Technical updates

Section 7

Technical updates

Principles of biocontrol

Michele Deveze

Biological control is the process of introducing natural enemies of exotic weeds or other pests to reduce their growth, reproductive capacity or life expectancy.

Establishment of a biological control program is lengthy and expensive because all potential agents must undergo testing against target and non-target plants under quarantine in Australia. This detailed testing is done to ensure that they will not attack native flora or economically important plants when they are released in Australia.

If quarantine testing in Australia indicates that the agent is definitely host specific, scientists make an application to the Australian Quarantine Information Service (AQIS) for approval to release the agent. Approved agents are then mass-reared to produce large numbers of individuals that can be distributed throughout the range of the weed in Australia. Because these agents are introduced without their parasites and diseases, and often into vacant ecological niches, their population can reach very high levels and thereby result in very effective biological control.

There can be great variation in the time required for biological agents to build up in population and have a noticeable effect on the plant that they were introduced to control. Some agents can have a visible effect on weeds within a year or two of introduction whereas others may be present for more than ten years before having a noticeable effect. There is also a percentage that will not be able to adapt to the environmental conditions of their new habitat and will fail to establish.

Rieks van Klinken

▲ Entomological quarantine building in Brisbane

Research and development of *Penthobruchus*

Catherine Lockett

The Australian Agricultural Council approved *Parkinsonia aculeata* as a target for biological control in Australia in 1983, and investigations began with a joint project between the Queensland, West Australian and Northern Territory governments. Between 1983 and 1987, biological control research aimed at finding natural enemies of parkinsonia was undertaken in the southern United States and northern Mexico.

Twelve insect species were identified as potential biological control agents because of the damage they caused. The two with greatest potential were *Mimosestes ulkei*, a seed-feeding beetle and *Rhinacloa callicrates*, a sap-sucking bug. A third insect, the seed beetle, *Penthobruchus germaini*, was later collected in Argentina. All three were brought to Australia for host specificity testing under strict quarantine.

In 1994 approval was obtained for the release of *Penthobruchus*. It is a small brown beetle, about 6 mm long, with large hind legs and black mottling on its wings. Individuals can live for up to two months but usually only live for about five weeks. The females lay up to 350 eggs each on parkinsonia pods, and after the eggs hatch the larvae tunnel into the seeds. The larvae will spend their entire development period in one seed and effectively destroy that seed.

Nathan March

Field release of biological control agent *Penthobruchus germaini* at Neumayer Valley, near Burketown

Catherine Lockett

The hole in the seed was made by the emerging *Penthobruchus germaini* beetle

Catherine Lockett

Penthobruchus germaini eggs laid on a parkinsonia seed pod

In early 1995 mass rearing of *Penthobruchus* started at the Tropical Weeds Research Centre (Charters Towers) and the Alan Fletcher Research Station (Brisbane) of the then Department of Natural Resources. More than 240 000 insects were released at over 125 sites including Winton, Rockhampton, Ayr, Cloncurry, Burketown, Normanton, Townsville, Georgetown and Charters Towers in Queensland. In the Northern Territory over 44 000 beetles were released. *Penthobruchus* has now been introduced to all major parkinsonia infestations in Queensland and has also been spread widely in the Northern Territory.

In the field the presence of *Penthobruchus* is indicated by white eggs under a pale membrane against the darker background of the pods. Round holes in the pods indicate that beetles have emerged.

Initial surveys in north and central Queensland showed that although there is a large variation in the success of the insects, *Penthobruchus* had in some cases destroyed up to 99 per cent of seeds over a season. Recent, ongoing research by CSIRO, however, has shown that although egg densities can be very high, seed mortalities are sometimes low and unlikely to significantly reduce parkinsonia populations in many parts of Australia. The main reason for low seed mortalities appears to be high parasitism of beetle eggs by native wasps.

Existing biological control agents alone will not control parkinsonia. They are just one of the control options that can be incorporated into integrated management practices.

Parkinsonia modelling

Michele Deveze with Rieks van Klinken

Models can help scientists and land managers assess the potential outcomes of a range of management options on a particular weed population, and determine which process will be the most cost effective. Models are commonly built on computers, and involve the computer performing a number of complex mathematical functions based on the interaction of known characteristics, or parameters, of the pest species.

