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New Biological Control Initiatives Against Weeds of South American Origin in Australia: *Nassella* Tussock Grasses and Blue Heliotrope

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Abstract

Several stipoid grasses of temperate South American origin have invaded Australia. One of these, *Nassella trichotoma*, is considered the most important grass weed of pastures in south-eastern Australia, while another, *Nassella neesiana* is viewed as a serious threat to native Australian grasslands. Blue heliotrope, *Heliotropium amplexicaule*, a toxic perennial broad-leaf weed, originates in the same area of South America, and is rapidly spreading in parts of south-eastern Australia. Landholder groups were formed to seek research into better control methods of *Nassella* tussock grasses and blue heliotrope, respectively, and in 1998 both groups were successful in lobbying for funds to investigate the potential of biological control. The *Nassella* project is the first one aimed at classical biological control of a grass weed and, based on preliminary surveys, will concentrate on pathogens. A similar survey on blue heliotrope has indicated that insects provide the best prospects for control of this weed. This paper outlines the aims of the research, and reports on the establishment of collaborative projects with scientists working in Argentina to carry out survey work for natural enemies of the weeds and evaluate their potential for biological control.

Keywords: Biological control, *Nassella trichotoma*, *Nassella neesiana*, *Heliotropium amplexicaule*

Introduction

Some of Australia's most successful biological control projects have been against weeds of South American origin, including several species of cactus and tropical or subtropical aquatic plants, such as salvinia, water hyacinth, water lettuce and alligator weed. Of the more temperate terrestrial weeds, less than 15% originated in South America (see Parsons and Cuthbertson. 1992) and recent classical biological control projects have been directed against invasive plants of Mediterranean or South African origin. However, two such South American species, the tussock grass *Nassella trichotoma* (Nees) Arech. (serrated tussock) and the perennial herb *Heliotropium amplexicaule* Vahl. (blue heliotrope), have undergone dramatic expansions in range and density in recent years, despite the use of herbicide-based control measures.

Serrated tussock probably accounts for a greater reduction in pasture productivity than any other weed in south-eastern Australia (Parsons and Cuthbertson, 1992). The main areas of infestation lie between latitudes 33 to 38°S, and it currently occupies about 1,000,000 ha in the southern and central tablelands of New South Wales and central southern Victoria (McLaren *et al.* 1998). In New South Wales alone, the economic cost of the weed has been estimated at AU$40 million per year (Jones and Vere 1998). Climate matching models indicate that a much greater area is at risk to invasion by this weed (McLaren *et al.* 1998). Five other South American species of *Nassella* also occur to a lesser extent, but these also have large potential ranges (McLaren *et al.* 1998). Blue heliotrope is not as widespread, and the more important infestations of this toxic weed are more northerly (between latitudes 25 to 34°S) than *Nassella* spp., occurring in temperate summer rainfall zones of southern Queensland and northern New South Wales. It infests over 110,000 ha in New South Wales alone (Newell 1997). More scattered colonies extend northward into subtropical central Queensland, south into Victoria and further westward into South Australia (Parsons and Cuthbertson 1992).

Grass-roots lobby groups (Serrated Tussock Working Group, Victorian Serrated Tussock Taskforce, Blue Heliotrope Action Committee) developed independently in the areas affected by both these weeds, and have vigorously publicised the adverse impact of weed infestations and strongly campaigned for improved management methods, including investigation of the prospects for biological control. Largely as a result of their activities, funding was obtained to initiate exploratory work in South America for potential biological control agents against the two weeds. This paper describes these projects and their research strategies.

The target weeds

Serrated tussock (*Nassella trichotoma* (Nees) Arech.) is a perennial tussock grass of southern South American origin that was accidentally introduced into Australia in the early 1900s and has since become a serious weed problem in south-eastern Australia (Campbell and Vere 1995). It has also become a weed when accidentally introduced into New Zealand, South Africa and the United States. It is highly invasive, producing large quantities of seed that are widely dispersed by wind, water and stock, and is capable of forming dense infestations. In Australia, most infestations occur on pasture land, where the weed greatly reduces carrying capacity, as the plant has high fibre and low protein content making it effectively indigestible to stock and wildlife. If forced to graze it, stock lose weight and may die (Campbell and Vere 1995). Increasingly, serrated tussock is invading natural environments, where it modifies natural habitats threatening native grasslands and wildlife. It is a declared noxious weed in New South Wales, Victoria and Tasmania. Despite this, current control measures, revolving around the use of the herbicide flupropionate, have not prevented the continued spread of the weed (Campbell and Vere 1995). Withdrawal of flupropionate from the market for economic reasons in 1998 has made the search for other control options, such as biological control, even more important.

