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Managing Queensland's natural resources
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Technical highlights

Weed and pest animal research

2005–06

Queensland **the Smart State**

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Message from the Executive Director, Natural Resource Sciences

Pest Management Research makes a significant contribution towards the improved management of pest plants and pest animals throughout Queensland as an integral part of the research portfolio of the Department of Natural Resources and Water.

Queensland's landholders, local governments, weed and pest management groups, primary producers and the environment all benefit from this research effort, and the development of improved pest management practices that result.

Notable achievements during this year include significant progress towards the biocontrol of cat's claw creeper; a better understanding of the importance of seasonal variation in determining the effectiveness of 1080 baiting programs; and research on the ecology and control of Class 1 eradication targets that included providing critical data for the Department's eradication programs. The 33 peer-reviewed national and international scientific journal papers produced by Pest Management Research during the year are evidence of quality science outputs and the high level of productivity of the group.

Successful collaboration with other research providers, such as the CRC for Australian Weed Management, the Bureau of Rural Sciences, CSIRO, the Grains Research and Development Corporation, Plant Protection Research Institute (South Africa), Invasive Animals CRC, Australian Centre for International Agricultural Research and several universities continues to be an important aspect of our work. Project collaborations also exist with all levels of government, federal, state and local. I would particularly like to extend the department's thanks to our on-ground collaborators: the landholders, local government staff, and regional and community groups without whose help much of our field work would not be possible.

The majority of the funding for the research program was provided directly by the Queensland Government and through Local Government precepts. In 2005–06 Pest Management Research attracted over $1.23 million in external funding, or some 18 per cent of the total research program budget from a variety of external funding bodies, which is excellent recognition of the value of the research being undertaken.

A couple of examples of this externally funded research include support from the CRC for Australian Weed Management to employ post-doctoral researchers working on the ecology and management of bird-dispersed weeds, and funding from the Bureau of Rural Sciences (National Feral Animal Control Program) to support multiple projects including development of effective 1080 meat baiting for feral pigs and development of a cyanide bait for rapid disease sampling and surveillance of feral pigs and foxes. Funds were provided to CSIRO to initiate the monitoring of invasive plant responses in the Wet Tropics following the large-scale disturbance caused by Cyclone Larry.

Finally, I note and acknowledge the significant effort in 2005–06 in developing a strategic plan for Pest Management Research for the coming years (2006–10) that aims to address both current and future issues and sets the direction and priorities for pest management research outputs into four research programs (Pest Animal Management; Integrated Weed Management; Landscape Protection and Restoration; and Research Services). The plan will be progressively implemented and regularly reviewed.

I commend staff for their professional and technical skills and commitment to Pest Management Research and congratulate them on the major advances made towards achieving the sustainable use of the state's natural resources.

Don Begbie

Acting Executive Director, Natural Resource Sciences

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Achievements

The summary of achievements illustrates the significant progress made by our research teams during the year. It reflects the professional and technical expertise and dedication of our staff and the excellent assistance provided by our operational and administrative support teams.

Among the notable successes this year were the completion of host-testing for two promising biocontrol agents for cat's claw creeper (*Macfadyena unguis-cati*); research providing a better understanding of the importance of dispersal and season in determining the effectiveness of 1080 baiting programs; and research on the ecology and control of Class 1 eradication targets providing critical information for our eradication program strategies for *Mimosa pigra*, *Limnocharis flava* and *Miconia calvescens*. Other significant studies included a study of effective 1080 meat baiting for feral pigs which confirmed that the lethal dose of 1080 to kill 90 per cent of feral pigs is quite variable and relatively large (i.e. greater than 3.0 mg/kg bodyweight), and research examining the effects of warren ripping on rabbit populations in drought refuge areas that has indicated that warren ripping is the most effective control method.

The value of our research was recognised when researchers presented invited as well as submitted papers and chaired sessions at both national and international conferences during the year. In terms of publications, the year was highly productive with 33 peer-reviewed scientific papers published, with 18 in international journals and 15 published in national journals. A further 18 conference papers were published by Pest Management Research staff during the year.

Funding

The Queensland Government provided $4.04 million in base funds and the Land Protection Fund provided $1.48 million. External funds totalling $1.23 million were received and are listed on page 5.

Review processes

Implementation of the recommendations of the 2005 strategic review of Pest Management Research resulted in the development of a Strategic Plan for Pest Management Research 2006–10, with research outputs now restructured within four major programs, namely Pest Animal Management, Integrated Weed Management, Landscape Protection and Restoration, and Research Services.

Pest Management Research also participated in an internally commissioned review of Data Management within Natural Resource Sciences, which was conducted by an independent external panel.

Research priorities for 2005–06 were based on the list of ongoing projects and previously identified priority weeds and feral animals. Project plans and associated budgets were prepared by research staff and considered by management when the budget for the new financial year was made known in July and reviewed by the Research Review Committee in April.

Conferences

During the year, a number of important conferences, workshops and seminars were attended by research staff. As well as presenting the work of our scientists at national and international levels, staff benefited from these unique opportunities to share ideas and keep abreast of the latest information in the wide range of disciplines represented. Conferences where our work was presented include the 20th Asian Pacific Weed Science Society Conference (Vietnam), the 4th International Symposium on Frugivores and Seed Dispersal (Brisbane), Ecological Society of Australia (Brisbane), Third Biennial Australasian Ornithological Conference (Blenheim, NZ), and the Entomological Society of America (Illinois).

Staff

The year saw some significant changes in staffing, particularly at Alan Fletcher Research Station (AFRS). A number of staff departures took place, including the resignation of Peter Mackey, Group Leader for Pest Management Research, in September 2005, and the retirement of Trevor Armstrong after 32 years of dedicated service in agronomy and weed management at AFRS. Stephen Jackson, Gina Paroz and Martin Hannan-Jones also moved from their positions, taking up new positions within the department. Dr Carl Gosper completed his Weeds CRC post-doctoral fellowship. New appointments included the appointment of Gabrielle Vivian-Smith as Principal Scientist, Lesley Ruddle as Chemist, Margie Cohn as a Pesticide Registration Officer, and Eve White as a Weeds CRC Post-doctoral Fellow.

Collaboration

Collaboration with other research groups is important in maximising the effective use of our resources and integrating our work with other natural resource management research.

Pest Management Research is a major partner in the CRC for Australian Weed Management. Dane Panetta leads projects within Program 1 (Weed Incursion and Risk Management), whilst in Program 3 (Landscape Management) Wayne Vogler, Shane Campbell, Michael Day and Gabrielle Vivian-Smith continued as Project Leaders. Other staff at both Tropical Weeds Research Centre and AFRS were involved in Weeds CRC research projects. Pest Management Research is also a participant in the Invasive Animals CRC and an equity partner in the Rainforest CRC.

A large number of project collaborations exist with Commonwealth, state and local government agencies and regional natural resource management (NRM) groups. We also collaborate directly with a wide range of national and international research institutions. These include The University of Queensland, Queensland University of Technology, Griffith University, Charles Darwin University, University of Adelaide, LaTrobe University and University of KwaZulu-Natal. Other research collaborators include CSIRO Entomology, CSIRO Plant Industry, the Botanical Research Institute of Texas and the Plant Protection Research Institute, South Africa.

Many of our research activities require field trials or sampling on the properties of private landholders. Their continued support is essential for our work and is greatly appreciated.

Extension

Communication of results is an essential part of our research. Research results are communicated to the scientific community through the publications and conference presentations that listed at the end of this volume. Land Protection Extension Officers continue to be associated with the various research stations, and research staff assist extension staff in the production of fact sheets, leaflets and other brochures and displays. Research staff also provide information for Pest Status Assessments Weed Risk Assessments and other reports by Land Protection and national and international agencies.

Staff communicate directly with landholders and land managers through talks and displays at field days and workshops, and to Landcare and Bushcare groups and producer organisations. Outstanding field days held during the year include the Bellyache Bush Field Day and the Baralaba Parkinsonia Ecology and Control Field Day. A successful open day was also held at AFRS for delegates attending the International Union of Forest Research Organisations 2005 World Congress (Brisbane).

I am pleased to present this report to the groups and individuals who are our clients as well as to our collaborators and colleagues. If you have any comments or require further information, please contact me, or one of the research group's Professional Leaders.

Gabrielle Vivian-Smith
Principal Scientist
Pest Management Research

Summary of achievements

Integrated weed management

A prickly acacia biocontrol agent, *Chiasmia assimilis* was present at all coastal sites over the summer and found for the first time at two western sites. Defoliation was high at some of the coastal sites. Twenty-four (24) releases totalling more than 19 000 insects of *Cometaster pyrula* were made at two coastal sites and one western site.

Evaluation of rubber vine at long-term monitoring sites indicated significant rust infection or insect defoliation by Euclasta larvae, and significant damage at virtually all of the sites during the year's near-average wet season.

Integrated weed management trials were completed enabling the identification of the most effective treatment strategies. Releases of the bellyache bush seed feeder, *Agonosoma trilineatum* recommenced with over 10 000 insects released at five different sites. CLIMEX modelling is underway to identify the most suitable potential release sites. Evaluation of the agent under controlled conditions indicates that at high densities seed mortality is high for both immature and mature seeds.

Mimosa pigra eradication research has indicated that the seedling recruitment and seed bank densities have declined significantly over the four-year eradication program. *M. pigra* was found to flower as early as 67 days after emergence, with pods being produced from 157 days. These findings, along with information from chemical and fire control studies, have informed the eradication program.

Research investigating integrated weed management options for parkinsonia has compared effectiveness (cost, mortality and regrowth responses) of different control methods. Other control studies have investigated the use of fire and camel grazing. Seed bank studies are reporting high levels of depletion within 24 months.

Landscape protection and restoration

Field and glasshouse studies of the Class 1 eradication target, *Limnocharis flava*, identified minimum age to maturity under local conditions. The information was used by the Four Tropical Weeds Eradication Team, enabling the team to modify their revisitation frequency at active control sites to more effectively prevent seed production. Other scientific studies of Class 1 eradication targets, including miconia and mikania, have also yielded useful information for the eradication programs.

Cat's claw creeper biocontrol advanced significantly with host-testing completed and applications submitted to the Department of Environment and Heritage (DEH) and Department of Fisheries and Forestry (DAFF) for release of two agents, the leaf-sucking tingid, *Carvalhotingis visenda* and the leaf-tying pyralid moth, *Hyposomia pyrochroma*. Climate matching indicated that conditions present in native range areas of northeast Argentina, south Brazil, Uruguay and Paraguay most closely matched the conditions where heavy infestations of cat's claw creeper were found in Australia. A genetic study tested plant material from cat's claw creeper introductions in Australia to determine where they originated in the native range, which extends from central America to Argentina. The results indicated the cat's claw creeper found in Australia mostly originated from the southern extent of the species' native range.

An externally funded ACIAR project continued with the release and establishment of the chromolaena gallfly, *Cecidochares connexa* in all 12 provinces of Papua New Guinea where there is chromolaena. The moth *Pareuchaetes pseudoinsulata* has established in only one province, while the fly *Claycomyza eupatorivora* failed to establish despite numerous attempts.

A new three-year ACIAR-funded project on the biocontrol of *Mikania micrantha* in PNG and Fiji has commenced, with the aim to control the weed in these countries and reduce the risk of further introductions to Queensland.

An application to release the Lantana budmite, *Aceria lantanae* has been prepared for submission, and host testing of the herring-bone miner, *Ophiomyia camarae* has been completed. The lantana rust, *Prospodium tuberculatum* is present at 18 sites in Queensland and 32 sites in New South Wales. Studies also investigated the relative-host suitability of *Aconophora compressa* of lantana and two native mangrove species as well as other verbenaceous species.

Studies continued in the area of bird-dispersed weeds with a review paper published and the completion of the functional traits study. The fruit trait most strongly associated with invasiveness was fruit size, with all highly invasive species having relatively small fruits. The diversity of bird consumers associated with a weed species was also positively correlated with the invasiveness of a species.

A study of lantana seed bank ecology is near completion, with work to date indicating that seed banks were both larger (higher seed densities) and more persistent (>3 years) than previously thought.

