Biological control of pasture weeds in New South Wales – an update of current research.

Royce H. Holtkamp

State Coordinator (Weed Biological Control), NSW Department of Primary Industries and Cooperative Research Centre for Australian Weed Management, 4 Marsden Park Rd, Tamworth, NSW 2340.

Introduction

Biological control of weeds is the use of living organisms such as insects, mites or pathogens to reduce the weeds abundance or limit its distribution. Biological control will not eradicate a target weed and should always be used as part of an integrated weed management strategy.

Biological control of weeds has been used in Australia since the early 20th century, commencing with projects on prickly pear (1912) and lantana (1914). Since then approximately 40 plant species, both of agricultural and conservation significance, have been the target of biological control programs in Australia. Some of these have never progressed beyond the survey stage while others have been highly successful.

Some of the weed species listed below affect a variety of systems but all have some impact on pastures. Although the rearing and redistribution phases of some of the programs listed below have now finished they continue to be the subject of ongoing interest so information has been included in this paper.

Target weeds

Blackberry (*Rubus fruticosus* aggregate)

Blackberries of the *R. fruticosus* aggregate originate in Europe and are now a major weed of pastures and forests on the tablelands and cooler parts of adjoining regions of NSW as well as other areas of wet temperate southern Australia. In NSW the *R. fruticosus* aggregate consists of at least seven taxa. *Rubus anglocandicans* (previously *Rubus procerus* or *Rubus discolour*) is the most common blackberry in NSW. A survey in 1984 estimated blackberry was causing an annual loss in NSW, Victoria and Tasmania of $42 million due to reduced production and control costs.

Biological control of blackberry began in the early 1980s with the study of the blackberry rust (*Phragmidium violaceum*). This rust was studied in Europe, where it originated, to assess its safety as a control agent of blackberries in Australia. Research showed the rust is specific to blackberry and will not damage other commercial *Rubus* species such as raspberries or loganberries. It did, however, damage thornless varieties of blackberry containing genetic material of the *R. fruticosus* complex.

Further strains of *P. violaceum*, are currently being sought in Europe. The illegal strain first detected in 1984 still appears to be common but ineffective. A damaging strain of the rust, first released in 1991, has not been found in the field in recent times. Unfortunately, in some areas it appears that susceptible forms of *R. anglocandicans* have been replaced by other taxa of blackberry more resistant to the original strain of rust. Hopefully new strains of blackberry rust currently being introduced are more damaging and more persistent than the strains released to date.

Blue heliotrope (*Heliotropium amplexicaule*)

Blue heliotrope is native to South America and was probably introduced as an ornamental plant during the 1800s. It is widespread in pastures and fallows in south-east Queensland and northern NSW but scattered populations can be found in most regions of the state.

Potential biological control agents for blue heliotrope were studied in Argentina and the most promising, blue heliotrope leaf beetle (*Deuterocampta quadrijuga*) was approved for release in 2001 by the Australian Quarantine Inspection Service (AQIS). Since that time a number of releases have been made in NSW. Some of these have established but the ongoing drought has severely impacted on the project. Further releases will form part of a continuing project jointly funded by Meat and Livestock Australia (MLA) and Australian Wool Innovations (AWI). *D. quadrijuga* will be included in a community and schools rearing and redistribution project called Weed Warriors which is partly funded by the CRC for Australian Weed Management in the near future.

Gorse (*Ulex europaeus*)

Gorse is native to Europe and is considered by New Zealand to be their worst pasture weed. It is highly invasive in grazing, forestry and conservation areas where it forms dense, often impenetrable thickets protected by the plants' spines. It occurs in the tablelands and slopes areas of NSW.

The gorse spider mite (*Tetranychus lintearius*) was first approved for release in Australia in 1997. Since that time a large number of releases have been made in Victoria and Tasmania. This mite appears to readily establish and is capable of causing significant damage to gorse. However, in New Zealand, the USA and Tasmania predatory mites have limited its effectiveness. A few releases were made in NSW in 2002 which have established but there has been limited spread from these somewhat isolated nursery sites. *T. lintearius* is the first in a suite of agents that could be released for gorse in NSW.