As indicated above, a number of other species of exotic stipoid grasses have established in Australia and are becoming, or risk becoming serious weeds (McLaren *et al.* 1998). One of these, Chilean needle grass (*Nassella neesiana*) has been described as being potentially the most destructive environmental weed of native grasslands in south-eastern Australia, and these other species will also form targets of the biological control project.

Blue heliotrope is a hairy prostrate perennial herb, native to South America, that was introduced into Australia, probably in the late 1800s. Since then there was a slow increase in density of this weed until ca. 1960, with new infestations developing in New South Wales and South Australia. A rapid and continuing expansion of its range since then has seen widespread infestations in south-east Queensland and northern New South Wales, with scattered colonies extending into Victoria and further into South Australia (Parsons and Cuthbertson 1992). It is now a declared noxious weed in 14 local government areas of New South Wales. In agricultural systems, production losses occur due to the ability of blue heliotrope to outcompete more desirable summer cropping and pasture species and through a decline in animal performance as a result of its toxicity to livestock - it contains pyrrolizidine alkaloids that can cause chronic liver damage and even death (Ketterer *et al.* 1987). Invasion of native vegetation by blue heliotrope reduces floral diversity and wildlife habitat (Newell 1997). It has recently started to cause concern as a competitor in Queensland sugar cane crops (Parsons and Cuthbertson 1992). Interestingly, the only other area of the world where blue heliotrope is weedy is in Mauritius, where it is a serious weed of sugar cane plantations (Rochecoust and Vaughan 1963). Control measures to date have generally been unsatisfactory and have not stopped the spread of this weed. The chemicals currently registered for blue heliotrope are considered costly and unreliable (Newell 1997), while cultivation encourages spread by stimulation of germination and regeneration from decapitated rootstocks and plant fragments.

Biological control of *Nassella* tussock grasses

Biological control of serrated tussock has been mooted as a management option for many years, but has always been rejected for several reasons. The relationship between the exotic *Nassella* tussock grasses and native Australian stipoid grasses has always been considered too close for there to be an agent that was sufficiently specific, as both *Nassella* and the Australian species were considered by some to be part of the genus *Stipa*. Moreover, previous surveys had suggested that insects occurring on this grass in South America were too generalist (Wells 1976), while no pathogens had been described from serrated tussock in its native range, suggesting that the likelihood of finding a suitable agent was low. Two recent events have now made the biological control of these grasses a more realistic option. Firstly, recent taxonomic work has indicated that the stipoid grasses are polyphyletic with many species being reassigned from *Stipa* to several other genera, indicating a stronger separation between native Australian and South American species (Table 1, see also Briese and Evans 1998). Secondly, recent surveys by H. Evans (see Briese and Evans 1998) and by R. Delhey, F. Anderson and M. Kiehr (unpublished) in Argentina have shown that there is a rich fungal flora on serrated tussock, Chilean needle grass and related species (Table 2). This improves the prospects of finding an effective control agent. As a consequence, funding for the project was raised through a consortium of State and local government bodies, landholder groups and the Rural Industry Research and Development Corporation.

The project is the first attempt in Australia to find a classical biological control agent for grass (Poaceae) weeds, and will focus on pathogens. Of primary interest are the

Table 1.
Currently recognised genera of stipoid grasses present in Australia and South America (many contain members previously included in the genus *Stipa*, now considered to be of Eurasian origin - it should be noted that taxonomic work on this group is ongoing).