Seed bank studies for harungana and hymenachne entered their sixth year, indicating that both species have persistent seed banks with significant viability retained after six years under field conditions.

Pond apple ecology studies indicate significant seedling mortality over the two-year period with surviving seedlings yet to reach maturity. Seed viability in water indicated that seeds germinated in fresh water but remained viable but dormant after 12 months in salt water, suggesting significant potential for dispersal via ocean currents.

A scoring system for the evaluation of progress towards eradication is being developed and is currently under testing in several eradication programs for Class 1 weeds, *Mikania micrantha* and *Limnocharis flava*. The scoring system utilises both delimitation and extinction information for each target species.

A field study evaluating off-target damage following application of haloxyfop to control hymenachne, measured breakdown and movement of the product in open and enclosed water systems. In both water bodies concentrations did not differ with sampling location measured (depth and distance) and had reached very low levels by 31 hours after application.

Cabomba control trials at several field locations indicated that a single application of carfentrazone has the ability to effectively control this aquatic weed. Glasshouse trials and field trials aiming to identify a herbicide for controlling Senegal tea plant found picloram to be effective.

Pest animal research

A three-year study that monitored the effect of 1080 baiting programs on wild dogs discovered significant seasonal differences in effectiveness. Between October and April wild dog activity most often increased after baiting. Dispersal of young wild dogs from properties that are not baited, or poorly baited, into areas made vacant by baiting is thought to be the cause. Between May and September 1080 baiting on average reduces wild dog activity by about 50 per cent.

Results from the monitoring of a second quoll population during an autumn 1080 baiting campaign has not identified any animal mortalities as a result of baiting, supporting earlier results that 1080 baiting of wild dogs has no population-level impacts on wild quolls.

A study of effective 1080 meat baiting for feral pigs has confirmed that the lethal dose of 1080 to kill 90 per cent of feral pigs is quite variable and relatively large (i.e. greater than 3.0 mg/kg bodyweight).

Investigations developing cyanide baits for rapid disease sampling and surveillance of feral pigs and foxes have yielded promising results, with a new prototype bait using potassium cyanide; however, further pen and field trials are needed.

Genetic studies using DNA technology as a tool to assess the population dynamics of rabbits and their reinvasion potential yielded promising initial results. Other research examining the effects of warren ripping on rabbit populations in drought refuge areas has indicated that warren ripping is the most effective control method.

Research services

A total of 189 investigations relating to suspected poisonings by sodium fluoroacetate, strychnine and anticoagulants were undertaken during the year. For sodium fluoroacetate, the percentage of confirmations was found to decline compared to previous years, although the total number of investigations rose.

A testing program to ensure that sodium fluoroacetate baiting meets agreed standards continued, with 100 sodium fluoroacetate, 100 solutions and 70 fresh meat baits tested during the year.

Methodology to determine the levels of the herbicide haloxyfop-methyl in water, fish, crustacean, molluscs, plant material and sediment was developed as part of a study undertaken to measure off-target effects of this herbicide for control of hymenachne in aquatic ecosystems. National Association of Testing Authorities (NATA) registration is being sought for the method.

External funding 2005–06

Project	Funds ($)	Funding body
Biological control of lantana (*Lantana camara*)	19 000	National Heritage Trust, NZ Landcare, CRC AWM
Biological control of chromolaena (*Chromolaena odorata*) in Papua New Guinea	99 100	ACIAR
Biological control of two weeds in East Timor	9 900	Charles Darwin University
Biological control of mile-a-minute (*Mikania micrantha*) in PNG and Fiji	156 300	ACIAR
Biocontrol of cat's claw creeper (*Macfadyena unguis-cati*)	21 000	Weeds CRC, Burnett Mary regional groups, Northern Rivers Catchment Management Authority, NSW
Biocontrol of weedy sporobolus grasses (*Sporobolus* spp.)	65 000	Meat and Livestock Australia
Investigations resulting from the non-target attack of *Aconophora compressa*	20 000	DPI&F
Ecology of bird-dispersed weeds	172 500	Weeds CRC, NHT2 WONS lantana, Exchange Incentive Fund (L&W Australia, Greening Australia)
Ecology of wet tropics weeds	60 700	Rainforest CRC, WONS, Four Tropical Weeds Eradication Project
Weed eradication feasibility and program evaluation	93 000	Weeds CRC
Integrated management of parkinsonia (*Parkinsonia aculeata*)	20 000	NHT2 WONS, Weeds CRC
Evaluating the risk of off-target damage through the application of chemicals to control hymenachne (*Hymenachne amplexicaulis*)	175 535	NHT
Aerial control of bellyache bush (*Jatropha gossypiifolia*)	6 500	Weeds CRC
Water weed management, and WONS Class 1 plant pests	61 400	NHT2
Monitoring impact of 1080 canid baiting on spotted-tail quolls	91 700	Bureau of Rural Sciences
Effective 1080 meat baiting for feral pigs	60 300	Bureau of Rural Sciences
Development of cyanide bait for rapid disease sampling and surveillance of feral pigs and foxes	25 653	Bureau of Rural Sciences
Pest management chemistry	45 000	Bureau of Rural Sciences
Diet and trapping strategies for feral pigs in tropical rainforests	9 000	Rainforest CRC
Refinement of a 1080 bait degradation model	9 700	Bureau of Rural Sciences

Chapter 1: Weed research biocontrol

Biocontrol of bellyache bush *(Jatropha gossypiifolia)*

Objective

To achieve biocontrol of bellyache bush by introducing, testing and releasing exotic insect species or pathogens.

Staff

Catherine Lockett (Leader) and Kelli Pukallus

Collaborators

Fiona Barron, Coordinator of the Mitchell River Watershed Management Group

Syd Clayton, Mareeba Shire Pest Management Officer

Merv Pyott, Land Protection Officer, Burdekin Shire Council

Russell Graham, Pest Management Officer, Cook Shire Council

Trevor Meldrum, Assistant Pest Management Officer, Cook Shire Council

Background

CSIRO Entomology began to survey insects and pathogens of *Jatropha gossypiifolia* and its close relative, *J. curcas* in tropical America and the Caribbean in 1997. As a result of this work, host specificity testing on one insect, the seed-feeding scutelerid, *Agonosoma trilineatum* was completed in 2002 and permission to release was received at the end of the year. A starter colony of insects was forwarded to TWRC in March 2003, with additional consignments of insects arriving in April. The first field release was made in June 2003.

Twenty releases were made at a total of seven sites, near Charters Towers and on the Burdekin River, between June 2003 and July 2004. These sites included sites for ecological studies on 'Mt Ravenswood' and 'Southern View'. All sites were checked in 2004. There were no signs of insect establishment at six of the seven release sites. Small numbers of insects were found at 'Mt Ravenswood' in January 2004 but not later in the season. Over 2600 adults had been released at 'Mt Ravenswood' over a 7-month period.

No insects were released between late July and early December 2004. Seed was scarce in the field and the *Agonosoma* colony remained relatively small during the period. The first release for the 2004–05 summer was made on the Burdekin River at 'King's Creek' in December 2004. Subsequent releases were focussed at 'Mt Ravenswood' on the Burdekin, with nine releases totalling 1660 adults being made between January and the end of June 2005. Field cages consisting of a gauze cover over a metal frame were used on three occasions at 'Mt Ravenswood'. Signs of field establishment were observed in February 2005, when approximately 20 nymphs of varying ages were found on plants near the site of the free releases and first cage setup. Evidence of feeding damage on seed capsules was also observed. However, subsequent inspections made in April, May and June found no further signs of the insects. The site remained very dry during this period and seed availability was limited.

Methods

Insects are currently being reared in plastic boxes in the laboratory and in gauze covered cages in the glasshouse. Cut foliage with seed capsules is collected once or twice weekly from field sites or from plants grown at TWRC. As seed is often difficult to find during winter, a variety of artificial diets made from combinations of fresh seed, frozen seed, dried seed and stems mixed with vitamins and minerals in an agar base were trialled in the glasshouse.

Of the combinations tested, adults and nymphs fed most readily on the following blended mix:

Base:
- 400 g fresh bellyache bush seed
- 600 mL distilled water
- 2 g sorbic acid

2 g vitamin mix
0.5 g casein powder mix
1 teaspoonwheat germ oil

Mix 1:
500 mL of above base mix
200 mL distilled water
10 g agar (with 200 mL distilled water)

Dried stems and dried or frozen seeds were not accepted in any of the media combinations. Frozen fresh seed placed directly into cages did provide an acceptable alternative/supplement to fresh seed and was fed upon over a period of several days.

Progress

Field releases recommenced in November 2005 at 'Barkla', near Charters Towers. Over a 5-month period almost 2800 adults and over 2000 nymphs were released at this site. Limited signs of insect activity have been observed to date.

Releases also commenced in the far north in February 2006. At one site on Emu Creek, near the Walsh River, Fiona Barron and Syd Clayton conducted five releases totalling 1637 adults. Rains from Cyclone Larry flooded the initial release area but plants recovered and there were early signs of insect establishment on the fresh seed.

TWRC staff released over 1000 adults and 1000 nymphs into an isolated infestation on the banks of the Palmer River on Mt Mulgrave Station in early June 2006. A second release of over 1200 adults and 450 nymphs was made by Russell Graham and Trevor Meldrum, Cook Shire Council, into the same Palmer River infestation on neighbouring Yambo Station.

A single release of 300 adults was made with the assistance of Merv Pyott on Peters Island near the mouth of the Burdekin River in May 2006.

The rearing and release program continues.

Funding

Queensland Government

Logistical support

Northern Territory Department of Business, Industry and Resource Development

CSIRO

Mitchell River Watershed Management Group

Cook Shire Council

Mareeba Shire Council

Burdekin Shire Council

Expected completion

Ongoing

Biological control of lantana (*Lantana camara*)

Objectives

To import, evaluate host specificity, mass rear, field release and monitor biological control agents for lantana (*Lantana camara*).

Staff

Michael Day (leader), Natasha Riding, Annerose Chamberlain

Collaborators

Local governments in Queensland

Environment Protection Agency

CSIRO Plant Industry

CSIRO Entomology

NSW Department of Primary Industries

NSW National Parks and Wildlife Service

Local governments in NSW

Botanical Research Institute of Texas

Plant Protection Research Institute, South Africa

The University of Queensland

Queensland University of Technology

Background

Lantana camara, a native to tropical America, was first introduced into Australia in the mid 1800s. It has since become a major weed of agricultural and natural ecosystems. In grazing lands, lantana out-competes preferred pasture species, thereby decreasing productivity, and also interferes with mustering. Some varieties are toxic to livestock. In natural ecosystems, lantana can become the dominant understorey species, blocking succession and decreasing biodiversity. Lantana is estimated to cost over $22 million per year in lost production and control costs. Lantana is a Class 3 weed in Queensland and has been the target of biocontrol programs since 1914.

Methods

Entomologists in Mexico and South Africa are contracted to locate and study the biology of potential agents prior to their introduction into quarantine in Australia.

Agents are imported and their host specificity is determined. Agents approved for field-release are then mass reared and released with the help of land protection officers, Department of Natural Resources and Water (LPOs) and local government weed officers.

The Plant Protection Research Institute (PPRI), South Africa has been contracted to study the biology, biotype preference and host specificity of several potential agents prior to their importation into Australia.

Progress

Aconophora compressa has established at a number of sites around Queensland. The insect is widespread throughout south-east Queensland, from Noosa in the north to Mt Glorious in the west and Coolangatta in the south. Small populations are also present around Toowoomba. In north Queensland, the insect is common around Atherton and populations are spreading around Mt Fox, north-west of Ingham. In New South Wales, *A. compressa* is present from the border south to Yamba, near Grafton.

A. compressa is also attacking and damaging fiddlewood (*Citharexylum spinosum*) and, to a lesser extent, several varieties of *Duranta erecta*. When populations are high, some spillover onto other species can result, causing superficial damage, but this is not sustained.

The mirid, *Falconia intermedia* has established at three sites, all in north Queensland, despite an intensive rearing and release program throughout Queensland. The insect is increasing at two of these sites, namely Julatten and Tarzali on the Atherton Tableland.

