BIOLOGICAL CONTROL OF FIREWEED

R. McFadyen and D. Sparks[A]
Co-operative Research Centre for Tropical Pest Management, Alan Fletcher Research Station,
PO Box 36, Sherwood, Queensland 4075, Australia
[A] Present address: 'Dundsandle', Bourke, New South Wales 2840, Australia

Summary Fireweed (*Senecio madagascariensis* Poiret) is a toxic weed of coastal pastures in New South Wales and southern Queensland. Existing control strategies are largely uneconomical and biological control has been proposed as the only long term solution. Surveys in Madagascar found 14 potential biocontrol agents, of which the two most promising were the moths *Phycitodes* sp. and *Lobesia* sp. These moths were established in quarantine in Australia where their host ranges were assessed. *Phycitodes* oviposited and developed on several native *Senecio* species, *Lobesia* sp. oviposited and developed on several species from the tribes Senecioneae and Calenduleae. *S. madagascariensis* and the native *S. lautus* seem equally suitable as hosts for *Lobesia.* As this was an unacceptably wide host-range for both moths, the colonies were destroyed. A short survey was made of the insects on *S. madagascariensis* in South Africa, but no insects were imported or tested.

DNA studies confirmed that *S. madagascariensis* from Australia is distinct from *S. lautus* and related Australian species, but samples from Madagascar are still needed to confirm the origin of *S. madagascariensis*. Fireweed is closely related to the native *S. lautus* so it may be difficult to find biocontrol agents that will not attack the native species. The precise origin of *S. madagascariensis* should be determined then a detailed search made there. If agents specific to *S. madagascariensis* cannot be found, a test case should be initiated for the release of an agent which also attack *S. lautus*.

INTRODUCTION

Fireweed (*Senecio madagascariensis* Poiret) is a major pest of coastal pastures in New South Wales and southern Queensland. It reduces pasture growth and is toxic to livestock. Integrated management strategies including herbicide use, mechanical methods and careful pasture management may be effective but are not economical in many situations. Biological control has appeared to be the only long term solution. The Lands Department entomologist based in Madagascar, Ms. J Marohasy, undertook surveys of fireweed and its insects in Madagascar in 1987 and 1988, and identified two promising biocontrol agents. In 1989 the MRC approved a funding application to import, test and release suitable insects, and the project started in July 1990.

IDENTIFICATION OF FIREWEED

The native *Senecio lautus* Forster complex consists of a number of subspecies, some of which appear very similar to fireweed, either as living plants in the field or as dried specimens. Fireweed was not distinguished from this complex until 1980, when P.W. Michael sent fireweed specimens from Australia to O.M. Hilliard in South Africa, who identified them as *S. madagascariensis* (Michael 1981). The biocontrol project was initiated on the basis of this taxonomic determination.

Observations of fireweed in Madagascar, South Africa and Australia, together with reviews of the published literature, led to further questions about the true identity of fireweed, whether it was indeed an introduced species and, if so, whether it originated from Madagascar or from Natal in South Africa (Marohasy 1993). Further studies were undertaken to settle this issue, of prime importance for any biological control program. Published records suggested that the *S. lautus* complex had 40 chromosomes (n=20) while South African *Senecio* species had 20 chromosomes (n=10). Chromosome counts for four populations of fireweed and five populations of *S. lautus* from Australia clearly showed that fireweed from Australia had a chromosome count of 20 (n=10), as did fireweed from Madagascar, while all *S. lautus* material gave a count of 40 (n=20) (Radford *et al*. 1995).

At the same time, L. Scott studied the DNA of the two species, using the ITS1 sequence, and also concluded that "fireweed is not part of the native (*S. lautus*) complex" (Scott 1994). Subsequently, he sequenced the same ITS1 DNA from specimens of *S. madagascariensis* and *S. inequidens* DC. collected from Natal in South Africa, as well as from specimens of *S. lautus* ssp. *maritimus* Ali, *lanceolatus* Ali and *dissectifolius* Ali from other areas of Queensland and New South Wales. This DNA sequence is reported to show clear differences at the specific level in *Senecio* from North America (Bain and Whitton 1994, Bain and Jansen 1995), but no differences were found between the three *lautus* subspecies from Australia. Nor were any differences found between *S. madagascariensis* from Australia, and *S. madagascariensis* and *S. inequidens* from Natal, South Africa, though these three were clearly different from the Australian *S. lautus* subspecies (L. Scott personal communication 1995).

Hybridization may be occurring between the Australian *S. lautus* and the introduced fireweed. Plants with

DNA showing characteristics of both groups have been found in south-east Queensland where both species occur together (Scott 1994), and one was recently found in Goondiwindi (Scott personal communication 1995), in an area where fireweed is not known to occur but seed may have been introduced in fodder from other areas. If hybridization is occurring, and the hybrids are both fertile and competitive, this has implications regarding the environmental impact of fireweed on the native species.

