Fireweed

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ABSTRACT

Senecio madagascariensis, fireweed, is one of the worst weeds of coastal pastures of southeast Queensland and New South Wales. Originating in southeastern Africa, it was accidentally introduced to the Hunter Valley in Australia prior to 1918 and has since spread to other coastal areas of NSW and southern Qld and is continuing to spread. It is also invasive in Japan, Hawaii, Argentina and Uruguay. A biocontrol program started in 1987, but only two insects were tested and neither was released. Investigations of a rust pathogen from South Africa also failed to result in any releases. Biocontrol continues to be promoted as a solution for fireweed, but the challenge remains of finding agents that would not attack the many Australian native *Senecio* spp. closely related to fireweed.

Key words: pasture weeds, native species, South Africa, *Puccinia, Lobesia, Phycitodes*

INTRODUCTION

Fireweed, *Senecio madagascariensis* Poir. (Asteraceae), is a short-lived perennial herb, with many stems reaching 70 cm tall from a single branched taproot up to 20 cm deep. It produces numerous bright yellow flowerheads which make it conspicuous when in flower. Cypselas (fruits that look like seeds, each containing a single seed, often called achenes) are 1-3 mm long with a pappus and are spread by wind, animals and machinery. Seeds germinate readily after rain from autumn to spring and seedlings can establish even in well-managed pastures. Fireweed is a serious invasive weed in temperate and subtropical pastures along the east coast of Australia. Containing pyrrolizidine alkaloids, it is poisonous to livestock, particularly cattle. However, once cattle are familiar with the weed, they tend to avoid it, which allows it to compete more vigorously with pasture species and reduce their productivity (Figure 1). Poisoning is more likely to occur where other feed is limited, when plants are young and not easily differentiated from the rest of the pasture, when contaminated hay is consumed or when stock are newly introduced to the weed

(Sindel *et al.* 1998). Herbicides are available that effectively kill fireweed, but year-long management is difficult and uneconomic because of the weed's ability to germinate and flower throughout much of the year (Sindel *et al.* 1998).

In Australia fireweed was introduced to the Hunter Valley at some time before 1918, probably as a contaminant of hay used in shipping horses. However, for many years it was thought to be a form of the native *Senecio lautus* G.Forst. ex Willd. (now *S. pinnatifolius* A.Rich.) complex and was not correctly identified until 1980 (Michael 1981). By the 1980s the weed had spread north and south in coastal NSW and southern Qld in similar climatic regions to those where it originated in southern Africa (Sindel and Michael 1992). It is continuing to spread in NSW, including the Bega area where it previously occurred only in isolated patches, the Monaro region in the Southern Tablelands and the Coffs Harbour and Dorrigo areas on the Northern Tablelands. In 2007 the weed was also found growing on the Atherton Tablelands in north Qld, in line with predictions by Sindel and Michael (1992). It is therefore clear that it has not yet reached its potential distribution in Australia. Climate change is also likely to affect the continued spread of fireweed and its potential distribution: movement into cooler highland areas and further south may increase, while continued spread north into the tropics is likely to slow. The current distribution based on specimens in Australia's Virtual Herbarium is shown in Figure 2.

BIOLOGICAL CONTROL HISTORY

Prior to 1988, biocontrol programs against *S. madagascariensis* had been suggested for both Argentina and Hawaii, but no work undertaken. A program began in Hawaii in the late 1990s with the importation and testing of potential insect agents and a rust fungus (Culliney *et al.* 2003). Introduction of the arctiid moth *Secusio extensa* (Butler) has been proposed, but no releases have yet been made (Hawaii Department of Agriculture 2008).

As a result of two short surveys in 1987 and 1988 of the insects attacking *S. madagascariensis* in southern Madagascar, a five-year project to import into quarantine, test and release suitable insects started in July 1990. The taxonomy of *S. madagascariensis* continued to be questioned, and it became clear that, despite its name, *S. madagascariensis* was in fact native to the KwaZulu-Natal region of South Africa. A further survey in South Africa was therefore undertaken in 1991.