The lantana rust, *Prospodium tuberculatum* has been released throughout all favourable areas in Queensland and New South Wales. The agent appears to have established at 18 sites in Queensland. However, drought conditions throughout much of Queensland have hampered establishment. In New South Wales, where conditions have been a little more favourable, the rust has established at 32 sites. In all areas where the rust is present, both in Queensland and New South Wales, infection levels are low and infection is confined to release sites. Teliospores, the dormant stage of the rust life cycle, have been found at nine sites.

The lantana herring-bone leaf-mining fly (*Ophiomyia camarae*) was imported into quarantine from PPRI in October 2004. A colony was successfully established and host testing has been completed on 11 species. No mines have been seen on any species other than lantana and *Lippia alba*. An application seeking its release is being prepared.

The biology, biotype preference and host specificity of the budmite, *Aceria lantanae* was studied under contract at PPRI. Host specificity testing has been completed and the agent appears to be host specific. An application requesting permission to release the agent has been prepared for submission to DEH and DAFF.

Lantana specimens from many different sites in eastern Australia have been identified by Dr Roger Sanders, a lantana taxonomist, as either *L. urticifolia* or *L. urticifolia* X *L. camara* hybrids. This supports previous DNA studies that have suggested that lantana in Australia has a close affinity to *L. urticifolia*. A collaborative project (with CSIRO Plant Industry) investigating the genetic characteristics of lantana from different regions has commenced.

Funding

Land Protection Fund

Natural Heritage Trust

NZ Landcare

CRC Australian Weed Management

Expected completion

Ongoing

Aceria lantanae induced galls on lantana in Mexico.

Ophiomyia camarae adult.

Falconia intermedia damage on the Atherton Tableland (photo P Davis).

Biological control of chromolaena (*Chromolaena odorata*) in Papua New Guinea

Objectives

Through the introduction and establishment of biocontrol agents for chromolaena in Papua New Guinea, this project aims to:

- reduce the impact of chromolaena to small block holders and plantation owners in areas where the weed is a problem
- reduce the seed load and thus the possibility of spread into northern Australia
- establish successful biocontrol methods that can be used in northern Australia if required
- promote biocontrol as a safe and successful weed control method
- train scientists in Papua New Guinea in biocontrol methods.

Staff

Michael Day (leader)

Collaborators

Australian Centre for International Agricultural Research (ACIAR)

National Agricultural Research Institute (NARI), Papua New Guinea

Plant Protection Research Institute, South Africa

Background

Chromolaena odorata is native to the Caribbean and is now a major weed in PNG, East Timor, Indonesia and most countries in south-east Asia. Chromolaena is currently confined to north Queensland in the Wet Tropics, where it has the potential to impact significantly on the sugar, horticultural, beef and tourist industries and to spread throughout northern Australia.

Chromolaena is a Class 1 weed in Queensland and is subject to a national cost share eradication program. Increased control of chromolaena in countries such as PNG and East Timor will reduce the risk of further spread into Queensland. Costs to eradicate the weed from Queensland, if it becomes widely established, will far exceed the cost of preventing it from entering this state. A greater understanding of chromolaena and its biocontrol agents will boost Queensland's capacity to respond to its incursion if the eradication program is unsuccessful. A project on the biological control of chromolaena in PNG, funded by ACIAR, was initiated in 1996.

Methods

Suitable agents are selected and imported into PNG based on results of host specificity testing and field observations in other countries. Information on the agents' life history and host range is sent to the collaborators in Papua New Guinea and import permits are requested. A nucleus colony of each agent is sent from other countries to PNG, where a quarantine colony is established at Bubia, Morobe Province. The insects are reared through one generation before being transferred to rearing facilities at Labu, Morobe.

Field releases of the agents will take place throughout PNG where chromolaena is a problem. Releases of agents will be conducted with the aid of Provincial staff, as part of their training in biocontrol activities. Programs will be set up for monitoring of plant density and spread, insect populations, and their impact on the plant.

Progress

This ACIAR-funded project has been extended from March 2005 until December 2006.

The gallfly, *Cecidochares connexa* has been released and has established in all 12 provinces in which chromolaena occurs. The insect is no longer being reared at Labu Research Station. However, galls are being collected from the field and distributed to chromolaena infestations where the agent is not already present. In Sandaun Province, the fly has spread up to 100 km in four years from some release sites and is causing substantial damage to chromolaena. Near Vanimo, the fly has controlled chromolaena and food gardens have now been re-established. Successful control of the weed has also been observed around Namatanai in New Ireland Province, where food gardens and pastures have re-established. The fly is also widespread and causing significant damage to chromolaena in Morobe, Oro and East New Britain provinces.

The moth, *Pareuchaetes pseudoinsulata* has been released in eight provinces but has established only in Morobe. The insect has established at 11 sites and is spreading up to 10 km away from a further nine sites. *P. pseudoinsulata* is causing significant damage on a seasonal basis, with plants becoming totally defoliated at some sites in the Markham Valley. Landowners are distributing the moth to new areas. The moth is no longer being reared at Labu because rearing is very labour intensive and the insect is difficult to establish.

The leaf-mining fly, *Calycomyza eupatorivora* has been imported into PNG several times. A colony was established at Labu Research Station but died out each time. The insect will not be imported again.

An application to import another agent, the weevil, *Lixus aemulus*, was submitted to the Department of Environment and Conservation but is no longer being considered.

Funding

ACIAR

Expected completion

December 2006

Chromolaena infestation at Likes in PNG (February 2003), before the release of *Cecidochares connexa*.

Chromolaena infestation at Likes in PNG (February 2006), three years after the release of *Cecidochares connexa*.

Chromolaena infestation at Mushu, PNG (June 1999), before the release of *Cecidochares connexa*.

Chromolaena infestation at Mushu, PNG (August 2005), four years after the release of *Cecidochares connexa*.

Biological control of two weeds in East Timor

Objectives

Through the introduction and establishment of biocontrol agents for chromolaena and *Mimosa diplotricha* in East Timor, this project aims to:

- reduce the impact of chromolaena and mimosa to small block holders and plantation owners in areas where the weeds are problems
- reduce the seed load and thus the possibility of further spread into northern Australia
- establish successful biocontrol methods that can be used in northern Australia if required
- promote biocontrol as a safe and successful weed control method
- train scientists in East Timor in biocontrol methods.

Staff

Michael Day (leader)

Collaborators

Australian Centre for International Agricultural Research (ACIAR)

Ministry of Agriculture, Forestry and Fisheries, East Timor

Charles Darwin University

Background

Chromolaena odorata is native to the Caribbean and is now a major weed in PNG, East Timor, Indonesia and most countries in south-east Asia. Chromolaena is currently confined to north Queensland in the Wet Tropics, where it has the potential to impact significantly on the sugar, horticultural, beef and tourist industries and to spread throughout northern Australia.

Chromolaena is a Class 1 weed in Queensland and is subject to a national cost share eradication program. Increased control of chromolaena in countries such as PNG and East Timor will reduce the risk of further spread into Queensland. Costs to eradicate the weed from Queensland, if it becomes widely established, will far exceed the cost of preventing it from entering this state. A greater understanding of chromolaena and its biocontrol agents will boost Queensland's capacity to respond to its incursion if the eradication program is unsuccessful. *Mimosa diplotricha* is a Class 2 weed in Queensland and, as such, is targeted for active control. The psyllid, *Heteropsylla spinulosa* has been introduced into Queensland and is controlling the plant in some areas. A project on the biological control of chromolaena and mimosa in East Timor was initiated in 2004 and is funded by ACIAR.

Methods

Suitable agents are selected and imported into East Timor based on results of host specificity testing and field observations in other countries. Information on the agents' life history and host range is sent to the collaborators in East Timor, and import permits are requested. A nucleus colony of each agent is sent from other countries to East Timor, where the insects can either be reared or released directly into the field.

Field releases of the agents will take place throughout East Timor where chromolaena and/or mimosa is a problem. Releases of agents will be conducted with the aid of university staff and students, as part of their training in biocontrol activities. Programs will be set up for monitoring of plant density and spread, insect populations, and their impact on the weeds.

Progress

The gall fly, *Cecidochares connexa* was introduced from PNG in March 2005 and released at four sites: Baccau, Tibar, Cribas and Maubara. Establishment was confirmed at the first two sites. The gall fly was also imported from West Timor in March 2006 and was released at Betano, Soibada, Mehara and Hatu-Udu. However, due to political unrest since this time, there has been no information received on the status of these sites. Monitoring of the sites where the gall fly is present has commenced with the aid of university students. Due to political unrest, all work on the psyllid has been postponed.

Funding

Charles Darwin University

Expected completion

December 2007

A chromolaena infestation at Baucau.

Sampling chromolaena at Baucau.

Biological control of mile-a-minute (*Mikania micrantha*) in PNG and Fiji

Objectives

Through the introduction and establishment of biocontrol agents for mikania in Fiji and PNG, this project aims to:

- reduce the impact of mikania to small block holders and plantation owners in areas where the weeds are problems
- reduce the seed load and thus the possibility of further spread into northern Australia
- establish successful biocontrol methods that can be used in northern Australia if required
- promote biocontrol as a safe and successful weed control method
- train scientists in Fiji and PNG in biocontrol methods.

Staff

Michael Day (leader)

Collaborators

Australian Centre for International Agricultural Research (ACIAR)

Secretariat for the Pacific Community (SPC)

Ministry of Agriculture (Fiji)

National Agricultural Research Institute (NARI), Papua New Guinea

Cocoa and Coconut Institute (CCI), Papua New Guinea

Oil Palm Research Association (OPRA), Papua New Guinea

Commonwealth Agricultural Bureau International (CABI), United Kingdom

Roch de Chenon, Consultant, Indonesia

Background

Mikania micrantha is native to the Caribbean and is now a major weed in most countries in the South Pacific and south-east Asia. Mikania is currently confined to north Queensland in the Wet Tropics, where it has the potential to impact significantly on the sugar, horticultural, beef and tourist industries and to spread throughout northern Australia. Mikania is a Class 1 weed in Queensland and is subject to a national cost share eradication program. Increased control of mikania in countries such as PNG and Fiji will reduce the risk of further spread into Queensland. Costs to eradicate the weed from Queensland, if it becomes widely established, will far exceed the cost of preventing it from entering this state. A greater understanding of mikania and its biocontrol agents will boost Queensland's capacity to respond to its incursion if the eradication program is unsuccessful.

Methods

Suitable agents are selected and imported into Fiji based on results of host specificity testing and field observations in other countries. Information on the agents' life history and host range is sent to the collaborators in Fiji and Papua New Guinea, and import permits are requested. For some agents, such as the butterflies, *Actinote anteas* and *A. thalia pyrrha*, additional host testing will need to be conducted in Fiji prior to their field release. For the rust, *Puccinia spegazzinii*, additional host testing will be conducted at CABI in the UK. Reports on the host testing of the agents will be submitted to quarantine authorities in Fiji and PNG. On approval, the agents will be reared for release in both Fiji and PNG.

Field releases of the agents will take place throughout Fiji and PNG where mikania is a problem. Releases of agents will be conducted with the aid of provincial staff, as part of their training in biocontrol activities. Programs will be set up for monitoring of plant density and spread, insect populations, and their impact on the plant.

Progress

ACIAR approved the project in November 2005 and an MOU was signed by all organisations in early 2006. The first payment was made in June 2006. All staff in Fiji were appointed or assigned by February 2006. The quarantine facility at Koronivia Research Station in Fiji was upgraded in February 2006 for the receipt of the butterflies when the project officially starts. Mikania plants from PNG and Fiji and all plants required for host testing the rust were sent to CABI in April 2006.

Funding

ACIAR

Expected completion

June 2009

Mikania flowers, PNG.

Mikania micrantha infestation in East New Britain, PNG.

Actinote sp. butterfly (photo RE McFadyen).

Actinote sp. larvae.

Biocontrol of cat's claw creeper (*Macfadyena unguis-cati*)

Objective

To achieve biocontrol of cat's claw creeper using introduced insect species.

Staff

K. Dhileepan (Leader), Mariano Treviño, Elizabeth Snow (till March 2006), Jade McCarthy (March to April 2006), Alexsis Wilson (January to June 2006), Michelle Rafter (from April 2006), Senaratne Wilmot (AFRS) and Dominique Sigg (March to June 2006).