Modellers feed into the computer model descriptive data about the pest species and its ecology, the range of environments that the species inhabits, the interaction between the species and environmental conditions, and the effect of different control methods on the survival of the species as a plant or a population.

When the modeller is satisfied that the model accurately represents the weed, its ecology and its responses to external stimuli, scenarios can be developed and the 'virtual weed' subjected to a range of 'virtual treatments' under different conditions. To confirm the predictions of the model and develop best practice methodology, the scientist will then replicate in the field the scenarios that performed best, and conduct formal assessments on their outcomes.

A parkinsonia modelling working group was established in 2000, consisting of state and federal government agencies including CSIRO, NRM&E and the Department of Primary Industries and Fisheries (Queensland), the Department of Primary Industries and Fisheries (Northern Territory), and the Department of Agriculture (Western Australia). At the inauguration of the modelling workgroup, little research had been conducted in Australia on parkinsonia and little information on its biology and ecology was available.

The parkinsonia modelling working group visiting the Leura field site near Rockhampton, Queensland

The working group's aims were to identify and address the current research gaps in parkinsonia biology, management techniques and potential biological control agents, and to devise a best practice management strategy for the weed as a part of the weeds of national significance parkinsonia strategic plan. The specific objective of building a parkinsonia model was to create a tool with which to design and evaluate a parkinsonia best management practice strategy that could be tailored for specific conditions around Australia. This would include looking at combinations of mechanical control, herbicide control, fire and biological control agents. The model will also provide an educational and predictive tool for managers, landholders and new employees.

Three workshops have already been held. Outcomes of these included gaining a clearer understanding of the parkinsonia lifecycle and the processes that affect parkinsonia growth, mortality and reproduction, as well as a clearer definition of the kind of data required to build a population dynamics model for parkinsonia.

The parkinsonia model working group have described the prototype model as 'almost operational' and are anticipating its practical use and further refinement in the near future. They commented that an incidental and unexpected outcome of developing the model was that background research designed to refine and define plant parameters has also provided indications of initial best practice management techniques.

Integrated parkinsonia management

Michelle Deveze with John McKenzie

In 2001 John McKenzie, rangelands weeds officer at the Tropical Weed Research Centre, Charters Towers, commenced a parkinsonia trial at Leura, near Duaringa in central Queensland. The Leura site was chosen because almost all of the 133 ha of the trial site were infested with parkinsonia, at an average density of 2200 plants per hectare.

The trial aimed to test the effectiveness of a range of parkinsonia control methods including herbicide, mechanical and fire. Factors assessed by the trial included plant mortality, regeneration, recruitment, soil seed bank changes, and grass response after each treatment.

The trial consisted of ten different treatment plots and a non-treated plot (known as a control plot). All plots were replicated three times.

The ten treatments were:

- Herbicide
  - Grazon DS (aerial application to the foliage)
  - Graslan (aerial application to the soil)
  - Velpar® L (soil application)
  - Access + diesel (basal bark technique)
- Mechanical
  - stick raking
  - blade ploughing
  - Ellrott ploughing
  - bulldozing
  - double pulling
- Fire

This trial at Leura has a four-year life span with final assessments scheduled for 2005.

John reports that preliminary indications are encouraging, though cautions that one should not jump to conclusions until a complete data set from the experiment is gathered. By the end of the trial he expects to be able to make a good comparison between these treatments with respect to their respective effectiveness in controlling parkinsonia. Existing results indicate, however, that each treatment is effective in controlling this weed, with individual circumstances dictating the 'best' situation in which to apply a particular treatment.

Herbicide treatment

Basal bark spraying is good for control in riparian areas and for isolated plants. Other application techniques using Grazon DS, Velpar® L and Graslan appear quite effective and relatively cheap, but to minimise damage to non-target vegetation their use should be restricted to areas away from watercourses and where there is minimal non-target vegetation.