Because of the lack of specificity of the agents tested, and the fact that Australia has a rich flora of native *Senecio* species including species very close to *S. madagascariensis*, the prospects for successful biocontrol were thought to be small and the program was discontinued in 1995. However, as fireweed continues to spread in the high-value coastal pastures of NSW and southern Qld, there has been continued stakeholder and political pressure for further biocontrol research against fireweed. Further surveys in South Africa were therefore undertaken in 2002, and a rust pathogen was investigated, but was found to have limited potential. Additional South African surveys, particularly focusing on invertebrates, are planned for the future.

PLANT TAXONOMY

Senecio madagascariensis was first described by Poiret in 1817 from specimens collected in Madagascar. In Australia it was initially confused with a similar native *Senecio* species (then called *S. lautus*), and was first recognized as a southern African plant and correctly named as *S. madagascariensis* in 1981 (Michael 1981). Subsequent investigations have shown that Australian *S. madagascariensis* is most similar to plants from the KwaZulu-Natal province in South Africa, and that it is from this region that our fireweed originated (Radford *et al.* 2000; Lafuma *et al.* 2003).

Continuing confusion over the identification of this group led to detailed taxonomic work on the *S. lautus* complex, as a result of which many Australian native plants previously confused with *S. madagascariensis* have now been re-assigned to *S. pinnatifolius* and other *Senecio* spp. (Thompson 2005). The native species *S. brigalowensis* I.Thomps., which is common and has become increasingly abundant and weedy in central Queensland from Roma to Rockhampton, will also cause cattle poisoning (Noble *et al.* 1994) and is easily confused with *S. madagascariensis.* Unfortunately there are still difficulties in the identification of some Australian native *Senecio* species, with possible hybridisation occurring (Prentis *et al.* 2007), and also difficulties in the identification of *S. madagascariensis* and related species in South Africa such as *Senecio inaequidens* DC. which is a major weed in Europe (Lafuma *et al.* 2003). A recent molecular phylogeny of the tribe Senecioneae has resulted in a new delimitation of the genus *Senecio* (Pelser *et al.* 2007), but additional molecular studies targeting the Australian native species are required to clarify interspecific relationships.

EXPLORATION

Fireweed was originally thought to originate from Madagascar, and initial surveys were therefore concentrated in southeast Madagascar, where *S. madagascariensis* is known to occur and the climate is most similar to that of affected areas of Australia. Initial surveys were undertaken in January 1987 and June 1988 by Jennifer Marohasy (then Turnour) who was based in southwest Madagascar studying potential biocontrol agents against rubbervine *Cryptostegia grandiflora* R.Br. (this volume). Both surveys were restricted to the Fort Dauphin area in the extreme south of Madagascar, where *S. madagascariensis* is present in disturbed land along tracks and in clearings (Marohasy 1989). In August 1991 she made a three-week survey in South Africa, searching on related *Senecio* species in KwaZulu-Natal and the Drakensberg region (Marohasy 1991; Table 1). She discovered several new insects feeding on *S. madagascariensis,* and recommended that further surveys be undertaken in the summer season. This however was not followed up due to lack of financial support. She also recommended further study and host-specificity testing on the stem and flower-feeder *Platyptilia* sp. nr. *molopias* Meyrick (Lep.: Pterophoridae), the flower-feeder *Homoeosoma stenotea* Hampson (Lep.: Pyralidae) and the stem-borer *Melanagromyza* sp. (Dipt.: Agromyzidae).

In 1996/97, *Senecio* specimens were collected in KwaZulu-Natal for a taxonomic study (Radford *et al.* 2000) and a rust fungus discovered attacking the leaves (P. Müller *pers. comm.* 1997). A second field trip was made in September 2002 specifically to collect this rust for study in quarantine in Australia (Morin 2003; Morin *et al.* 2009). However, no general survey of the pathogens attacking *S. madagascariensis* in KwaZulu-Natal has been undertaken.