Cathyn Conrad (CRC summer student, University of Queensland)

Deanna Bayliss (Honours student, University of Queensland)

Collaborators

Hester Williams and Stefan Neser (PPRI, South Africa)

Andrew Lowe (University of Queensland/University of Adelaide).

Background

Cat's claw creeper (*Macfadyena unguis-cati*) is a major weed in coastal Queensland and New South Wales, where it poses a significant threat to biodiversity in riparian and rainforest communities. Cat's claw creeper is a structural parasite and produces stolons and subterranean root tubers. Classical biological control appears to be the most suitable management option for this weed. The management objectives for cat's claw creeper are focused on reducing the rate of shoot growth to limit its ability to climb and smother native vegetation, as well as reducing tuber biomass to minimise the tuber bank.

We propose to use 'plant genotype' and 'climatic' similarities as filters to identify areas for future agent exploration in cat's claw creeper's native range, and plant response to herbivory and pre-release evaluation as 'predictive' filters for agent prioritisation. Agents from areas with similar climatic conditions and from the same plant genotype are more likely to provide effective biological control. Adopting such a systematic approach makes agent selection decisions explicit, allows more rigorous evaluation of agent performance and yields a better understanding of the success and failure of agents in weed biological control.

Methods

Host specificity tests

Biological and host specificity testing was conducted using potted plants in a temperature-controlled (22–27 °C) quarantine insectary at AFRS. The potential host ranges of a leaf-sucking tingid bug, *Carvalhotingis visenda* (Drake & Hambleton) (Hemiptera: Tingidae) and a leaf-tying pyralid moth, *Hypocosmia pyrochroma* (Jones) (Lepidoptera: Pyralidae) were evaluated on the basis of nymphal/larval survival and development, adult feeding and survival, and oviposition preference using choice and no-choice tests involving 38 plant species in 12 families.

Pre-release evaluations

We tested whether the results from glasshouse-based simulated herbivory can be used to prioritise potential biological control agents by evaluating the impact of *C. visenda* in quarantine and assessed the likely effectiveness of the leaf-sucking tingid after its release in the field.

The study was conducted in the quarantine insectary using similar-sized, field-collected *M. unguis-cati* seedlings with a single tuber. Treatments consisted of low density herbivory (2 male and 2 female tingids per plant), high density herbivory (5 male and 5 female tingids per plant) and a control group not exposed to *C. visenda*. There were 30 plants with 10 replicates per treatment. The experiment was conducted over a 7-week period, which is the approximate time of one generation of *C. visenda*. Shoot length, number of leaves and numbers of tingids (adults and nymphs) were recorded on a weekly basis. Plants were harvested at week seven and the following parameters recorded: shoot length, root length, tuber width, number of leaves and leaf chlorophyll content of mature leaves. Plants were dried in an oven at 55 °C, and dry weights of leaf, stem, tuber and root were recorded.

Climate matching

Inferential modelling software, CLIMEX, was used to predict the distribution of climatically suitable habitats for *M. unguis-cati* in both its native and introduced ranges. The 'Match Climates' function of CLIMEX was used to determine: a) the climatic similarity of locations of heavy infestation in some of the introduced ranges with the native range; and b) the climatic similarity of locations in the native range (where potential biological control agents have been surveyed) with introduced ranges. A CLIMEX model was also developed, based on the introduced range of *M. unguis-cati* in Australia, to predict where in the native range exploration for an 'ideal' biological control agent should be prioritised.

Plant genotype matching

In total, 241 samples of *M. unguis-cati* from 31 countries (121 samples from Australia) and seven samples of *M. uncata* from five countries in the native range were used in this study. DNA was extracted using a Qiagen® DNeasy® 96 Plant Kit. A 10 mg segment of dry leaf material was ground to a fine powder using a grinding mill, after which the DNeasy extraction kit protocol was followed. DNA pellets were eluted in 100 µL of the provided buffer. DNA was quantified by running on an agarose electrophoresis gel with a ladder of known DNA concentration. Ten chloroplast microsatellite markers were assessed for their ability to amplify DNA fragments in the two *Macfadyena* species. Polymorphic chloroplast microsatellites were used to estimate haplotype diversity across the species' native ranges, and to subsequently match the genetic signature of the invasive populations to that of their source.

Progress

Host specificity of *C. visenda*

Although adults survived on a few of the non-target plants in no-choice tests, no eggs were laid on any of the non-target plants. There was also no visible feeding damage on any of the non-target plants. Further evidence from chlorophyll estimation studies indicated that there was no feeding-induced chlorosis in any of the non-target plants. Nymphs developed and became adults only on the target weed in no-choice tests and no nymphal development occurred on any of the non-target plants. Adults showed a distinct preference for the target weed in choice tests, and the number of adults on the cage wall was consistently more than on any non-target plants. No adults were evident on any non-target plants at the end of the trial. Although very few eggs were laid on non-target *Graptophyllum excelsum* (Acanthaceae) plants in the choice trials, all nymphs died soon without further development. No choice demography studies on *G. excelsum* confirmed that a viable population could not be sustained on this non-target plant.

The results overall suggest that *C. visenda* is specific to *M. unguis-cati* and it does not pose risk to any of the non-target plants tested. Host specificity tests conducted in South Africa further support this.

Host specificity of *H. pyrochroma*

The host specificity trials conducted in Australia supplement and support South African studies, which indicate that the leaf-tying moth, *H. pyrochroma* is a highly host specific insect, which does not pose risk to any non-target plants in Australia. Larvae did not survive or complete development on any the plants except for the target weed in no-choice tests. Oviposition and larval development was evident only on cat's claw creeper in multiple choice oviposition preference tests. The results overall suggest that *H. pyrochroma* is specific to *M. unguis-cati*.

Pre-release evaluations

A single generation of *C. visenda* has the potential to reduce leaf chlorophyll content significantly (Figure 1.1), resulting in reduced plant height (Figure 1.2), number of leaves (Figure 1.3) and leaf biomass (Figure 1.4). However, the impact of one generation of tingid herbivory on below-ground plant components, including roots and tubers, was not significant (Figure 1.4). These findings are consistent with results obtained from a simulated herbivory trial, highlighting the potential role of simulated herbivory studies in agent prioritisation. Ongoing study over several generations of tingids should provide a better insight into the response of different plant modules to long-term foliar herbivory.

Climate matching

The 'Match Climates' function of CLIMEX revealed an area covering northeast Argentina, south Brazil, Uruguay and Paraguay in the native range as having high (> 0.6) match indices to sites of heavy *M. unguis-cati* infestation in introduced locations. Investigation of where best to find a biological control agent in the native range revealed an area slightly north of that depicted by the 'Match Climates' exercise and, surprisingly, the coastal zone of Venezuela. The relative consistency of the area in the native range that was best matched to the introduced ranges, suggests CLIMEX is a useful tool for prioritising areas for biological control agent exploration.

Plant genotype matching

In total, 34 haplotypes were identified for cat's claw creeper, which was characterised by high haplotype diversity across the native range. In contrast, over 90% of samples collected from countries where this species has been introduced belonged to a single haplotype. This haplotype matched a sample collected from Paraguay, and similar haplotypes were also identified in the southern extent of the species' native range, from Peru, Bolivia, Paraguay and Argentina. These results strongly suggest that samples of the cat's claw creeper were initially collected from these regions before being cultivated and distributed around the world.

Funding

Land Protection Fund

CRC Australian Weed Management

Burnett Mary Regional Groups (Qld)

Northern Rivers Catchment Management Authority (NSW)

Logistical support

Burnett Mary Regional Groups (Qld)

The University of Queensland

Missouri Botanic Gardens (USA)

Illinois Natural History Survey (USA)

Expected completion

Ongoing

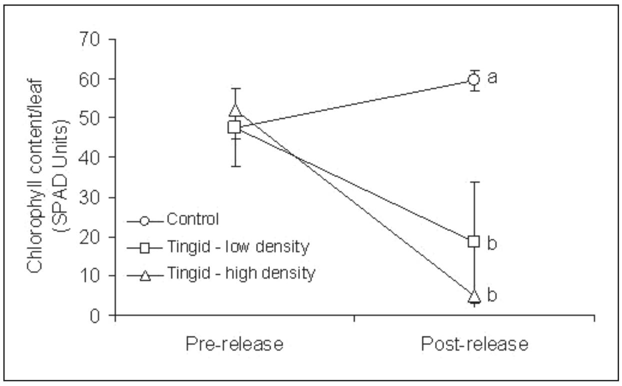


Figure 1.1: Leaf chlorophyll content (Mean ± SE per leaf) of cat's claw creeper seedlings prior to (week 0) and following (week 6) tingid herbivory. Tukey Test: means with the same letter are not significantly different (P › 0.05).

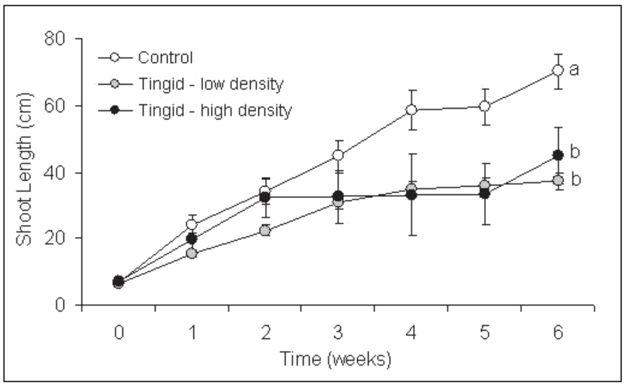


Figure 1.2: Changes in the shoot length (Mean ± SE) of cat's claw creeper seedlings over a 6-week period with and without tingid herbivory. Tukey Test: means with the same letter are not significantly different (P › 0.05).

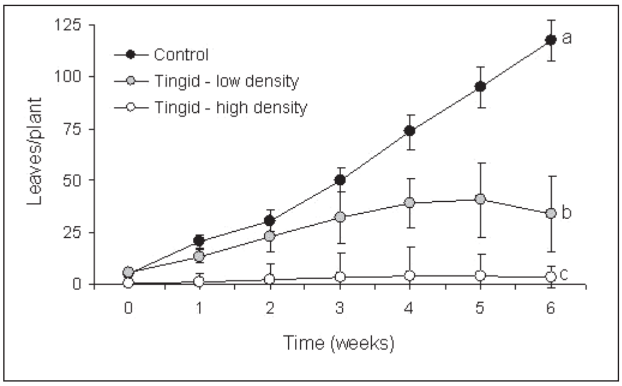


Figure 1.3: Changes in the number of leaves per plant (Mean ± SE) over a 6-week period with and without tingid herbivory. Tukey Test: means with the same letter are not significantly different (P › 0.05).

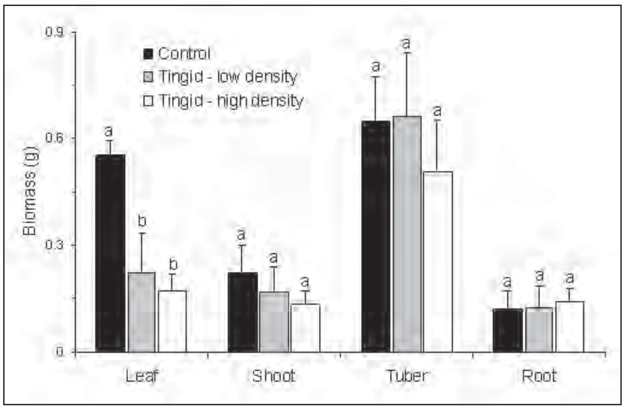


Figure 1.4: Impact of tingid herbivory on plant biomass (Mean + SE). Tukey Test: for each plant parameter, means with the same letter are not significantly different (P › 0.05).

Cat's claw poses a significant threat to biodiversity in riparian and rainforest communities.

Cat's claw creeper is able to climb natural and human-made structures.

Mass rearing and release of biocontrol agents for prickly acacia (*Acacia nilotica*)

Objectives

- To mass rear and release approved biocontrol agents.
- To determine the impact of these agents on prickly acacia under field conditions.