Groundsel bush (*Baccharis halimifolia*)

Groundsel bush is a native of Florida and coastal areas adjacent to the eastern side of the Gulf of Mexico. It was introduced into the Brisbane region as an ornamental plant in 1900 and has spread through coastal areas of south-east Queensland and northern NSW. It is also beginning to extend its range inland. It is a rapid coloniser of cleared, unused land in both agricultural and environmental areas where it is particularly suited to moist gullies, salt marsh areas and wetlands. It is also well adapted to high, cleared slopes.

A biological control program against groundsel bush began in 1967. Since then over 35 different species of insects have been tested but only six have established in the field. Overall, biological control has not been achieved and research on insects has now been curtailed in preference for research on plant diseases. The first releases of a rust fungus (*Puccinia evadens*) from Florida commenced in 1998 and this pathogen is now established at several sites. It acts as both a leaf and stem parasite, causing defoliation during summer and winter and stem dieback over summer.

Horehound (*Marrubium vulgare*)

Horehound is native to Europe, Asia and northern Africa. It is found in most areas of NSW and is a common weed of disturbed areas and pastures, particularly in inland NSW.

Horehound plume moth (*Wheeleria spilodactylus*) was first released in NSW in 1994. Since that time a large number of releases have been made and this insect appears to readily establish at most sites. It is capable of causing significant defoliation at many of these sites. Horehound clearwing moth (*Chamaesphecia mysiniformis*),was first released in NSW in 2004, following earlier releases in Victoria and South Australia. It is too early to evaluate the status of this insect but releases will continue as part of a project jointly funded by MLA and AWI.

Lantana (*Lantana camara*)

Lantana is a significant weed of coastal and sub-coastal eastern Australia from Cape York, Queensland to Mt Dromedary, NSW. It is also present in the Northern Territory and Western Australia. It invades national parks reducing biodiversity, as well as forestry and grazing areas, where it decreases pasture production and poisons cattle and sheep.

Biological control of *L. camara* began in Australia in 1914 and 29 agents have been introduced with 17 species establishing, although only four appear to cause regular significant damage. These are the leaf-mining beetles (*Octotoma scabripennis* and *Uroplata girardi*), the sap-sucking bug (*Teleonemia scrupulosa*) and the seed fly (*Ophiomyia lantanae*). The current focus is on lantana rust (*Prospodium tuberculatum*) which was approved for release in 2001. Since then a number of releases have been made but unfortunately these were severely impacted upon by the prolonged drought in NSW. Despite initial setbacks *P. tuberculatum* has now established at over 40 sites and it appears it has potential to cause significant damage to lantana. Recent rains on the NSW coastal strip have increased the likelihood of establishment of this extremely damaging pathogen.

Nodding thistle (*Carduus nutans*)

Nodding thistle is native to Europe, northern Africa and Asia. It occurs primarily in annual pasture systems on the tablelands areas of NSW. Three agents have been released for the control of nodding thistle. These were a weevil (*Rhinocyllus conicus*) which feeds in the thistle flower receptacle and destroys the developing seeds, nodding thistle seed fly (*Urophora solstitialis*) which also feeds in the receptacle and nodding thistle rosette weevil (Trichosirocalus mortadelo (previously *T. horridus*)). All three of these insects have established throughout the range of nodding thistle with *T. mortadelo* being the most damaging causing up to 40% mortality of rosettes and reducing seed production by more than 70%. The effectiveness of *U. solstitialis* has been limited by interspecific competition with *R. conicus*.

Paterson's curse (*Echium planatagineum*)

Paterson's curse is native to the Mediterranean region and western Europe. It is found in all regions of NSW but is particularly abundant in the central and south-western slopes and eastern Riverina regions where it often becomes the dominant plant in pastures. Six agents have been released over a number of years, all of which have established in the field. These are the leaf-mining moth (*Dialectica scalariella*), the crown weevil (*Mogulones larvatus*), the root weevil (*Mogulones geographicus*), the flea beetle (*Longitarsus echii*), the stem beetle

(*Phytoecia coerulescens*) and the flower-feeding beetle (*Meligethes planiusculus*).