John McKenzie

Parkinsonia plants at the Leura trial site before treatment

John McKenzie

After treatment with foliar herbicide (Grazon DS)

John McKenzie

Before treatment

John McKenzie

After treatment with soil-applied herbicide (Graslan)

Mechanical methods

The main benefit of mechanical methods is that they reduce the size of parkinsonia, encouraging grass to grow and compete with the weed. The result is that the area is more open and provides easier access for stock. Similarly, parkinsonia that has been pushed into stacks can be burned. By contrast, parkinsonia trees that have been killed by basal bark or foliar spraying remain as standing dead trees for around a year.

John recommends that the Ellrott plough and the conventional blade plough be used for thick infestations away from watercourses—'they'll kill almost all adult parkinsonia present'. At this stage of the experiment it is not possible to predict the level of recruitment from seed. Perhaps because of the presence and activity of the seed-boring beetle (*Penthobruchus*) at the site, it will not be significant.

▲ Before treatment

▲ After treatment by mechanical means (Ellrott ploughing)

▲ Before treatment

▲ After treatment by mechanical means (bulldozing)

Bulldozing, stick raking and double pulling are rated as similar in effectiveness. Initial results indicate a mortality ranging from 24 per cent for double pulling to 43 per cent for stick raking. However, John again warned that the overall costs of each would finally depend on the recruitment level after each treatment: 'it is still too early in the experiment, and environmental variables over the next few years will affect the results'.

'Follow-up treatments will be dependent on seedling density: it may be basal barking, soil-applied herbicide, foliar spraying, aerial spraying or mechanical control.'

John regards the experiment as very valuable because it is trialing a range of treatments at the one site.

Conditions such as climate, land usages, vegetation, fire properties and relative palatability of parkinsonia to cattle can be very different in other parts of Australia, so results and recommendations will not necessarily apply universally. Other research, including ecological work throughout Australia and the development of a computer management model, is therefore aimed at working out how management methods are likely to work best under other conditions.

Getting the most out of your basal spraying program

John McKenzie and Michele Deveze

Your basal spraying technique can make all the difference to the success of your spraying program. If you do not spray the weeds properly, your kill rate will probably be decreased and your follow-up work will take more time and herbicide. Making sure of a few simple points can mean the difference between a successful day's work and a waste of time.

Nev Mills

▲ Basal bark spraying

These include the following:

- Ensure that the herbicide that you're using is registered for the purpose.
- Use clean diesel.
- Mix at the right rate (see 'Herbicide use and mixing' page 92).
- Mix only the amount you will be using for the day.
- Ensure that the herbicide is thoroughly mixed through the diesel.
- Ensure that the stem is clean from grass, debris, mud and moisture.
- Spray at about 45 degrees to the stem to minimise splash-off.
- Use less rather than more pressure.
- To increase the flow rate, increase the apertures of the spray piece rather than increasing pressure.
- Ensure that complete circumference of the plant stem is covered with mix.
- The larger the diameter of the stem, and the taller the plant, the higher up the stem should be sprayed. As a general rule parkinsonia plants up to 50 mm basal diameter should be sprayed from the ground up to knee height. Plants bigger than this should be basal bark sprayed from the ground up to hip height.
- Although basal bark spraying will work throughout the year, the best time for treatment is when plants are actively growing and the soil moisture is good.

Nev Mills

▲ Before treatment

Nev Mills

▲ Basal bark spraying can be an effective tool in controlling parkinsonia

Herbicide use and mixing

Michele Deveze

How you mix your herbicides can make the difference between whether a weed control program is a success or a failure. If the mix is not strong enough your kill rate will be reduced, meaning that you will probably need to return and do some or most of the job again. If your herbicide mix is too strong, it may affect the way that the herbicide works by killing the outside cells, stopping it from being absorbed into the plant's sap system. At the very least, using a mix that is too strong will cost you more than is necessary. Table 4 contains a guide to the volume of chemical or concentrate required, when using different tank sizes, to make up the desired ratio of mixture.