Genus	No. of species in Australia		No. of species in South America	
	Native	Exotic [a]	Native	Exotic [a]
Austrostipa	62			
Nassella		7 S	~80	
Achnatherum		2 S	?	
Jarava		1 S	~12	
Piptochaetium		1 S	~20	
Piptatherum		1 E		1 E
Nicoraella			7	
Aciachne			1	
Orthachne			2	
Stipa				1 E

a S = species of South American origin, E = species of Eurasian origin

Puccinia rusts of *Nassella* spp. Rusts of this genus are known for their high degree of host specificity and species have been associated with several very successful biological control projects, e.g. *P. chondrillina* against skeleton weed and *P. xanthii* against noogoora burr (Julien and Griffiths 1998). Literature records (Greene and Cummins, 1958, Viégas, 1961, Lindquist, 1982) and recent surveys of fungal parasites carried out by R. Delhey, F. Anderson and M. Kiehr, indicated that there are a number of *Puccinia* species associated with South American stipoid grasses. In particular, during his 1995 survey, H. Evans found *P. nasellae* heavily attacking populations of serrated tussock at one location in northern Argentina (see Briese and Evans 1998), while Delhey, Anderson and Kiehr (unpublished) have observed several damaging infestations of *P. graminella* on Chilean needle grass in central Argentina. The other pathogen of initial interest is *Corticium* sp., an undescribed basidiomycete that was associated with severe tussock decline at a number of locations surveyed by Evans (see Briese and Evans 1998).

A collaborative agreement has been reached between the Cooperative Research Centre for Weed Management Systems in Australia and CERZOS (Centro de Recursos Naturales Renovables de la Zona Semiarida) in Bahia Blanca, Argentina to base an Australian biocontrol scientist (WP) there and to contract a locally engaged pathologist (FA) from the Universidad Nacional del Sur. The main tasks of the project are to:

- undertake studies on the ecology of serrated tussock and Chilean needle grass in South America, with an emphasis on the impact of pathogens on their population dynamics
- conduct more extensive surveys for pathogens throughout their native range

Table 2.
Pathogens collected from *Nassella* spp. in Argentina during 1988-1999 by Evans and Ellison (see Briese and Evans 1998) and Delhey *et al.* (unpublished).

Fungal pathogen	Nassella spp. infected [a]
Teliomycetes	
Puccinia graminella	*N. hyalina* [b], *N. neesiana* [b], *N. tenuis* [b]
Puccinia interveniens	*N. tenuis* [b]
Puccinia nasellae	*N. neesiana* [b], *N. trichotoma* [c]
Puccinia saltensis var. *faldensis*	*N. burkartii* [b], *N. clarazii* [b]
Puccinia saltensis var. *saltensis*	*N. neesiana* [b], *N. tenuissima* [b]
Uredo sp.	*N. neesiana* [b], *N. tenuis* [b], *N. trichotoma* [c]
Ustomycetes	
Ustilago hypodytes	*N. neesiana* [b], *N. tenuis* [b], *N. trichotoma* [c]
Basidiomycetes	
Corticium sp.	*N. trichotoma* [c]
Coelomycetes	
Ascochyta leptospora	*N. trichotoma* [c]
Stagonospora sp.	*N. trichotoma* [c]
Hendersonula sp.	*N. trichotoma* [c]
Agonomycetes	
Rhizoctonia sp.	*N. trichotoma* [c]

[a] Circumscription of species within the genus follows that of Barkworth (1990)
[b] surveys of Delhey, Anderson and Kiehr (unpublished)
[c] Briese and Evans (1998)

- develop culture methods for candidate pathogens, determine optimum conditions for infection and disease development and assess their virulence against the target weeds
- test the specificity of these pathogens against key non-target species, such as members of the related stipoid grass genera listed in Table 1.

Biological control of blue heliotrope

The genus *Heliotropium* is well represented in both Australia and South America (see Table 3). As there are no important economic plants in this genus, the native Australian species are of key concern for the assessment of agent host-specificity. Many of these native species have limited ranges and are restricted to the far north and north-west of the continent. In fact only six species have ranges that overlap with that of the exotic *H. amplexicaule* (Craven 1996). The great majority of Australian natives belong to the section *Orthostachys* with only a few species in the section *Heliotropium*. The composition of the genus is quite different in Argentina, where there are a number of sections not represented in Australia (Table 3). There are no Argentine representatives of the section *Heliotropium*, with the only section in common being *Orthostachys*. Members of this section will be key species for initial host-specificity studies.

Table 3.
Australian and Argentine species of *Heliotropium*
(data from Craven (1996) and Gangui (1955)).