Staff

K. Dhileepan and Bill Palmer (AFRS)

Catherine Lockett, Margie Robinson and Kelli Pukallus (TWRC)

Background

The leaf-feeding geometrid, *Chiasmia assimilis* was introduced into Australia from South Africa in 2002. Over 75 000 adults were released at both coastal and inland sites before mass rearing and release ceased in September 2004. Establishment at all coastal release sites was confirmed within the first year.

Infestations of prickly acacia between Home Hill and Bowen were heavily attacked by *C. assimilis* in early March 2005. Landholders reported hundreds of small moths and caterpillars together with large areas of partial to total defoliation. The insect continued to cause damage at 'Inkerman' into late June 2005, with large numbers of adults present at the site. Sampling of caterpillars and feeding damage commenced in March 2005 at the original coastal release site, 'Ashfield' and is conducted at 6-weekly intervals.

Field releases of the latest biocontrol agent, *Cometaster pyrula* commenced in September 2004 and approximately 6000 larvae and 380 moths were released over a 10-month period at 'Ashfield'.

Methods

After approval for release from quarantine, agents are mass reared at the Tropical Weeds Research Centre and released throughout the range of the weed in Queensland. Ongoing monitoring determines establishment and any appreciable effect of the agent on the plant.

The impact of defoliation on the vigour and fitness of prickly acacia is not known. It has been suggested that seedlings and juveniles are the most susceptible life stages to target for control. An insecticide exclusion trial was conducted on 'Inkerman' over a five-month period to quantify the impact of *C. assimilis* on seedling survival and growth under field conditions. Similar sized seedlings 5–6 weeks old (n = 160) were used. For each seedling, shoot length, root length, basal diameter, number of leaves and total wet weight were recorded before assignment to one of two main treatments (exposed to biocontrol agents and excluded from biocontrol agents). Ten seedlings placed in a large plastic container were treated as one replicate.

A total of 16 plastic containers were used in this trial. Eight containers were exposed to biocontrol agents. Plants in the remaining containers were protected by using the insecticide Folimat (2 g kg^{-1} Omethoate). Four containers of each type (exposed and protected) were placed underneath the prickly acacia canopy and the remaining containers were placed in open sun away from the canopy. The inclusion of under and away from canopy sub-treatments was intended to determine whether insect damage occurs more in shaded than unshaded conditions. The trays containing seedlings were watered at weekly or fortnightly intervals as required. Plants were inspected regularly and numbers of larvae and eggs were recorded, together with estimates of the percent defoliation caused by the insects. Measurements of plant height, basal diameter, number of leaves and number of shoots were also recorded at regular intervals. The trial will finish in early August 2006 and at this time dry weights of all remaining seedlings will be recorded.

A second, joint experiment between AFRS and TWRC, designed to investigate the response of prickly acacia to simulated herbivory, commenced at TWRC in early 2006. The aim of the experiment is to identify weaknesses of the weed that can be exploited and provide a focus in the future search for effective agents. While seedlings and juveniles have been suggested as suitable targets for biocontrol, no information is available on the plant part(s) (i.e. leaf, shoot and root, in isolation or in combination) most susceptible to herbivory.

Similarly sized seedlings 16–18 weeks old (n = 360) were used in the experiment. For each seedling, shoot length, basal diameter, number of leaves, root length, and total wet weight were recorded before assignment to one of the following six main treatments: defoliation (100%), shoot damage (30%), root damage (30%), defoliation plus root damage, shoot plus root damage and defoliation plus shoot damage. Within each main treatment, four sub-treatments were imposed. These were: no herbivory, a single bout of herbivory, two bouts of herbivory and three bouts of herbivory.

Progress

Field releases of the latest biocontrol agent, *C. pyrula*, continue. Releases over the past year were concentrated at three sites: 'Ashfield' and 'Inkerman' on the coast and 'Mona Vale', between Prairie and Hughenden in the west. Between September 2005 and May 2006, 15 releases totalling over 12 900 larvae and 500 moths were made on 'Ashfield'. 'Inkerman' received four releases totalling over 1100 larvae and 'Mona Vale' five releases totalling over 4700 larvae and 190 moths. Establishment of this insect has not been confirmed, although field released larvae have persisted on trees, feeding damage has been observed and small numbers of pupae have been recovered from soil beneath trees. Releases will continue into the coming summer.

The leaf-feeding geometrid, *C. assimilis* was found for the first time at two western sites, 'Mona Vale' and the Hughenden showgrounds in the 2005–06 summer. Numbers increased at both sites during late summer and autumn. Feeding damage was evident on trees, although to a lesser extent than that seen at coastal sites. Samples of both larvae and adults have been collected and will be forwarded to South Africa for confirmation of identification. Western areas will be monitored throughout the coming summer for further signs of establishment and spread of the agent.

C. assimilis was found again in large numbers at all coastal sites during the 2005–06 summer. Large areas of defoliation were again noted, particularly on 'Inkerman' near Home Hill.

No analysis of data from the defoliation trial has taken place, although initial observations confirmed the presence of both eggs and larvae of *C. assimilis* on unsprayed seedlings.

Single and double herbivory treatments have been completed at TWRC. The final herbivory treatment is due in October 2006 and the experiment will be finished two months later.

Funding

Queensland Government

Expected completion

Ongoing

Bioevaluation of rubber vine (*Cryptostegia grandiflora*): impacts of biocontrol agents on rubber vine and associated ecosystems

Objectives

- To assess the impact of the established biocontrol agents (rust, *Maravalia cryptostegiae* and moth, *Euclasta gigantalis*) on establishment, growth and survival of rubber vine plants and associated plant communities under a range of conditions of climate, land type and management.
- To establish and document a system of monitoring that can be applied consistently over a lengthy period of time.

Staff

Wayne Vogler (TWRC)

Background

Permanent 50 m x 4 m transects were established at two locations (Ten Mile Creek and Anabranch) near Charters Towers in 1991, prior to the release of the rubber vine biocontrol agents. Each transect was oriented along an environmental gradient provided by a slope running away from a creek and sampled a range of rubber vine densities. The locations of all woody plants on transects were recorded and the diameters of stems at 20 cm above the ground were measured. Canopy cover, foliage cover and height of rubber vine plants were recorded. These transects provided base data, prior to agent release, against which impacts of the biocontrol agents could be assessed.

Methods

Monitoring of vegetation at several sites commenced in spring 1997, post biocontrol agent release. The sites are spread over the geographical range of rubber vine and represent a range of landforms, soil types and management regimes. At Ten Mile Creek and

Anabranch, additional transects of the same design as those established in 1991 were set up. At Ten Mile Creek one is a replicate of the original transect, while the other two are on sites carrying somewhat different vegetation. At Anabranch the one additional transect is a replicate of the 1991 transect.

Also at Ten Mile Creek five 8 m x 8 m fenced exclusion zones have been established to exclude stock. Transects and exclusion zones assess the impacts of biocontrol agents with and without grazing and under a range of conditions. All woody plants on transects and in exclusion zones are mapped and tagged. Seedlings are also mapped. Specimens are collected for identification of all species.

The following variables are assessed during June/July each year:

- stem diameter of woody perennials at 20 cm above the ground
- height of the bulk of the rubber vine in each plot and maximum height of whips
- flower and pod production of rubber vine
- rust and moth infestation of rubber vine
- infestation of rubber vine climbing on other woody plants
- soil seed banks (rubber vine).

Serial photographs are being taken at clearly defined photo-points once a year.

Progress

The near average wet season during 2005–06 has resulted in significant rust infection across all sites except Hughenden, where rust was present but not at damaging levels. Extensive defoliation occurred at all sites except Hughenden due to either rust infection or Euclasta larvae. Some pods have been produced in the vicinity of research sites and on transects at Ten Mile Creek and Hughenden, even though rust infection was significant at all sites except Hughenden. This is most likely due to the late rust infection or, in the case of the Hughenden site, the lack of significant rust attack.

There was substantial rubber vine mortality at Anabranch, most likely due to the combined effects of previous rust infection and the low rainfall over the past few years. The remaining sites had only slight or no reduction in plant numbers during the past year (Table 1.1), due to the late rust infection and previous years of low rust infection owing to low rainfall. The plant deaths at Hughenden were due to the site being burnt late in 2005. No new seedlings were observed at any site despite seed production during 2005–06 and near average rainfall.

The lack of new seedlings at all sites is due to the depletion of the rubber vine soil seed bank (Table 1.2) resulting from very few seeds being produced and the short period of seed survival in soil. The re-occurrence of pods on or near transects this year is due to late or nil rust infection and near average rainfall and indicates that early rust infection is necessary to eliminate seed production. Substantial numbers of Euclasta larvae were observed at Ten Mile Creek but not at any other site. This is the first significant infestation of Euclasta for more than five years and indicates that while egg parasitism was largely responsible for reducing Euclasta to extremely low levels, the moth is still present and will from time to time build up to damaging levels.

Funding

Queensland Government

Expected completion

2007

Table 1.1: Change in number of rubber vine plants on transects at eight sites

	Site							
Sampling time	**Anabranch**	**Ten Mile Creek**	**Dalrymple**	**Mt Hay**	**Delta Downs**	**Strathmore**	**Wrotham Park**	**Hughenden**
Spring 1997	435	512	188	159	102	53	37	NA
Spring 1999	390 (-45)*	413 (-99)	173 (-15)	169 (+10)	76 (-26)	54 (+1)	14 (-23)	NA
Spring 2000	275 (-115)	227 (-186)	152 (-21)	125 (-44)	51 (-25)	NA	NA	NA
Spring 2001	250 (-25)	193 (-34)	141 (-11)	93 (-32)	31 (-20)	NA	NA	NA
Winter 2002	214 (-36)	141 (-52)	116 (-25)	81 (-12)	23 (-8)	NA	NA	58
Winter 2003	195 (-19)	121 (-20)	102 (-14)	70 (-11)	22 (-1)	NA	NA	58 (0)
Winter 2004	108 (-88)	79 (-42)	101 (-1)	59 (-11)	19 (-3)	NA	NA	58 (0)
Winter 2005	35 (-73)	78 (-1)	99 (-2)	46 (-13)	19 (0)	NA	NA	58 (0)
Winter 2006	17 (-18)	78 (0)	97 (-2)	43 (-3)	18 (-1)	NA	NA	55 (-3)

* Numbers in brackets indicate change in number of plants between years.

Table 1.2: Germinable soil seed bank (seeds m^{-2}) of rubber vine at seven sites

	Site						
Sampling time	**'Anabranch'**	**'Ten Mile Creek'**	**'Mt Hay'**	**'Delta Downs'**	**'Strathmore'**	**'Wrotham Park'**	**Hughenden**
Spring 1999	0	0.4	1.6	0	5.6	0	NA
Spring 2000	0	0	0	0.4	NA	NA	NA
Spring 2001	0	0	0	0	NA	NA	NA
Spring 2002	0	0	0	0	NA	NA	NA
Spring 2003	0	0	0	0	NA	NA	0
Spring 2004	0	0	0	0	NA	NA	0
Spring 2005	0	0	0	0	NA	NA	0
Spring 2006	0	0	0	0	NA	NA	0

Biological control of parthenium (*Parthenium hysterophorus*)

Objectives

- To monitor the field establishment and persistence of the parthenium summer rust.
- To monitor the field establishment and population build-up of the parthenium clear-wing moth and the parthenium stem-galling weevil.

Staff

K. Dhileepan, Mariano Trevino (AFRS)

Catherine Lockett (TWRC)

Background

The summer rust, *Puccinia melampodii*, an agent most suited to areas with hot and dry weather conditions, was introduced from Mexico in 1999. Since then, releases have been made at more than 50 parthenium-infested sites (Figure 1.5). But the field establishment status of this rust is not known. The clear-wing moth, *Carmenta ithacae* is native to Mexico and was first released in Queensland in September 1998. A total of 12 600 moths were released between 1998 and 2002. However, the establishment status of this agent is not known. The stem-galling weevil, *Conotrachelus albocinereus* was released in Queensland in November 1995. Since then over 15 000 weevils have been released, but the establishment status of this species is not known.