CANDIDATE AGENTS

Pathogens:

While an extensive range of pathogens, from rust and mildew to facultative parasitic fungi, have been recorded on *Senecio* species in South Africa (Farr and Rossman 2010), no fungi had been recorded on *S. madagascariensis* prior to the 2002 survey in KwaZulu-Natal. In this survey, disease symptoms caused by what was thought to be an *Aecidium* sp. rust fungus and the cosmopolitan biotrophic fungus *Albugo tragopogonis* (Pers.) Gray were found on *S. madagascariensis* (L Morin unpubl. data 2002). Since *A. tragopogonis* is known for its wide host-range within Asteraceae and already occurs on fireweed in Australia (Plant Health Australia 2001), only the rust fungus was imported into quarantine in Canberra for detailed studies (Morin 2003). This rust fungus was initially referred to an *Aecidium* sp. because only the aecial stage was present on specimens collected. DNA sequence and RFLP analyses revealed that one of the imported rust isolates was similar to Australian isolates of *Puccinia lagenophorae* Cooke (Morin *et al.* 2009), a fungus known to attack fireweed and other *Senecio* species in Australia and several other countries (Holtkamp and Hosking 1993; Farr and Rossman 2010). In contrast, all other South African rust isolates investigated were found to be putative hybrids between *P. lagenophorae* and another unknown rust species. In pathogenicity tests, none of the three South African isolates tested (including the non-hybrid isolate) produced more damage on Australian fireweed accessions than did Australian *P. lagenophorae* isolates (Morin 2003). In concurrent tests, the native *S. pinnatifolius* did not develop any disease symptoms following inoculation with two of the isolates from South Africa and two from Australia. While these initial results suggest that the South African rust isolates may not pose a threat to Australian native *Senecio* spp., it is unlikely that their introduction into Australia would lead to improved control of fireweed.

Insects:

In her surveys in Madagascar and South Africa, J Marohasy found several potentially useful insects, nine species from Madagascar and eighteen from South Africa (Marohasy 1989, 1991; Table 1). The two most easily collected species from Madagascar, the flower - feeding pyralid *Phycitodes* new sp. and the stem-feeding tortricid moth *Lobesia* new sp., were imported into quarantine in Brisbane in July 1990 for detailed host-testing. There were considerable logistical problems, as J Marohasy was based in Kenya at the time and went over to Madagascar to make the collections, where she had to use facilities of a Canadian mining firm operating in Fort Dauphin in southern Madagascar. Shipments were sent via Mauritius and Singapore and took several days, but about 70% of the larvae survived, sufficient to establish quarantine colonies. Repeat collections in 1991 were not possible due to rioting in the capital and major towns, but in July 1992 she was able to collect and send a shipment of several hundred larvae.

In 1992 permits were obtained to import two of the recommended species from South Africa, the flower-feeding pyralid moth *Homoeosoma stenotea* and the stem-boring agromyzid fly *Melanagromyza* sp. However, problems in finding collaborators to collect the insects meant that no shipments were received before the funding finished in 1995 (McFadyen 1995) and no further investigations have been made on these species. In addition, both species have close relatives in Australia that attack fireweed and therefore it was potentially unlikely that the introduction of similar African species would improve overall biocontrol. *Homoeosoma stenotea* is closely related to the blue stem borer moth *Patagoniodes (Homoeosoma) farinaria* (Turner), native to Australia and New Zealand where it bores stems and roots of a small group of native and introduced *Senecio* species (McQuillan and Ireson 1987). *Melanagromyza* is a large genus of mainly host-specific species, with the native Australian species *M. seneciophila* Spencer known to attack *S. madagascariensis* as well as other *Senecio* spp. (Holtkamp and Hosking 1993).