Sections of *Heliotropium*	Australia		Argentina	Common species
	native	exotic		
Chaemotropium		1		
Heliotropium	5	1		
Orthostachys	71		8	
Platygyne		1	2	*H. curassavicum*
Tiaridium		1	3	*H. indicum*
Heliophytum		1	4	*H. amplexicaule*
Coeloma			4	
Hypsogenia			1	
Plagiomeris			2	

In contrast to the project on *Nassella* tussock grasses, biological control of blue heliotrope is primarily targeting insects as control agents. This is based upon the result of a survey in Argentina carried out by Wapshere (1991) which identified a number of insect species as having control potential (Table 4). Two rust fungi, *Puccinia heliotropicola* and *Puccinia heliotropii*, have been recorded from *Heliotropium* spp. in South America (Viegas 1961), but Wapshere did not find these during his survey, nor any other pathogen causing significant damage to the plants. The most damaging agents were the defoliating beetle, *Deuterocampta quadrijuga*, and the cell-sucking bugs, *Dictyla* spp. *Dictyla* spp., whose feeding caused leaf chlorosis and death, seem to be the most widespread agent (Table 4), while *D. quadrijuga* only occurred in one of the four regions surveyed (Table 4). However, massive larval and adult populations of the beetle have been recorded defoliating blue heliotrope in the past (Bruch 1940), and recent observations in the Cordoba region (MZ) confirm that heavy defoliation by the beetle contributed to die-back of the plant in autumn. Adults of the flea-beetle, *Longitarsus* sp. were found more rarely feeding on leaves, but, as their larvae normally feed on root tissue, they are of interest for biological control. Recent observations at the Pergamino site (MZ), where the flea-beetle is most common, suggest that they can cause plant death. The other agent of interest is a

Table 4.
Insects with biocontrol potential collected from *Heliotropium amplexicaule* in Argentina during 1998-99 (Zapater and Briese, unpublished data).

Insect	**Region**			
	Cordoba	Pergamino	Sierra de la Ventana	Tandil
Coleoptera: Curculionidae				
Deuterocampta quadrijuga	+++	0	0	0
Coleoptera: Halticini				
Longitarsus sp.	+	+++	+	+
Homoptera: Tingidae				
Dictyla spp.	++	+	+++	+
Thripidae				
Haplothrips sp.	+	+	0	+

0 = not found, + = rare, ++ = common, +++ = abundant

species of thrips, *Haplothrips* sp., which fed on growing points causing stunting and deformation of leaves and shoots, though it did not appear able to kill plants.

Work on this project commenced in Argentina in late 1998 through a contracted entomologist (MZ) at the Universidad de Buenos Aires. The main tasks of the project are to:

- undertake studies on the biology of the candidate insect control agents and evaluate their impact on blue heliotrope populations in South America
- conduct more extensive surveys for other potential agents throughout the native range of blue heliotrope
- test the specificity of the candidate insects against key non-target species, such as members of the various sections of the genus *Heliotropium* listed in Table 3.

Early survey work has confirmed the four species recorded by Wapshere (1991) as being the most important invertebrate herbivores of blue heliotrope in its native range. Colonies of three species, the defoliating beetle *Deuterocampta quadrijuga*, the cell-sucking bug, *Dictyla* sp. and the thrips, *Haplothrips* sp., have been established in the laboratory in order to study the basic biology of the candidate agents and optimise rearing procedures for them. Once this has been done, the species will be tested against several *Heliotropium* species and key species from other genera of the family Boraginaceae prior to importation into Australia for full safety testing in quarantine. Like the project on *Nassella* tussock grasses, there will also be a strong emphasis on looking at the population dynamics of the target weed. A critical component of the work will involve an evaluation of the impact of these natural enemies, both under natural conditions and in cage experiments where agent densities can be augmented.

Conclusion

Biological control projects against these two important weeds of pastures in eastern Australia have now been successfully initiated, with research bases in Argentina. The work to be undertaken will indicate whether there are pathogens or arthropod agents in the native South American ranges that have the potential to reduce the density and / or vigour of their respective target weeds. Moreover, it should also provide an initial indication of the degree of host-specialisation of candidate agents. Should these be positive, a second phase will be required for each project leading to the quarantine clearance and eventual field release of selected agents. One clear message from this work comes from the separate successes of landholders affected by each weed to organise effective lobby groups for funding of the respective projects. In the Australian context at least, this may signal that future funding for biological control of particular weeds will depend on affected parties or community groups taking a more proactive stance.

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