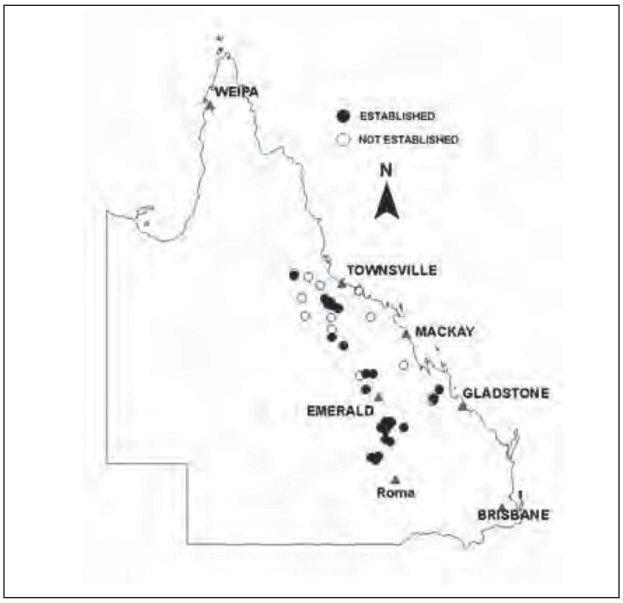


Figure 1.5: Summer rust release sites in Queensland.

Methods

Parthenium sites in central Queensland (Hutton Creek in Timor Station; Moolayember Creek; Albinia National Park; Springsure; Gordon Road between Emerald and Capella; Clermont; Wycarbah and Delargum) and in north Queensland (Cardigan Station and Plain Creek) were sampled and the incidences of *P. melampodii*, *C. ithacae* and *C. albocinereus* were recorded. Sites in central Queensland were sampled during 3–7 April 2006.

At each site, 5 x 0.25 m² quadrats were sampled randomly and the following parameters recorded: number of parthenium plants, number of plants with rust, the number of leaves with rust in each plant, and the number of *C. ithacae* and *C. albocinereus* larvae and pupae per plant. In north Queensland sampling was carried out only for *P. melampodii*, in February 2006 and May 2006. Five sites were sampled on each of the selected properties. In each site, 5 x 1 m² quadrats were sampled, with the following parameters recorded: total number of parthenium plants, number of plants with rust infection, and proportion of leaf area (%) with rust infection.

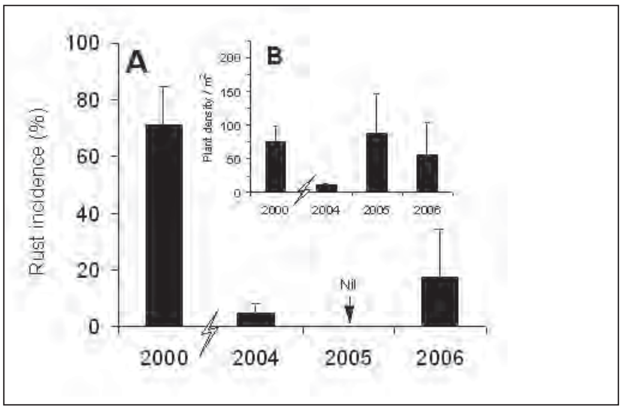


Figure 1.6: Seasonal variation (mean ± SE) in summer rust incidence (A) and parthenium abundance (B) at Plain Creek.

Progress

Parthenium summer rust

At Plain Creek in north Queensland, the level of rust incidence declined from 71 ± 14% in 2000 to 4.76 ± 3.44% (mean ± SE) in 2004. Rust incidence was not evident in the summer of 2005–06. Though the summer rust reappeared in mid-autumn of 2006 (Figure 1.6), the proportion of leaves with rust remained low (8.7 ± 5.1%). The changes in rust incidence levels appear unrelated to parthenium weed availability (Figure 1.6). At Cardigan Station in north Queensland no summer rust incidence was evident during the 2005–06 summer season.

In central Queensland, the rust was evident in only in one site (Moolayember Creek). The proportion of plants with summer rust at this site remained very low (mean ± SE = 26 ± 19%; n = 24). The density of parthenium plants at this site was 4.8 ± 1.8 plants 0.25 m^{-2}.

Clear-wing moth

C. ithacae was detected only in one of the eight sites surveyed (Wycarbah) in central Queensland. At this site, all quadrats sampled showed sign of *C. ithacae* infestation. A total of eight larva and two pupae were collected. All larvae and pupae collected have turned into adults and have been positively identified.

Stem-galling weevil

C. albocinereus was detected only at Moolayember Creek and the proportion of plants with this weevil remained low (mean ± SE = 26 ± 11.3%; n = 20). Only three larvae were recovered from two of the five quadrats sampled.

Funding

Queensland Government

Logistical support

Nil

Expected completion

Ongoing

Biological control of weedy sporobolus grasses (*Sporobolus* spp.)

Objectives

- To achieve biological control of the five weedy sporobolus grasses (*Sporobolus pyramidalis*, *S. natalensis*, *S. fertilis*, *S. africanus* and *S. jacquemontii*) infesting areas of Australia.
- To determine the biology and host specificity of two organisms: the leaf smut, *Ustilago sporoboli-indici* and the stem wasp, *Tetramesa* sp., which have been identified as potential biological control agents.
- To propose the release of *U. sporoboli-indici* and *Tetramesa* spp. in Australia should they prove to be host specific.

Staff

Bill Palmer (Leader), Wilmot Senaratne (AFRS)

Collaborators

Roger Shivas (DPI&F)

Bryan Simon (EPA)

Mark Laing, Mike Morris and Kwasi Yobo (University of KwaZulu-Natal)

Arne Witt and Ayanda Nongogo (Plant Protection Research Institute, South Africa)

Methods

Application was made to have the weedy sporobolus grasses approved as targets for biological control by the Natural Resource Management Standing Committee.

A contract was negotiated with Prof. Mark Laing of the University of KwaZulu-Natal to undertake biology and host specificity studies of the leaf smut, *Ustilago sporoboli-indici*, which had previously been found in South Africa to be infecting the three African species of the weedy sporobolus grasses.

The studies on the smut will be divided into two phases. In the first phase the smut will be cultured and methods for infecting plants investigated. The smut will then be tested against Australian populations of all the weedy sporobolus grasses to determine their susceptibility, as well as against a small number of Australian native *Sporobolus* spp. The results of these studies will determine whether full host testing leading to release in Australia should proceed. All studies will be conducted overseas in South Africa.

The studies on the stem wasp will also be divided into two phases. In the first phase, which will be undertaken in South Africa, it will be necessary to determine whether the insect can be reared in the laboratory. A contract was negotiated with Mr Arne Witt of the Plant Protection Research Institute, Pretoria, to undertake this phase of the work. If the insect can be successfully reared and shipped, it will be imported into quarantine facilities at AFRS, where full host testing of the insect will then be undertaken.

Progress

The application to have the weedy sporobolus grasses approved as targets for biological control was supported by Australian Weeds Committee but has still not been finalised by Natural Resource Management Standing Committee.

Study of the leaf smut, *U. sporoboli-indici* commenced in January 2005 at the University of KwaZulu-Natal. Samples of the smut were collected from the field and isolated on artificial media in the laboratory. Storage methods for the smut were evaluated. Agar blocks carrying smut mycelia were stored under double-sterilized distilled water. The viability of basidiospores stored on silica gel was also evaluated.

Pathogenicity studies were completed on Australian populations of *S. pyramidalis*, *S. natalensis*, *S. africanus*, *S. fertilis* and *S. jacquemontii*, using samples collected and shipped from AFRS. Infections were observed on *S. pyramidalis*, *S. natalensis*, *S. africanus* and *S. fertilis* but not on *S. jacquemontii*. This result was of particular interest because *S. jacquemontii* is the only species of American origin. The result was interpreted as a promising indication that the smut could discriminate between *Sporobolus* spp. and therefore may be sufficiently host specific for biocontrol purposes.

Seed samples of 10 native *Sporobolus* spp. were collected from various parts of Queensland. The samples were tested for germinability and grass specimens associated with the collections were submitted to the Queensland Herbarium for expert identification. The samples were then shipped to South Africa, where they were utilised for testing of the smut.

Studies to assess potential smut/herbicide interactions were also commenced.

Studies on the stem wasp commenced in December 2006 at the Plant Protection Research Institute. A site near Modimolle in Limpopo Province, South Africa, was selected as the primary site for ascertaining the phenology and impact of *Tetramesa* sp. on *S. pyramidalis*. This site was selected because there was an abundance of *S. pyramidalis* and *Tetramesa* spp. (based on the number of emergence holes in grass culms). *S. pyramidalis* culms and inflorescences were collected at monthly intervals from December 2005. The number of larvae and pupae in culms remained relatively low until April, after which larvae became much more abundant. Attempts to rear larvae on an artificial medium were unsuccessful when the diet became contaminated with a fungus. However, it did not appear that the larvae were feeding before the contamination and larvae with and without access to diet survived equally well. There was also some suggestion that the larvae enter a winter diapause.

Funding

Rural Lands Protection Trust Fund

Meat and Livestock Australia

Expected completion

2008

A giant rats tail grass (*Sporobolus pyramidalis*) infected with smut.

Biocontrol of Madeira vine (*Anredera cordifolia*) with insects

Objective

To achieve biocontrol of Madeira vine using introduced insect species

Staff

WA Palmer, K Dhileepan (AFRS)

Collaborators

Stefan Neser and Liame van der Westhuizen (PPRI)

Methods

Exploratory surveys were conducted by Stefan Neser and his team in southern Brazil and northern Argentina to identify potential biocontrol agents for Madeira vine. Suitable agents were imported into quarantine in South Africa for host specificity testing. These insects will then be made available to Pest Management Research for supplementary host testing in quarantine facilities at AFRS. Insects thought to be sufficiently host specific will be approved for release, mass reared and released at appropriate sites in southern Queensland and northern New South Wales.

Progress

- An application has been made to have Madeira vine approved as a target for biological control by Natural Resource Management Standing Committee.
- The evaluation of the leaf beetle, *Phenrica* sp. has been completed in South Africa. It was considered adequately host-specific for South Africa, although three species of Basellaceae (including Madeira vine) and one species of Portulacaceae supported larval development.
- The second chrysomelid, *Plectonycha correntina* has also been evaluated in Argentina and publication of the results is anticipated.

Funding

Queensland Government

Expected completion

2009

Investigations resulting from the non-target attack of *Aconophora compressa*

Objective

To investigate various aspects of the non-target attack of *Aconophora compressa*, including its host range, susceptibility to high temperature, biotic control factors and treatment by insecticide.

Staff

Bill Palmer (Leader) K Dhileepan, Michael Day, Mariano Trevino, Liz Snow (AFRS)

Collaborators

Judy King, Manon Griffiths, Pam Bowles, Wayne Thompson (DPI&F)

Andrew Manners (CRC Australian Weed Management)

Methods

A. compressa is a membracid bug released for the biological control of lantana, but has attacked a non-target host, fiddlewood (*Citharexylum spinosum*), and other plants. A comprehensive research program was implemented in 2003–04 to address the important issues. The program on *A. compressa* provided scientific information on the actual and potential impacts of the bug that could be conveyed to the community through associated communication and extension activities. It was designed to assist on-ground management and address negative perceptions of the community. It also assisted decision making by providing the department with risk assessment tools, addressed public concerns and developed improved protocols for testing and releasing biocontrol agents.

Progress

A replicated trial was conducted to evaluate the relative suitability of lantana and the native mangrove species, *Avicennia marina* and *Aegiceras corniculatum* as hosts for *A. compressa*. Unfortunately, heatwave conditions resulted in the bug's populations being drastically reduced in October 2005. *A. compressa* was able to complete its development on all three species, but it was thought very unlikely that the insect posed any risk to either mangrove species.

Observations were made throughout 2005 and 2006 on the abundance of *A. compressa* on fiddlewood. Populations had previously crashed after heatwaves in February 2004, with only remnant populations surviving in cooler areas such as the bay side suburbs of Brisbane, Mt Tambourine and Byron Bay. Although there was again a reduction in population caused by summer heat, populations recovered so that by June 2006 the insect was again widespread and sometimes in significant populations. It was found at several new areas, including Toowoomba.