Flower-feeding moth *Phycitodes* new sp. (Lep.: Pyralidae)

Adults of this moth were reared from larvae feeding in seed heads of *S. madagascariensis* in southern Madagascar and it was identified by the Commonwealth Institute of Entomology (CIE) as a new species (Marohasy 1989). There is little published information on the biology of other species in the genus; *Phycitodes binaevella* (Hübner) has been recorded from the flowerheads of *Cirsium vulgare* (Savi) Ten. in Holland and larvae of an undetermined species of *Phycitodes* were recorded from flowerheads of *Ptilostemon (Cirsium) gnaphaloides* (Cirillo) Soják in Crete, both Asteraceae (McFadyen 1995).

Larvae from Madagascar were readily reared on fireweed flowers in quarantine. The larvae fed primarily on the developing achenes in the flowerheads, tying the damaged flowerheads together with a few strands of silk and moving to adjacent flowerheads as they were consumed. Once all flowerheads were consumed, larvae moved down to bore into leaf axils and fed in the stem, killing the stem portion above their feeding site. Feeding by several larvae killed plants. Full-grown larvae left the plant to pupate in a silk cocoon in leaf litter, dry leaves or attached to dry bark. Adults, 10-12 mm long, with narrow grey-brown wings held rolled over the back, emerged in a few days and lived for 10-18 days. They were nocturnal, and fed on nectar. Females only laid on flowerheads, and the cylindrical eggs were laid singly, carefully inserted into a concealed position between bracts and florets on the flowerheads. In summer temperatures (daily range 20-30^{o}C), the whole life cycle from egg to adult was completed in 21 days (McFadyen and Sparks 1996).

In quarantine, *Phycitodes* new sp. was extremely destructive to fireweed plants, with 20 adult moths on 12 well-grown fireweed plants resulting in the complete destruction of plants by the time the larvae had reached maturity in two weeks. However the colony died out suddenly in January 1991, and again in January 1993 the new colony died out in the same way. Fireweed flowers less often in summer in Australia, but flowering plants were always provided for adult oviposition, and eggs were laid as usual. However on both occasions the resulting larvae did not survive and the colonies died out. The reason for this failure to survive is not known; no disease could be found and temperatures were not unusually high. It is unlikely that it was due to Australian *S. madagascariensis* being an unsuitable host, as there was not a gradual decline in each quarantine generation, but rather in both years a sudden complete failure of survival of larvae from eggs laid in December and January.

Stem and root-boring moth *Lobesia* new sp. (Lep.: Tortricidae)

Adults reared from larvae feeding in *S. madagascariensis* in Madagascar were identified by CIE as a new species of *Lobesia.* Other species in the genus have been recorded from plants in several plant families in the Old World. Some are damaging pest species but all are specific to one or a small group of host plants. For example, *Lobesia euphorbiana* (Freyer) was introduced into Canada and the USA for the biocontrol of its host plant leafy spurge *Euphorbia esula* L. (Julien and Griffiths 1998).

Adults of the *Lobesia* sp. from Madagascar are 4-8 mm long, grey with wings at rest folded across the body. Although largely nocturnal, oviposition in quarantine occurred during the day with a peak at dawn (D. Sparks *pers. comm.* 1995). Adults fed on nectar and lived for 8 to 14 days. Flattened, circular, translucent white eggs were laid singly on leaves, petioles or stem tips. Newly-hatched larvae wandered over the leaf to the axil where they bored into and fed down the stems as far as the crown or even roots. Frass was ejected through holes in the stems and pupation occurred in the stem. Feeding destroyed the stems above the feeding site. The complete life cycle took about 28 days at temperatures of 20^{o} (night) to 30^{o}C (day) (McFadyen and Sparks 1996).