Most agents breed slowly so it will take many years for them to breed up and disperse naturally throughout NSW. The weevils and flea beetle are expected to be the most damaging agents with more than 50% of Paterson's curse and viper's bugloss (*Echium vulgare*) rosettes being killed at ungrazed research sites seven years after release.

Scotch broom (*Cytisus scoparius*)

Scotch broom originated in Europe and has now spread across many temperate areas of the world. Its history is Australia is somewhat clouded although it is likely that original introductions of this species were as ornamentals. It is a serious problem in some parts of the tablelands regions of NSW, particularly Barrington Tops, where it seriously affects native bushland, forestry and grazing land. Scotch broom is also a significant problem in Victoria and Tasmania and to a lesser extent in the Adelaide Hills, South Australia.

A biological control campaign against Scotch broom commenced in 1990. The first release of a biological control agent was the twig mining moth (*Leucoptera spartifoliella*) in 1993. The larvae of *L. spartifoliella* mine shoots of Scotch broom and heavy attack will stunt plant growth. It has since been released at a number of sites in NSW, Tasmania and Victoria and has established at some of these but has only built up into damaging numbers in southern NSW. However it is still in low numbers at Barrington Tops. Many releases have now been made from insects reared in the field in southern NSW. The program continued with the release of the psyllid (*Arytainilla spartiophila*) in 1994. This insect feeds on buds and stunts the growth of young shoots. At present *A. spartifoliella* is only known to be established in the Southern Tablelands region of NSW. The third insect to be released was a seed feeding bruchid (*Bruchidius villosus*) in 1995. Larvae of this beetle feed on the developing seeds of Scotch broom. It is also only known to have established in the southern tablelands of NSW.

Scotch, Illyrian and stemless thistles (*Onopordum* spp.)

Despite their name, Scotch thistles are not Scottish. They, as well as Illyrian and stemless thistles are native to Europe, the Mediterranean region, western and central Asia and Asia Minor. This apparent discrepancy in common names highlights the importance of correct taxonomic identification of plant hosts.

These thistles are found in most areas of NSW. Scotch thistle (*O. acanthium*) is a weed of pastures and lucerne crops in the tablelands and slopes areas. Illyrian thistle (*O. illyricum*) occurs in the central and southern tablelands areas and appears to have hybridised with *O. acanthium* in many areas. Stemless thistle (*O. acaulon*), is found in the northern tablelands, slopes and plains but is most serious in pastures in south-western NSW.

A number of insect species have been released for biological control of *Onopordum* thistles. The first of these was the seed-head weevil (*Larinus latus*) which is now widely established. Its ability to destroy most of the seed in a flowerhead makes it a good biological control agent. At some NSW sites this insect has reduced seed production by more than 80%. The second agent is the stem-boring weevil (*Lixus cardui*) which is now widely established. *L. cardui* is not capable of killing *Onopordum* thistles, but its activity weakens the plant, makes it less competitive and reduces seed production. This action allows insects such as *L. latus* to have a greater impact on the plant. Another insect which is established on *Onopordum* thistles is the crown moth (*Eublemma amoena*). Larvae can bore into the crown and root of the plant leading to the death of smaller plants. Larvae of subsequent generations feed in the leaves of bolting stems, causing similar leaf shrivelling and death. The rosette weevil (*Trichosirocalus briesei*) was first released in 1997 but at present there is little evidence of establishment.

Spear thistle (*Cirsium vulgare*)

Spear thistle is native to Europe, western Asia and northern Africa. It is found throughout NSW and occurs in most types of environment. It is particularly common in overgrazed pastures. Three agents have been released, all of which have established. These are spear thistle receptacle weevil (*Rhinocyllus conicus*), spear thistle seed fly (*Urophora stylata*) and spear thistle rosette weevil (*Trichosirocalus horridus*). *U. stylata* is fairly widespread and is capable of causing significant damage at times.