A PhD study into the behavioural basis for non-target selection and utilization commenced in 2004. In no-choice tests, adult survival was statistically equivalent across four verbenaceous plant taxa tested: fiddlewood, lantana and duranta (var. 'geisha girl' and var. 'sheena's gold'), but much lower on the two non-verbenaceous host plants: jacaranda (Bignoniaceae) and *Myoporum acuminatum* (Myoporaceae). Significantly more eggs were deposited on fiddlewood than on lantana, 'geisha girl' and 'sheena's gold', and none were observed on jacaranda or *M. acuminatum*. Nymphal development was fastest on fiddlewood followed by lantana, 'geisha girl', and 'sheena's gold'. Nymphal survival across verbenaceous host plants ranged from 42% to 65%, but differences were not significant. *A. compressa* can survive and reproduce on lantana and build up to high numbers in laboratory settings but this is rarely observed in the field.

Funding

Rural Lands Protection Trust Fund

Queensland Department of Primary Industries and Fisheries

CRC Australian Weed Management

Expected completion

2006

Biological control of mother-of-millions (*Bryophyllum* spp.)

Objective

To achieve biological control of the poisonous weed, mother-of-millions, by introducing and releasing exotic insect species or pathogens.

Staff

Bill Palmer (leader) Wilmot Senaratne, AFRS

Methods

The extent of the weed problem to Queensland stakeholders and its amenability to a solution by biological control was assessed. Faunistic surveys of *Bryophyllum delagoense* and closely related species were undertaken in areas where the plant occurs naturally in Madagascar and southern Africa and potential biocontrol agents were identified from these surveys. The biology and host range of these identified agents were studied in both the South African Field Station and in the quarantine facility of AFRS. Upon receiving approval to release, agents considered to be safe will be mass reared and released throughout the range of the weed in Queensland. Releases will be monitored to determine establishment and any appreciable effect of the agent on the plant.

Progress

Earlier research has determined the biology and host range of four potential biocontrol agents. Because *Osphilia tenuipes* and *Alcidodes sedi* (Coleoptera: Curculionidae) can utilise *Kalanchoe blossfeldiana* and *Echeveria* spp. as hosts, it would be necessary to release these, and most probably the other two insects [*Eurytoma* sp. (Hymenoptera: Eurytomidae) and *Rhembastus* sp. (Coleoptera: Chrysomelidae)] as declared agent organisms under the *Biological Control Act 1987*. Additionally, all *Bryophyllum* spp. would need to be declared target organisms under the Act. Approval under this Act requires the unanimous support of all members of Ministerial Council. Processes for proceeding under this Act with the support of state and federal governments are being investigated. Cultures of *O. tenuipes* and *A. sedi* are presently being maintained in quarantine pending a decision on using the Act.

The exotic thrips, *Scirtothrips aurantii* which appeared in Queensland in 2002, has now spread to most of southern Queensland, including the Darling and Western Downs. In some cases this thrips has caused noticeable damage to mother-of-millions.

Funding

Rural Lands Protection Trust Fund

NSW Department of Land and Water Conservation

Various shire councils

Expected completion

2007

Development of proposal to use the *Biological Control Act 1987* for mother-of-millions

Objectives

- To produce risk, economic, stakeholder and partner analyses for the mother-of-millions weed problem.
- To support any application under the Biological Control Act through the various processes of the Act.
- To determine whether the Biological Control Act can be used to assist weed management research projects.

Staff

Bill Palmer (leader), Martin Hannan-Jones, Wilmot Senaratne (AFRS)

Jim Thompson, Tony Pople, Tessie Tumaneng-Diete, Jef Cummings, Moya Calvert (Land Protection)

Chris Curteis (Economic Services)

Collaborators

Janet Barker, Adam Logan (Queensland Murray Darling Committee), Helen McLaren (Murilla Landcare) Jane Bromley, Hugh McMicking, Keith and Judy Richardson (landholders)

Background

Mother-of-millions has environmental, social and economic impacts. It is toxic to cattle and so can have a substantial economic impact to the beef and dairy cattle industry in eastern Australia. Environmental costs of the weed include competition with native plants, loss of food plants for native herbivores and loss of amenity value. All potential biocontrol agents for mother-of-millions are capable of attacking very closely related, exotic, ornamental plants such as *Kalanchoe blossfeldiana* and *Echeveria* spp.

When conflicts of interest exist with the biological control of a weed, Australian proponents for the control can have both targets and agent organisms declared under biological control legislation. This means that they are not legally liable for identified adverse effects and legal injunctions cannot be brought to prevent releases of the agent. The process involves making an application to the Natural Resource Management Ministerial Council (NRMMC). If NRMMC by unanimous agreement supports the application, procedures are then undertaken under the auspices of a biological control authority to ascertain the views of all stakeholders and to determine the relative benefits and costs that might be attributed to the proposed biological control. If, on balance, the benefits clearly outweigh costs, NRMMC may by unanimous opinion approve the declaration of target and agent organisms under the Act.

The process of using the Act is recognised as being expensive. Costs have generally been considered to range from $200 000 to $750 000 but there is little precedent or corporate memory within agencies that have previously used the Act on which to estimate costs accurately. This project aims to clarify procedures and expenses relating to the use of the *Biological Control Act 1987* through the mother-of-millions case study.

Methods

A multidisciplinary project team was assembled to gather and assess relevant data. Members of the project team visited badly affected areas on the Western Downs to improve their understanding of the problem.

Progress

The following information was derived to contribute to any decision to use the Act.

The species is widespread, already spanning throughout Queensland, with a potential to spread much further into New South Wales. Major infestations exist in southeast Queensland and northeast New South Wales. The potential cost in lost production to the beef and dairy cattle industries in both New South Wales and Queensland is about $85 million per year. Based on the 2005 distribution for mother-of-millions, the opportunity cost in lost production to the beef and dairy cattle industries in Queensland was estimated at about $20 million per year. The current cost of weed control in Queensland by local governments and private landholders is $1.5 million. This cost is likely to increase to $2.3 million if mother-of-millions realises its potential distribution in both New South Wales and Queensland.

A biological control program has the highest potential for controlling mother-of-millions in Australia. The effectiveness of two weevils, *Osphilia tenuipes* and *Alcidodes sedi,* has been investigated by a conceptual model (using CLIMEX). It has been found that:

- both weevils should be able to flourish over most of the areas where mother-of-millions is a weed
- both insects are damaging to populations of mother-of-millions in their native habitat and in the laboratory, being capable of killing potted plants in the latter situation
- populations of 1 adult beetle to 2–3 plants should result in very good biological control.
- both insects should build up to damaging numbers as they are relatively fecund, have long-lived adult stages, have very few close relatives in the Australian fauna (reducing the chances of parasites transferring to them) and have population increases of 5–10 fold per generation.

The available evidence about range, average abundance, and effect per insect therefore leads to the conclusion that there are good prospects that both insects would bring about biological control of the weed and that the costs of putting them through the Biological Control Act are justified.

Laboratory trials demonstrated that although no native Australian flora would be attacked by the weevils, these insects were capable of attacking other closely related crassulaceous plants, such as the commercially important ornamental *Kalanchoe blossfeldiana* and *Echeveria* spp. Therefore, a risk analysis was undertaken, comprising risk assessment, risk management, risk communication and comparative risk. The findings include:

- wholesale nurseries are most likely to be affected but the level of risk is moderate
- the use of several management procedures would lessen both the likelihood of attack and consequences of any attack; these include good hygiene, ensuring any stock introduced to the nursery is insect free and an insecticide application

- effective risk communication is possible, including public advertising, workshop/field days to a relatively small number of major players and appropriate web-based information and fact sheets
- it is unlikely that biological control could be achieved without use of the presently identified agents, although the South African insect, *Scirtothrips aurantii*, which has appeared in Queensland since 2002, may have some effect. Other forms of control such as burning or spraying have not been effective in reducing the overall weed problem.

The economic aspect of the investment strategy aims to ensure that outcomes of biological control provide maximum net benefits to society. The estimated value of kalanchoe and echeveria production in Queensland is about $2.1 million, which is less than 1% of the total nursery industry output of $502 million in 2004–05 prices. Economic loss to the nursery trade will probably be appreciably less than this total value because if consumers discriminate against the non-target species affected by the biological control agents, they are highly likely to purchase alternative plants. To the degree that the substitute plants provide the same level of economic value added, there would be no meaningful economic impact, if both producers and consumers have made the transition to substitute species.

If no biological control is undertaken, it is likely that indicative production losses in the cattle industry of about $20 million dollars per year could escalate to about $60 million dollars per year when the potential distribution of mother-of-millions is reached. This is in addition to the annual weed control costs of about $1.5 million borne by private landholders, NRM bodies and local and state governments. These costs could be averted or significantly reduced by a successful biological control program.

It was estimated that the cost of an application to use the Biological Control Act for mother-of-millions would be approximately $225 000 and that 45% of this total cost would consist of departmental salaries. Because decisions are required from NRMMC on three occasions, it is unlikely that the process would be completed in less than two years.

Funding

Rural Lands Protection Trust Fund

Expected completion

2008

Chapter 2: Weed research ecology

Ecology of bird-dispersed weeds

Objective

To better understand weed seed dispersal by birds in order to design more effective integrated weed management strategies.

Staff

Gabrielle Vivian-Smith (Leader), Carl Gosper, Eve White and Dane Panetta (AFRS)

Methods

Bird-dispersed weeds constitute a complex weed problem for land managers. There is little quantitative information regarding the dispersal process and rates and patterns of weed spread. Furthermore, management strategies specific to this unique mode of dispersal are only in the early stages of development.

This project is now investigating patterns of weed seed dispersal by birds with the aim of identifying the major 'sources' and 'sinks' for propagules that can be targeted through integrated weed management. Major current and future focus areas for the study include:

- determining existing knowledge and developing novel management approaches, including the application of fruit functional traits to identify replacement plants suitable for use in habitat restoration
- plant fruit traits: analysis of morphology, phenology, nutritional quality and display characteristics
- recruitment dynamics and seed bank persistence for selected bird-dispersed weed species
- assessing the potential for a popular, fleshy-fruited garden species to become an environmental weed in south-east Queensland
- Determining whether it is possible to identify the areas of weed infestation with the greatest dispersal effectiveness, based on plant and patch characteristics (i.e. major 'sources').

The project is located in southeast Queensland, where a wide variety of bird-dispersed environmental weeds exist.

Progress

Existing knowledge and novel management approaches

A review paper was developed in collaboration with a wide variety of international contributors (Buckley et al. 2006, *Journal of Applied Ecology*). This investigated the functional group approach to the problem of invasive plants and highlights other aspects, such as the application of modelling approaches to the problem and the conservation concerns relating to frugivore species that are increasingly reliant on fruits of invasive plants.

Plant fruit traits

We analysed fruit trait data, for traits known to influence fruit consumption, across a wide range of invasive species in south-eastern Queensland. The results indicated that many bird-dispersed invasive plants produce fruits throughout the year, with most found to be small (<15 mm in diameter), watery, high in sugars and low in proteins and lipids, although there are exceptions. This large data set was also used to determine whether functional groups of invasive plants could be identified based upon fruit characteristics. Relationships between these traits and other factors, such as plant invasiveness and the number of disperser species were also examined. The fruit trait most strongly associated with invasiveness was fruit size, with all highly invasive species having relatively small fruits. Diversity of bird consumers was also positively correlated to invasiveness. Two summary manuscripts were prepared for publication, one presenting the data set, the other undertaking a functional trait analysis.

Replacement plants

We applied our knowledge of fruit functional traits and frugivore diets to provide science-based guidelines for recommending native food plant alternatives for invasive plants, such as lantana (*Lantana camara*). Native replacement plants that have similar fruit functional traits to the target weed may effectively compete with the weed species as a food source for birds (Gosper and Vivian-Smith in press, *Ecological management and restoration*). Such an approach aims to foster desirable dispersal services (i.e. for local native plants) whilst filtering out less desirable outcomes, such as weed spread. Another beneficial aspect of the approach is that it can provide food resources to support native frugivore populations and reduce the impact of weed management interventions upon these animals.