HOST TESTING

Plants tested: the list of plants to be tested, approved in 1989, was largely restricted to the family Asteraceae with only five species from other families (McFadyen and Sparks 1996). Asteraceae is a natural family with well-established limits, and the many biocontrol programs against Asteraceae weeds have demonstrated that suitable biocontrol agents, i.e. insects specific to a small group of species within the family, do not damage plants outside the family. The list (Table 2) included all 18 native *Senecio* species then recorded from coastal eastern NSW and southeast Qld, including the *S. lautus* (now *S. pinnatifolius*) complex, plus four ornamental **Senecio** species. Because of confusion in the taxonomy of *Senecio* in eastern Australia prior to the revision by Thompson (2006), it is not possible to assign many of the plants used in the tests in 1989 to currently recognised species. The test list also included species (native and introduced ornamentals) from other genera in the tribe Senecioneae present in Australia. Native species and/or species of economic importance from other tribes within the Asteraceae, which occur in Australia, were included. A representative species from other families of the order Asterales was included, selecting species with a similar habit to fireweed. In addition, for testing of the moth *Lobesia* new sp., the known host plants of other species of *Lobesia* were added.

Methods used: for both species, the host-selection stage is the adult female, as larvae do not normally move from plant to plant. Therefore all tests used adult moths, usually in standard cages 50 × 80 × 100 cm with metal bases and gauze sides and top. Test plants were grown in pots. For tests, the cage base rested on the pot rims with the upper parts of the plants entering the cage through narrow holes in the cage base. Moths thus had free access to the plants but not to soil. Honey and water in cotton wicks were supplied, and moths of both species were seen to feed on these.

In initial tests, two test plants and four fireweed plants were used per test. In later tests, two or more test plants were used per cage, with separate control cages containing fireweed plants. Ten female and ten male moths were released into each cage. After two weeks (by which time all moths were dead), the plants were removed, examined and then held in separate cages for larval development. Damage from larval feeding was recorded on a four-point assessment scale and any adult emergence recorded.

For *Lobesia* sp., additional tests in a larger cage 3 × 3 × 2.5 m were conducted with those test plants attacked in the smaller cages. Four plants of each test species plus four plants of fireweed were distributed in the cage and 15 male and 15 female moths released into the cage. Subsequent procedures were as above.

Results - *Phycitodes* sp.: some larval feeding occurred on the ornamentals chrysanthemum (*Chrysanthemum indicum* L.), dahlia (*Dahlia* x hybrid), and *Calendula* sp., in other tribes within the family Asteraceae, and on the native plants *Euryops chrysanthemoides* (DC.) B.Nord., *Callistephus chinensis* (L .) Nees, and *Olearia nernstii* (F.Muell.) in the Asteraceae, and *Stylidium graminifolium* Sw. in the Stylidiaceae. Development through to the adult only occurred on chrysanthemum and dahlia, and numbers were small and development abnormally slow. On plants within the tribe Senecioneae, development to the adult occurred on fireweed and on the native species *S. pinnatifolius* var. *pinnatifolius* and *S. quadridentatus* Labill. On both these species, the number of adults reared was 50% or less of those on fireweed, but this may not be significant due to differences in the size of the plants. There was no attack on the other species tested including the natives *S.*

pinnatifolius var. *serratus* I.Thomps., *S. bipinnatisectus* Belcher, *S. minimus* Poir., and *Gynura drymophila* (F.Muell.) F.G.Davies. Only six species of *Senecio* were tested and no large cage tests had been undertaken by January 1993 when the colony died out.

***Lobesia* sp.:** in the small cage tests, 23 *Senecio* species were tested (Table 2) and larval feeding and normal development through to adult occurred on four of these (*S. pinnatifolius* var. *pinnatifolius, S. pinnatifolius* var. *serratus, S. quadridentatus, S. anethifolius* A. Cunn. ex DC.), with a few adults also developing on the ornamental *Senecio confusus* Britten. Thirty-seven other species were tested (Table 2) and comparable numbers of adults were reared from *Calendula* sp., *Dahlia* sp., and *Flaveria australasica* Hook. from other tribes within the Asteraceae. Small numbers of adults were reared from *Crassocephalum crepidioides* (Benth.) S. Moore, *Emilia sonchifolia* (L.) DC., *Erechtites valerianifolius* (Wolf) DC., *Cotula australis* (Sieber ex Spreng.) Hook.f., and *Soliva anthemifolia* (Juss.) Sweet.