Spiny emex (*Emex australis*)

Spiny emex is native to southern Africa but has now been spread to most areas of the world. It is believed to have been introduced to Western Australia as a vegetable (cape spinach) in the 1800s. It is common in crops and pastures throughout southern, temperate Australia. Several releases of the red apion weevil (*Apion miniatum*) have been made in both southern and northern NSW since 1999. No evidence of establishment has been found and the program has now been discontinued.

St John's wort (*Hypericum perforatum*)

St John's wort is native to Europe, western Asia and northern Africa. It was introduced into Australia for ornamental and/or medicinal purposes during the mid 1800s and is now a serious pasture and bushland weed in the tablelands and slopes regions of NSW. It may also cause photosensitisation and dermatitis in light skinned stock, especially sheep. Three insects, a beetle (*Chrysolina quadrigemina*), an aphid (*Aphis chloris*), a root boring beetle (*Agrilus hyperici*) and a mite (*Aculus hyperici*), have been introduced for its control. With the exception of *A. hyperici* these are now widely established and having variable impact on *H. perforatum*.

Conflicts of interest

Fireweed (*Senecio madagascariensis*)

Fireweed is an annual or biennial herb that has become a troublesome pasture weed in eastern Australia. It was approved in 1991 as a target weed for biological control in Australia. The centre of origin of Australian forms of fireweed has now been identified as South Africa, in particular the Natal province rather than Madagascar as its name might imply.

Early surveys to find biological control agents focussed on Madagascar and failed to find any insect sufficiently host specific to consider for importation. This is not surprising, since the surveys were carried out on the wrong plant. However, the number of insect species found in Australia on both *S. madagascariensis* and Australian native *Senecio* spp., especially *Senecio pinnatifolius*, would indicate that the likelihood of success is very low. Investigations were carried out in Natal and under quarantine conditions in Australia on a strain of rust fungus (*Puccinia lagenophorae*). Experiments demonstrated that Australian *S. madagascariensis* plants were susceptible to isolates of the South African rust fungus. However, the virulence of the South African rust fungus isolates was not superior to Australian *P. lagenophorae* isolates. Therefore, no attempt will be made to introduce any of the South African isolates.

Lippia (*Phyla canescens*)

Lippia is native to South America where it occurs in southern Ecuador, Peru, Chile, Argentina, Uruguay, Paraguay and Bolivia. In Australia it is found in South Australia, Victoria, NSW, Western Australia and Queensland. Lippia was estimated to infest 5.3 million hectares of the Murray-Darling Basin in 2004. It was originally introduced as a lawn species and used to stabilise soil and prevent erosion on banks of irrigation canals and around weirs but has now become an important weed of inland areas subject to flooding, usually downstream of irrigation areas. Lippia spreads mainly by movement of plant pieces but also by seed. It overruns native vegetation, has limited forage value and appears to be capable of suppressing the growth of neighbouring plants. It is closely related to *Phyla nodiflora* which is essentially non-weedy and is regarded by some taxonomists as native although this status is disputed by others. Lippia's close affinity with *P. nodiflora* could create problems for future biological control programs although lippia is currently in the process of being nominated as a target species by the Australian Weeds Committee.

Silver-leaf nightshade (*Solanum elaeagnifolium*)

Silver-leaf nightshade is native to areas of central and south-western North America and temperate South America. It is a competitive, deep-rooted perennial weed whose root system can reach 5 m in depth with roots interconnecting with other plants. It depletes soil moisture and nutrient reserves, competes strongly with crops and pastures and reduces the value of land. It can also be poisonous to stock although is not readily eaten. In infested areas winter cereal and annual pasture production can be significantly reduced. Broadleaf summer crops are virtually impossible to grow due to its competitive ability and because there are no herbicides which can be used against it in those crops. Silverleaf nightshade also quickly produces a large seedbank, with one plant producing 60 berries, each containing up to 70 seeds. Seeds can remain viable for up to 10 years. The plant thrives on summer rains and its seed is easily spread by birds, sheep, machinery, water and contaminated produce. It can also be spread rapidly by cultivation, with plants regenerating from pieces of root 1 cm long and from depths of 1 m.