Unfortunately, because no fresh plant material from Madagascar was available for comparison, it is still not clear whether Australian fireweed originated from Madagascar or from South Africa. Of the two, Natal in South Africa is much more likely to be the region of origin, for two reasons. First, the first plants in Australia were found in Sydney in 1918 (Radford *et al*. 1995), and there was regular ship traffic from Durban in Natal to Sydney throughout the 1800s and early 1900s, while there has never been much traffic between Madagascar and Australia. Secondly, specimens of *S. madagascariensis* from Natal resemble fireweed from Australia much more closely than do specimens from Madagascar, both in the dried specimens (op. cit.) and in the field (Marohasy 1993). Even if Australian fireweed arrived from South Africa, it is possible that South African fireweed originated in Madagascar during the long history of trade between the two regions. DNA studies of Madagascan material are needed to settle this question.

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Overseas surveys As the plant was presumed to originate in Madagascar, surveys of *S. madagascariensis* and the insects attacking it were made in January 1987 and June 1988, both surveys in the Fort Dauphin area, in the extreme south of Madagascar. *S. madagascariensis* was present in disturbed land along roads, tracks and clearings in forest, and in and just behind sand dunes along the coast. Several insect species were collected and identified (Marohasy 1989).

In August 1991 a survey of the occurrence of fireweed and related species and the insects attacking it was undertaken in Natal, on the north coast of South Africa. *Senecio* species were found to be common in the area, but the plant taxonomy was difficult and correct identification of specimens not easy. However, specimens collected were apparently the same species as *S. madagascariensis* from Australia, and several insects were found attacking these plants (Marohasy 1991).

Insects selected Of the 14 species of insects found in Madagascar, many were known to be polyphagous and therefore unsuitable as biocontrol agents. Nine species were not recorded from other hosts, of which the flower-feeding pyralid *Phycitodes* sp. and the stem- and root-boring tortricid *Lobesia* sp. were identified as damaging to the plant, and probably host-specific. Permits to import these two species into quarantine for detailed testing were received in 1989.

When problems were experienced with the insects from Madagascar, the insects found in South Africa were reviewed. From the 18 species not known to have other hosts (Marohasy 1991), two were selected as being damaging and probably host-specific, the flower-feeding pyralid *Homeosoma stenotea* and the stem-boring agromyzid *Melanagromyza* sp. Permits to import these into quarantine for testing were received in 1992, but problems were experienced in finding them again in the field and no shipments were received from South Africa.

THE TWO MADAGASCAN INSECTS *PHYCITODES* SP. AND *LOBESIA* SP.

***Phycitodes* sp.** Adults are 10–12 mm long, with narrow grey-brown wings held rolled over the back. They are nocturnal, with most activities including mating and oviposition believed to occur during the night. Fed on honey and water solution, adults lived for 10–18 days. The eggs are cylindrical with pointed ends, translucent white in colour, and are laid singly, carefully inserted between the bracts and the florets on the flowers so that the eggs are concealed.

Larvae feed on the developing achenes in the flowerhead. When the original flowerhead is consumed, larvae move to adjacent flowers, often tying these together with a few strands of silk, or down to a leaf axil where they bore into the stem, killing the stem above their feeding site. Feeding by several larvae may completely destroy plants. Full grown larvae leave the plant and spin a silk cocoon, in which pupation takes place, in leaf litter, on dry leaves or attached to cage walls etc. The whole life cycle from egg to adult takes about 21 days at temperatures from 20 to 30°C.

***Lobesia* sp.** Adults are 4–8 mm long, resting with wings folded across the body. They fly little during the day, and mating and dispersal is believed to occur at night. However, oviposition only occurs during the day, with a peak immediately after dawn (Sparks unpublished data). Adults fed on honey and water solution lived for 8–14 days. The eggs are flattened, roughly circular, translucent almost transparent white, and are laid singly on the leaves or occasionally on the petioles or stem tips. The larvae hatch through the top surface of the egg and wander over the leaf to the axil, where they bore into the stems, and feed down inside the stems, at times as far as the crown or even roots. Frass is ejected through holes in

the stems. Pupation occurs in the stem. Feeding destroys the stems above the feeding site. The life cycle from egg to adult takes about 28 days at temperatures from 20 to 30°C.

HOST SPECIFICITY TESTING

A list of plants to be tested was drawn up in consultation with botanists in Queensland and other states, and approved by AQIS and ANCA. The list included all native *Senecio* species and subspecies of the closely related *S. lautus* complex found within coastal New South Wales and south-east Queensland. Some ornamental and introduced *Senecio* species were also included. Representatives of the other five genera of the Senecioneae native to Australia were included, together with representatives of the other tribes of the Asteraceae. Four species from other families were tested with *Lobesia* sp.: grape, coffee, euphorbia and larch.