Results from the large cage tests were very different; of the five *Senecio* species tested, larval feeding and normal adult development occurred only on *S. pinnatifolius* var. *pinnatifolius*, and feeding but greatly reduced numbers of adults (10% of controls) on *S. pinnatifolius* var. *serratus*. Of the eight species in other tribes of Asteraceae tested, there was no feeding in *E. sonchifolia*, *Dahlia* sp, *F. australasica*, *C. australis* and *S. anthemifolia*, and feeding but greatly reduced numbers of adults from *C. crepidioides* (50% of controls), *E. valerianifolius* (10% of controls), and in one of five replicates of *Calendula* sp. (50% of controls). However, two generations of apparently normal moths were reared on *Calendula* sp. In the light of these results, which implied a potential host-range across two or more tribes within the family Asteraceae, host-testing was terminated and the colony destroyed (McFadyen and Sparks 1996).

DISCUSSION

The Australian biocontrol program against fireweed has been plagued throughout by the taxonomic problems with *Senecio*. The taxonomy of *Senecio* in southern Africa, the native range of *S. madagascariensis*, was confused, and initially Australian fireweed was thought to originate from Madagascar, but subsequent molecular studies indicated that its origin was Kwazulu-Natal, South Africa (Radford *et al.* 2000; Lafuma *et al.* 2003). Similarly, there are many native Australian plants in the genus *Senecio*, some very difficult to distinguish from each other and from fireweed. Given the large number of native Australian

Senecio species that are very similar to fireweed, both chemically and in habit and habitat, it is clear that only a very specific agent will attack fireweed without also causing damage to at least some of these native species. Yet one of the native species, *S. brigalowensis,* is known to cause cattle deaths and economic losses in grazing properties in central Queensland (Noble *et al.* 1994) and has greatly increased in abundance due to clearing of native forest for grazing in central Qld (McFadyen unpublished data 2008). It would seem appropriate to undertake a cost benefit analysis to weigh up the advantages and disadvantages of the release of agents that might attack these native species as well as fireweed, and this is possible under the *Biological Control Act 1984.* However, other native Australian *Senecio* species are listed as rare and threatened (Briggs and Leigh 1996), and there is little likelihood of support for the release of any agents that might damage any of these species.

Host-specificity testing of the two moths from Madagascar was never fully completed. With *Lobesia* sp. a decision was made that the host range was unacceptably wide. The difference between the small and large-cage test results demonstrated that female moths exhibited a significantly narrower choice in their egg-laying when given more natural conditions. It is therefore likely that their behaviour in the wild would be even more selective (McFadyen *et al.* 2002). Nevertheless, the apparently normal development of the insect on plants in other tribes within the Asteraceae was judged to indicate an unacceptably wide host range, and it is unlikely that further testing would reverse this decision.

For *Phycitodes* sp. the situation is somewhat different. Even in small cages, oviposition and larval development only occurred on two of six native *Senecio* spp. tested, and it is likely that even fewer species would have been attacked if tested in larger cages (and hence by extrapolation in the wild) (McFadyen *et al.* 2002). Further, the *Phycitodes* sp. tested was collected in Madagascar from a *Senecio* which is now known not to be the same as that found in Australia. If a similar *Phycitodes* sp. were to be found in South Africa it might prove to be specific to the Australian fireweed.

There is already a significant suite of native insects and at least one damaging pathogen *P. lagenophorae* which attack fireweed in the field in Australia (Holtkamp and Hosking 1993). This does not provide satisfactory control of fireweed in most grazing situations. A successful agent would therefore either need to attack plants earlier in the season, i.e. during the seedling stage, or achieve much higher densities than the native insects by being, for example, less susceptible to native parasitoids and predators (McQuillan and Ireson 1987).