There has been a considerable amount of work done in South Africa on this weed, culminating with the release of the chrysomelid beetle (*Leptinotarsa texana*). Host testing in South Africa indicated that this beetle would attack eggplant in no-choice tests, a risk the South African authorities were ultimately prepared to take. Field studies following the release of *L. texana* have shown no attack of eggplant to occur. As eggplant is an important crop in some areas in Australia, this situation would have to be clarified. Negotiations are underway with the University of Cape Town to undertake some host testing of Australian eggplant cultivars and Australian native species of *Solanum* which are taxonomically close to *S. elaeagnifolium* in an effort to resolve the situation.

The future

Chilean needle grass and serrated tussock

A project initiated by the Victorian Department of Primary Industries and CSIRO is investigating potential biological control agents for grass Weeds of National Significance, Chilean needlegrass (*Nassella neesiana)* and serrated tussock (*Nassella trichotoma*).. *N. trichotoma* was declared a target for biological control in 1998 while it is anticipated that *N. neesiana* will be declared a target for biological control during 2006. This project has been underway in Bahia Blanca, Argentina since 1999 and surveys have identified three rust fungi (*Puccinia nassellae*, *P. graminella* and *Uromyces pencanus*) attacking *N. neesiana*. *P. nassellae*, a smut (*Ustilago* spp.) and a crown rotting fungus (Corticiaceae) have also been found attacking *N. trichotoma*. The potential agents identified for *N. neesiana* are showing much more promise than those for *N. trichotoma*. The program is currently beginning host specificity testing of the *N. neesiana* biological control agents.

Sporobolus spp.

An application to get weedy *Sporobolus* species declared as targets for biological control is currently being assessed. The Queensland Department of Natural Resources, Mines and Water has initiated a project in Africa looking for potential biological control agents of Parramatta grass (*Sporobolus africanus*), giant rat's tail grasses (*S. natalensis* and *S. pyramidalis*), and giant Parramatta grass (*S. fertilis*). To date a smut fungus (*Ustilago sporoboli-indici*) and stem wasp (*Tetrasema* sp.) have been identified as showing some promise. It is anticipated that host specificity testing of these agents will begin later this year or early 2007.

Hudson pear (*Cylindropuntia rosea*)

Hudson pear is a native of Mexico which was probably deliberately introduced to Australian opal fields by miners and used to protect their diggings from nocturnal prowlers and thieves. *C. rosea* has particularly vicious spines which are capable of penetrating footwear and even tyres on vehicles. The current Australian distribution of *C. rosea* is north-western NSW (primarily around the opal fields of Lightning Ridge, Grawin and Glen Garry), South Australia and parts of Western Australia although there are unconfirmed reports of its presence around opal mining areas in Queensland. *C. rosea* reproduces vegetatively and not by seed. Prospects for satisfactory levels of control using traditional methods, such as chemical application, are poor given the types of terrain and vegetation in which infestations are located. Any missed plants or plant parts have the capacity to form new infestations if they come into contact with the ground and form roots.

The prospects for successful biological control of *C. rosea* are reasonable as previous biological control programs targeting cacti have proven highly successful. *Dactylopius tomentosus*, a species of cochineal insect introduced to control rope pear (*C. imbricata*), attacks *C. rosea* but is not particularly damaging. Recent South African research has shown that there are several strains of D. tomentosus present in Mexico, at least one of which is likely to be more damaging to *C. rosea*. There should be few host specificity issues as there are no native species in the Cactaceae. Additionally, *D. tomentosus* is already present in Australia so relatively little quarantine testing should be required to obtain approval for the release of a different strain of this insect.

Take home message

Biological control of pasture weeds, if successful, may reduce them to minor components of the invaded system. However, it must be remembered that biological control will not eradicate any weed species. Integrated control utilising a combination of biological control, strategic herbicide application and other suitable techniques may also be necessary. Any integrated program will have to ensure that sufficient biological control agents remain following other forms of treatment to ensure re-establishment of biological control agent populations. An ongoing commitment to control is vitally important as many of the target weed species have long lived seed banks. It is also essential to prevent the niche previously occupied by a weed being reinvaded by the same species or by another (possibly worse) weed species.

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