The main points are as follows:

- **Read the label and have a MSDS sheet on hand when applying herbicide**.
  - Material safety data sheets can be obtained from the herbicide distributor and supplier, or online.
- **Observe all recommended safety precautions**.
  - Wear gloves, aprons and face/eye protection for mixing.
  - Wear overalls, gloves and eye protection for spraying.
  - Wash hands after mixing and using herbicide, and before smoking or eating.
- **Mix up only the amount that is required for the day**.
  - Measure herbicides and diesel/water using calibrated containers.
  - Use a wetting agent or other additive if recommended.
  - Fill the tank to about two thirds full, add the herbicide concentrate, and then continue filling the tank.
- **Make sure the herbicide is thoroughly mixed into the water or diesel**.
  - Do not use bare hands for mixing wettable powders or granules (of any herbicide).
  - Use a paddle or mechanical agitator to keep the solution in suspension for foliar herbicides.
- **Dispose of unused mixed herbicide and used containers in a lawful and responsible manner.**

Table 4 Volume of herbicide concentrate added to differently sized tanks to achieve specific mix ratios

Mix ratio	Tank volume (litres)							
	1	2	5	10	50	100	200	500
1:40	0.025 L (25 ml)	0.05 L (50 ml)	0.125 L (125 ml)	0.25 L (250 ml)	1.25 L (1250 ml)	2.5 L (2500 ml)	5 L (5000 ml)	12.5 L (12 500 ml)
1:50	0.02 L (20 ml)	0.04 L (40 ml)	0.1 L (100 ml)	0.2 L (200 ml)	1 L (1000 ml)	2 L (2000 ml)	4 L (4000 ml)	10 L (10 000 ml)
1:60	0.017 L (17 ml)	0.033 L (33 ml)	0.083 L (83 ml)	0.167 L (167 ml)	0.833 L (833 ml)	1.667 L (1667 ml)	3.333 L (3333 ml)	8.333 L (8333 ml)
1:100	0.01 L (10 ml)	0.02 L (20 ml)	0.05 L (50 ml)	0.1 L (100 ml)	0.5 L (500 ml)	1 L (1000 ml)	2 L (2000 ml)	5 L (5000 ml)
1:200	0.005 L (5 ml)	0.01 L (10 ml)	0.025 L (25 ml)	0.05 L (50 ml)	0.25 L (250 ml)	0.5 L (500 ml)	1 L (1000 ml)	2.5 L (2500 ml)
1:300	0.003 L (3 ml)	0.007 L (7 ml)	0.017 L (17 ml)	0.033 L (33 ml)	0.167 L (167 ml)	0.333 L (333 ml)	0.667 L (667 ml)	1.667 L (1667 ml)
	Concentrate volume							

Can you fight parkinsonia with fire?

John McKenzie, Shane Campbell and Tony Grice

People are asking if parkinsonia can be controlled with a planned burning program. At this stage scientists at the Tropical Weeds Research Centre (TWRC) in Charters Towers, north Queensland, are not sure. However, along with CSIRO they are researching the effects of fire on parkinsonia infestations.

John McKenzie, rangeland weeds officer at TWRC says that he has heard from landholders that burning gives mixed results. In some areas there has been virtually no mortality following what appeared to be fairly intense fires, whereas some—but by no means all—cooler low-intensity fires, lit during breaks in the wet season, resulted in fairly good kill rates.

CSIRO scientist Dr Tony Grice monitored survival of parkinsonia following a dry season fire in the Charters Towers region. He found that 50 per cent of plants of a range of size-classes were killed even though the fire was of relatively low intensity.

Current research is examining the responses of parkinsonia to different seasons and intensities of fire in order to identify burning regimes that will cause maximum parkinsonia mortality. The research is being undertaken at Fletchervale, which is located near Charters Towers and has a fairly dense infestation of parkinsonia growing on an alluvial basalt soil.

John McKenzie

▲ Scientists of NRM&E's Tropical Weed Research Centre are continuing fire trials in collaboration with CSIRO

John McKenzie

▸ A fire trial underway at Fletchervale, near Charters Towers, Queensland

This experiment should give us a sound understanding of how differently sized plants handle fire, how fires affect parkinsonia density, and whether fires kill seeds in or on the soil. Researchers are recording the characteristics of each experimental fire, and the condition of plants at the time of burning, so that reliable recommendations can be made to landholders.