As fireweed continues to spread in eastern Australia, and conventional control measures remain ineffective or uneconomic, there is continued pressure to seek a biocontrol solution. A thorough and detailed investigation of the insects and pathogens attacking *S. madagascariensis* and related *Senecio* species in KwaZulu-Natal, together with their specificity and potential efficacy undertaken by expert(s) resident in the area over several seasons, will be essential to identify any new potential biocontrol agents.

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Table 1: Insects collected on *S. madagascariensis* in Madagascar and South Africa (from Marohasy 1989,1991: identifications from CIE)

	Insect species	Country	Plant part attacked	Other information
Lepidoptera	**Noctuidae:**			
	Thysanoplusia orichalcea (Fab.)	Madagascar	Leaves	Known polyphagous pest species
	Condica conducta Walker	Madagascar	Leaves	Known generalist on Asteraceae
	Geometridae:			
	Indet. genus and sp.	Madagascar	Leaves	No other information
	Pyralidae:			
	Homoeosoma stenotea Hampson	South Africa	Flowers	Damaging - potential agent
	Phycitodes new sp.	Madagascar	Flowers and stems	Imported and tested in quarantine
	Crambidae:			
	Udea ferrugalis (Hübner)	South Africa	Leaves	
	Tortricidae:			
	Indet. genus and sp.	South Africa	Stem-boring in pith	Not very damaging
	Epichorestodes acerbella Walker	South Africa	Leaves	
	Lobesia new sp.	Madagascar	Stems	Imported and tested in quarantine
	Platyptilia ?molopias Meyrick	South Africa	Stems and flowers	Damaging - potential agent
Diptera	**Tephritidae:**			
	Sphenella marginata (Fallen)	Madagascar	Flowers	Cosmopolitan species present in Australia
	Cryptophorellia peringueyi (Bezzi)	South Africa	Flowers	Also from other *Senecio* spp.
	Agromyzidae:			
	Liriomyza trifolii (Burgess)	Madagascar	Leaves	Known polyphagous pest species
	Melanagromyza sp.	South Africa	Stem boring	Damaging but similar to *M. seneciophila* in Australia
	Cecidomyiidae:			
	Indet. genus and sp.	South Africa	Flowers	Host range unknown
	Sciaridae:			

	Indet. genus and sp.	South Africa	Boring in pith of stem and root	Host range unknown
Homoptera	**Pseudococcidae:**			
	Tylococcus ?harongae Mamet	Madagascar	Phloem feeding	Host range unknown
	Coccidae:			
	Pulvinaria sp.	South Africa	Phloem feeding	Host range unknown
	Cicadellidae:			
	Indet. genus and sp.	South Africa	Phloem feeding	Host range unknown
	Tettigometridae:			
	Hilda sp.	South Africa	Phloem feeding	Host range unknown
	Aphididae:			
	Aphis fabae ssp. *solanella* Theobald	South Africa	Phloem feeding	Known polyphagous pest species
	Aphis gossypii Glover	Madagascar	Phloem feeding	Known polyphagous pest species
	Brachycaudus helichrysi (Kaltenbach)	South Africa	Phloem feeding	Known polyphagous pest species
	Macrosiphum euphorbiae (Thomas)	South Africa	Phloem feeding	Known polyphagous pest species
	Myzus ornatus Laing	South Africa	Phloem feeding	Known polyphagous pest species
Heteroptera	**Lygaeidae:**			
	Nysius albipennis Distant	Madagascar	Seed heads	Host range unknown: other *Nysius* spp. attacking *Senecio* spp. in Australia
	Nysius ericae (Schilling)	Madagascar and South Africa	Seed heads	Host range unknown
	Nysius ?graminicola (Kolenati)	South Africa	Seed heads	Host range unknown
	Nysius ?senecionis Schilling	South Africa	Seed heads	Host range unknown
	Rhopalidae:			
	Strictopleurus scutellaris coquerelli (Signoret)	Madagascar	Phloem feeding	Host range unknown