The main host-finding stage is the ovipositing female moth. The test method was to release moths into cages containing fireweed and test plants and leave them for host selection and oviposition to occur. After 7–14 days, the plants were searched for eggs and larvae and if any were found, the plants were isolated. This allowed accurate counts of the number of larvae completing development and prevented the confounding of oviposition choice with larval movement. Emerging adults were counted.

***Phycitodes* sp.** There is little information on the biology of other species in the genus: larvae of *Phycitodes binaevella* (Hubner) have been recorded attacking the flower heads of *Cirsium vulgare* (Asteraceae) in Holland (Klinkhammer *et al.* 1988), and larvae of an undetermined species of *Phycitodes* were recorded in flower heads of *Ptilostemon gnaphaloides* (Asteraceae) in Crete (Neuenschwander 1984). *Phycitodes* sp. is only known from *S. madagascarienis*. Our tests showed that normal development occurred in three species of *Senecio*, *S. madagascariensis, S. lautus* ssp. *dissectifolius,* and *S. quadridentatus* Labill., but only six species in the Senecionae were tested, and oviposition and development might have occurred on other species as well. In particular, *S. quadridentatus* is in a different subgroup to *S. madagascariensis* and *S.lautus* ssp. *dissectifolius,* having flowers without ray florets, which implies an ability to oviposit and develop in at least some species in both major subgroups of the Australian native *Senecio* species. No tests were undertaken in larger cages, however, and in the field females might not lay on these other species. Nevertheless, the attack on native *Senecio* species was considered unacceptable, and testing was not continued.

***Lobesia* sp.** The genus *Lobesia* contains three pest species, *L. aeolopa* Meyr on coffee (Evans 1970), *L. botrana* on grape (Marcelin 1985) and *L. reliquana* on larch (Golutvina 1973). Another species, *L. euphorbiana,* was released in North America as a biological control agent after testing showed it was specific to two *Euphorbia* species (Schroeder 1981). *Lobesia* sp. is an undescribed species apparently specific to *S. madagascariensis* and an unidentified *Senecio* species found on the dunes in Madagascar (Marohasy 1989).

Host specificity testing of *Lobesia* was conducted in two stages. Initially multiple choice oviposition and survival tests were conducted in the standard cages, 80 × 50 × 100 cm., and subsequently plants that were attacked in these were re-tested in a larger cage, 3 × 3 × 2.5 m. A total of 58 plant species were tested, all in the Asteraceae.

In the small cage tests, there was damage to 15 species from four tribes (Senecioneae, Calenduleae, Heliantheae, Anthemidieae). Damage to most was substantial, and the adult moths produced exceeded the number of moths initially introduced into the cages. In the large cages, there was significant damage and complete development on five species from two tribes (Senecioneae and Calenduleae). All other species attacked in the small cage trials were not damaged in the larger cage trials.

Of the species attacked in the large cage trials, *Calendula* sp. was damaged moderately in one replicate, from which 26 adults emerged. Rate of development, size and number of adults produced were normal and a second generation was reared through on this plant. *Dahlia* was damaged in one replicate and three adults emerged. The other four species attacked were all in the tribe Senecioneae. Substantial damage was caused with several adults emerging from each plant of *Crassocephalum crepidioides* and *Erechthites* sp. Less substantial damage was caused to *Senecio lautus dissectifolius,* with an average of three adults emerged per plant. Severe damage was caused to *S. l. lanceolatus*, the plants being killed in all replicates with an average of 19 *Lobesia* adults emerging per plant. Between 27 and 43 adults emerged per plant of *S. madagascariensi*s in the same trials. As this is an unacceptably wide host range, testing was terminated and the colony destroyed.

RECOMMENDATIONS FOR FUTURE WORK

Before any further biocontrol investigations, the country of origin of Australian fireweed should be confirmed by DNA or other appropriate studies. Detailed surveys for potential biocontrol agents, plus studies of the host range and seasonal biology of potential agents, should then be carried out in Madagascar and South Africa, giving

priority to the country identified as the origin of fireweed. Agents identified as likely to be specific to *S. madagascariensis* should be imported and host-tested against the native *S. lautus* complex. Fireweed-specific agents should then be field-released. If no fireweed-specific agents are found, a test case could be initiated for release of an agent known to attack a native plant species or group of species. This would involve an economic study of the impact of fireweed on the grazing economy of coastal NSW and southern Queensland, and an environmental impact study of the effects of fireweed and of potential agents on the native *Senecio lautus* complex.

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