The effects of intensity are being evaluated through comparisons between fast moving head-fires (burning with the wind) and slow moving back-fires (burning into the wind). Four different seasonal burns are being studied: early dry season, late dry season, early wet season and mid wet season.

John said that preliminary results suggested that the seeds sitting on the soil surface might be damaged by fire, and that in some treatments already implemented, a number of plants appear to be dead or dying.

This research is in its early stages and recommendations will be published as results become available. It will then be possible to determine what role fire has to play in parkinsonia management, either as a stand-alone treatment or as a component of an integrated approach.

Seed viability and dormancy

Rieks van Klinken

Parkinsonia seeds can remain dormant for long periods, and the resulting long-lived seed banks can be a real problem for control. For seeds to lose dormancy and germinate, the very tough, hard seed coat needs to be damaged, or weakened sufficiently to let water in.

Many different factors can result in loss of seed dormancy. Moisture, heat (bare soil temperatures frequently heat up over 40ºC), and damage (e.g. from insects) are probably particularly important. These conditions will differ depending on climatic conditions, ground cover, depth in soil, levels of inundation and other factors. A proportion of seeds (often about 10 per cent) are never dormant.

To properly predict the long-term outcome of different control techniques, it is valuable to know not only the size of existing seed banks but what proportion of the seeds are actually viable, and what proportion of those are dormant and therefore likely to remain in the soil well beyond the next major rainfall event.

CSIRO and the Northern Territory's Department of Infrastucture, Planning and Environment (DIPE) have recently developed a standard test for determining whether or not seeds are viable and dormant. To determine dormancy levels, seeds are placed in water at 20ºC for four days; those that have not swelled up (imbibed) after that period are considered to be dormant.


Rieks van Klinken

▲ Dormant parkinsonia seed

To determine viability, seeds are soaked until they are fully imbibed, and then placed on paper and kept moist at 20–30ºC until they either germinate (i.e. are viable) or rot. The seed coat of dormant seeds needs to be damaged (with sandpaper) before their viability is determined in the germination test.

These tests are currently being used in conjunction with Australia-wide studies aimed at determining seed density and distribution in the soil as well as seed bank longevity under different climates, habitats, ground covers and soil depths.

Rieks van Klinken

A seed burial experiment in Darwin is examining the effect of depth, shade cover, burial time, and soil temperature and moisture on parkinsonia seed longevity

Rieks van Klinken

Seed burial packets. Each packet contains 50 seeds and is buried for later retrieval

Do feral pigs spread parkinsonia?

Ben Lynes

The Tropical Weeds Research Centre (TWRC), wanted to find out if feral pigs might account for some of the spread of parkinsonia seed.

Based on a feeding trial, TWRC reported that the pigs did not appear to like to eat parkinsonia seed. Even when the seeds were coated with molasses, they only ate 35 per cent of the pods. Mostly they just licked the molasses off.

Of the small amount of seed that they did eat, it took from three to eight days for the seeds to pass through their digestive system; of these, 50 per cent remained viable and capable of germinating.

However, based on the feeding trial it appears that parkinsonia is not a preferred food source and consequently feral pigs may not be major dispersers of parkinsonia seed.

Ben Lynes

Feral pigs do not seem to eat parkinsonia seed

Do I really need a tree clearing permit to clear weeds?

Michele Deveze and Ann Doak

Weed control should aim to avoid or minimise damage to non-target native vegetation. However when controlling parkinsonia, land managers may choose to use methods that involve the clearing of adjacent or interspersed native vegetation, particularly in heavily infested areas. In these cases, the clearing of the native vegetation may require a permit.

In addition, landholders may use methods of weed control that result in incidental damage to native vegetation. In these cases, the damage to the native vegetation is considered to be clearing, and may also require a permit.

If using control methods such as mechanical, fire or herbicides, there may be a risk that native vegetation could be affected. If a proposed weed control program may result (intentionally or accidentally) in the clearing or death of native vegetation, it is essential to comply with the relevant state and/or local government native vegetation legislation. So check this before starting work.

Clearing of parkinsonia working around native vegetation

Michele Deveze