	Miridae:			
	Ellenia obscuricornis (Poppius)	South Africa	Flowers	Host range unknown
Hymenoptera	**Eucoilidae:**			Host range unknown; may be
	Diglyphosema sp.	South Africa	Stem boring	parasite of agromyzid
Coleoptera	**Curculionidae:**			
	? Throgonius sp.	Madagascar	Adults at flowers	Larval host unknown
	Gasteroclisus tricostalis (Thunberg)	South Africa	Boring in stem pith	Common but not very damaging
Thysanoptera	**Phlaeothripidae:**			
	Haplothrips nigricornis (Bagnall)	Madagascar	Seed heads	Pest of sunflower?

Table 2. Plants tested with *Lobesia* sp. and *Phycitodes* sp.
* Australia native; # also tested with *Phycitodes*; @only tested with *Phycitodes*

Family Asteraceae, Tribe Senecioneae	*Senecio:* 21 native species or sub-species, 5 also tested with *Phycitodes (nb. determination of actual species is not possible).* *S. cineraria* DC., *S. confusus* Britten, *S. macroglossus* DC., *S. tamoides* DC.
	**Bedfordia arborescens* Hochr.
	Brachyglottis greyi (Hook.f.) B.Nord.
	Crassocephalum crepidioides (Benth.) S Moore
	Delairea odorata Lem.
	**Emilia sonchifolia* (L.) DC
	Erechtites valerianifolius (Wolf) DC.
	#*Euryops chrysanthemoides* (DC.) B.Nord.
	*#*Gynura drymophila* (F.Muell.) FG Davies
	Ligularia sp.
	Roldana (*Senecio*) *petasitis* (Sims) H.Rob. & Bretell.
Tribe Calenduleae	#*Calendula* sp.

Tribe Heliantheae	#*Dahlia* sp.
	**Flaveria australasica* Hook.
	Gaillardia sp.
	#*Helianthus annuus* L. (two commercial varieties)
Tribe Inuleae	*#*Cassinia laevis* R.Br.
	**Euchiton sphaericus* (Willd.) Holub
	**Xerochrysum bracteatum* (Vent.) Tzvelev
Tribe Anthemideae	#*Chrysanthemum* sp.
	*#*Cotula australis* (Sieber ex Spreng.) Hook.f.
	Soliva anthemifolia (Juss.) Sweet
	Soliva sessilis Ruiz & Pav.
Tribe Astereae	@*Aster subulatus* Michx.
	#*Callistephus chinensis* (L .) Nees
	*#*Olearia nernstii* (F.Muell.) Benth.
	**Vittadinia sulcata* N.T.Burb.
Tribe Eupatoriaea	*#*Adenostemma lavenia* (L.) Kuntze
Tribe Vernonieae	*Vernonia cinerea* (L.) Less.
Tribe Lactuceae	*Cichorium intybus* L.
	#*Lactuca sativa* L.
Tribe Mutiseae	*Gerbera* sp.
Tribe Cynareae	*Carthamus tinctorius* L.
Family Campanulaceae	**Pratia purpurascens* (R.Br.) E.Wimm.
	Isotoma anethifolia Summerh.
Family Goodeniaceae	**Brunonia australis* Sm. ex R.Br.
	**Scaevola humilis* R.Br.
Family Stylidiaceae	*#*Stylidium graminifolium* Sw.
Family Euphorbiaceae	*Euphorbia* sp.

Family Rubiaceae	*Coffea arabica* L.
Family Vitaceae	*Vitis vinifera* L.
Family Pinaceae	*Larix europaea* DC

Figure 1 Fireweed infestation in pasture at Bega, NSW, Sept 2006. (R McFadyen, Weeds CRC)

Figure 2 Fireweed distribution in Australia (from Australian Virtual Herbarium June 2010)