Popular garden plants as potential weeds

We utilised a variety of approaches to assess the potential of a garden hedge plant murraya (*Murraya paniculata*) to be dispersed into nearby bushland and become an environmental weed. These involved testing germination and seed persistence under a range of environmental conditions, quantifying the importance of murraya fruit in the diet of the figbird (*Sphecotheres viridis*) in Brisbane, and conducting structured field surveys in four rainforest patches in suburban Brisbane to determine the extent of murraya establishment.

These studies demonstrated the high potential for murraya to become an environmental weed. Murraya seed has relatively high germination rates (60–80%) under a range of environmental conditions. Murraya fruit formed an important component of the diet of the figbird during winter and spring, comprising 12–14% of the non-*Ficus* component of their diet during August and September, and seed proved to be germinable after gut passage. Figbirds (as well as other bird species) are therefore likely to act as seed dispersers for this species. Our field surveys confirmed that murraya is being dispersed into and establishing in rainforest sites in suburban areas (Figure 2.1), and that plants can grow to maturity beneath the rainforest canopy. One positive outcome of the study was the finding that murraya seed persistence is less than 12 months. We will be presenting the results of this research at the 15th Australian Weeds Conference (White et al., paper in press, *Proceedings of the 15th Australian Weeds Conference 2006*).

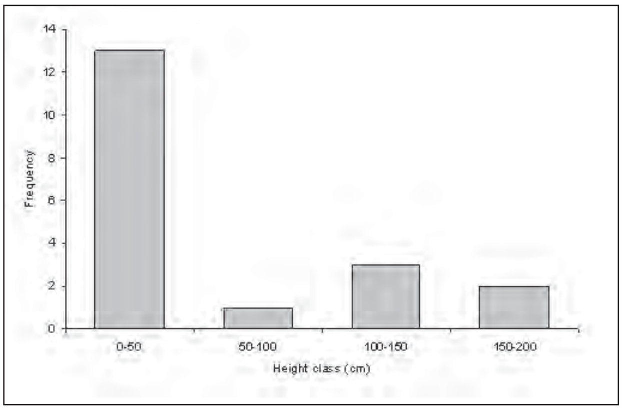


Figure 2.1: Frequency of *Murraya paniculata* plants of different height classes established in four riparian rainforest patches in Brisbane.

Lantana seed bank ecology

Seed banks were sampled at eight populations and seed densities were found to be much greater than those presented in other published studies of lantana. At all populations, we retrieved high, but variable, densities of lantana seeds, ranging on average from 599.3–3674 seeds m^{-2}. However, germination tests and seed viability analysis indicated that only a small proportion (5.6–16.4%) of the many seeds present were viable, with mean viable seed densities across the populations ranging from 78.6–402.8 seeds m^{-2} (Vivian-Smith et al. 2006, *Biological Control*).

After 36 months under field conditions, mean persistence of seeds of the pink and pink-edged-red biotypes ranged from 5–8% (surface sown seeds) and 12–22% (seeds buried at 1 cm). This indicates that lantana seed banks are both larger and more persistent than previously thought.

Lantana patch size and fruit removal

To assess the influence of plant and patch characteristics on fruit removal, we used lantana as a model species. The following methods were used:

- Fruit removal from randomly selected infructescences was monitored every two days over the course of eight weeks in lantana patches in Brisbane Forest Park.
- For each patch we quantified a range of characteristics likely to influence fruit removal rates by birds. These included: patch size, distance to nearest neighbouring patch, other fruiting species in the area, fruit density, *Ophiomyia* infestation levels, and fruit ripening synchrony.
- We used multiple regression analysis to determine whether there was a relationship between fruit removal and any of the above patch characteristics.

The results demonstrated that one third of all lantana fruits are removed from infructescences (the remainder either desiccating in situ or falling beneath the bush). A range of other plant species, both native and introduced, was fruiting in the vicinity of the lantana patches, but their presence did not influence fruit removal rates from lantana.

There was a positive relationship between fruit ripening synchrony (mean percent of fruits ripening per day) and fruit removal rate, and a negative relationship between percent of fruit damaged by the biocontrol agent *Ophiomyia* and fruit removal rates. Neither patch size (Figure 2.2) nor fruit density had an influence on fruit removal. This may be because of the close proximity of patches to one another—lantana is so abundant in this area that no patch was further than 80 m from the nearest neighbouring patch. The outcome may be different in an area more recently invaded by lantana, with more scattered and isolated patches. This will be the focus of a future study, in which we plan to experimentally manipulate patch size and distance between patches.

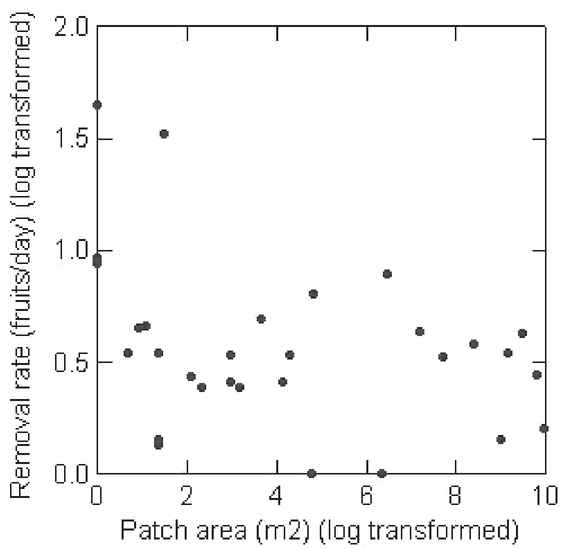


Figure 2.2: Relationship between lantana patch size and fruit removal rate.

Funding

CRC for Australian Weed Management

Queensland Government

NHT2 Weeds of National Significance (Lantana)

Expected completion

July 2008

Ecology of Wet Tropics weeds

Objective

To increase our understanding of the ecology of key Wet Tropics weeds, in order to improve their management.

Staff

Stephen Setter, Melissa Setter (part-time), Brodie Akacich (part-time), Michael Graham (part-time) (CWTA)

Collaborators

Rainforest CRC, CRC for Australian Weed Management, Weeds of National Significance, DPI&F (Walkamin Research Centre), Douglas Shire Council, Siam Weed Eradication Project, Four Tropical Weeds Eradication Project

Background

Weeds have the potential to degrade the high environmental, social, cultural and economic values of the Wet Tropics area. This project, started in 1999, aims to develop a sound ecological knowledge of priority Wet Tropics weeds as needed to improve weed management strategies for this important bioregion.

Methods

Field, shadehouse, and laboratory experiments are being undertaken on a number of weed species, including pond apple (*Annona glabra*), sicklepod (*Senna obtusifolia*), hairy senna (*Senna hirsuta*), harungana (*Harungana madagascariensis*), hymenachne (*Hymenachne amplexicaulis*), chromolaena/Siam weed (*Chromolaena odorata*), miconia (*Miconia calvescens*), limnocharis (*Limnocharis flava*), clidemia (*Clidemia hirta*), mikania (*Mikania micrantha*) and tobacco weed (*Elephantopus mollis*). Specific studies include the following.

Seed longevity

The longevity of seeds of sicklepod, hairy senna, harungana, hymenachne, tobacco weed and chromolaena/Siam weed is being tested under field conditions at various soil depths. Results will indicate how long the seed bank of these species will persist, and provide information about dormancy periods.

Pond apple

Seedling mortality and age to reproduction

A field experiment has been established to determine the survival and time to reproduction of pond apple seedlings. A clearer picture of the invasive characteristics of pond apple, as well as what to expect after initial control programs, will be gained. This information, along with the already determined seed longevity, will improve our ability to manage this weed.

Fruit traps

Pond apple flowering period and the volume of fruit produced is being determined within its current geographical range. Permanent fruit traps and field observations, in combination with previously mentioned studies, will aid land managers in the control of this weed of national significance (WONS).

Seed buoyancy and viability in fresh and saline water

A laboratory experiment has commenced to determine for how long pond apple fruit and seed can remain floating in fresh and saline water, as well as effects on seed viability and germination. The experiment is being undertaken using fish tanks containing fruit/seed in field-collected fresh and salt water.

A WONS-funded modelling study is being conducted to determine how far pond apple seeds and fruits will travel after being washed out of rivers, including during episodes of flooding. Multiple rivers and release times are being simulated, based on the potential distribution of pond apple and knowledge of its fruiting patterns.

Information from these studies will provide an insight into where new infestations could possibly occur through water dispersal of propagules.

Hymenachne: utilising revegetation to reduce impact

A field experiment has been established to determine the potential for revegetation to suppress hymenachne growth. Native trees and artificial shade structures, in conjunction with various chemical application regimes, are being tested to identify hymenachne control options for use in riparian systems.

Chromolaena (Siam weed): quantification of eradication effort

An isolated infestation of chromolaena is being used to quantify the resources (in terms of hours of labour involved for survey and control, and the volume of herbicide used) required for eradication. This population is growing under relatively dry environmental conditions, which more closely resemble those of overseas infestations than other Australian populations. To date the majority of chromolaena infestations in Australia have been found along the wetter coastal strip.

Miconia: timing of flowering and fruit maturity

Three accessible and reproductive miconia trees have been retained for this experiment, tree growth is also being recorded. Flowering panicles 0–3 m above ground level have been covered with strong, fine mesh bags. These bags are secured tightly around the stems, to minimise any possibility of seed escape, and any panicles above 3 m are removed. The trees are monitored monthly and, closer to flowering, every 1–2 weeks until fruits begin to mature. As the first fruits on each panicle begin to mature the panicles are then removed with bags intact and disposed of safely. The time of year and time from flowering to fruit maturation has been recorded in 2005 and 2006; this is the first monitoring of flowering under Australian conditions.

Clidemia: seedling survival and age to reproduction

A study has been established to monitor seedling survival and to determine how long it takes for newly emerged seedlings to become reproductive in the field. Approximately 270 seedlings have been tagged and their fates recorded on a monthly basis. A shadehouse trial is being undertaken concurrently, with 40 newly emerged seedlings transplanted into pots and monitored on a regular basis.

Mikania: eradicating an infestation

A small infestation of mikania is being used to quantify the effort required for its control and to monitor regeneration and subsequent control. This, in conjunction with a pot trial assessing age to reproduction, will assist the eradication teams. Permanent transects and quadrats are in place and monitoring of growth parameters is occurring every three months.

Progress

Seed longevity

Some species have now been buried for six years, with seed bank rundown still ongoing for most of these. Harungana seed viability is notably high after 6 years for buried seeds. On the surface, 10% of seeds remain viable, whilst below ground (buried at 2 and

10 cm) approximately 80% are alive and capable of germinating. Hymenachne is also persistent, with up to 21% of seed on the surface still viable after six years. Similarly, a small portion of chromolaena (2%) seed located on the soil surface is still viable after five years. Note that these results pertain to the experimental field conditions; seed persistence may differ under other conditions.

Pond apple

Seedling mortality and age to reproduction

Just over 500 pond apple seedlings of known age have been tagged in untreated (control) and treated (with the mature over storey and older seedlings removed) transects. A description of the initial population has been recorded (including adults, juveniles and older seedlings), and the survival and growth of newly emerged seedlings, along with their reproductive status, are being monitored.

After two years approximately 85% of seedlings have died, at least some due to animal activity. None appear to be close to reproductive maturity.

Fruit traps

One season's data for fruit production and flowering seasonality has been collected. Data have been collected for three locations representing large infestations within the current range of this weed. Results to date are mixed, with a high proportion of fruit being aborted prior to full development and large variations between populations. The reproductive population at the southern location at Innisfail was severely affected by Cyclone Larry and will have to be treated separately. These trees are expected to fruit, but in a much diminished capacity.

Seed buoyancy and viability in fresh and saline water

Viable seeds are still present after five months of placement in both fresh and salt water. A pilot study found that the majority of seeds had germinated while still floating in fresh water after approximately six months, but were dormant and viable after 12 months in salt water.

The study investigating pond apple distribution via water currents is still in its early stages, with preliminary modelling taking into account wind speed, direction and coastal topography. The final report will be available towards the end of 2006.

Hymenachne: utilising revegetation to reduce impact

Biomass and soil seed bank sampling is ongoing, in conjunction with the continued application of some treatments. Hymenachne biomass appears to be less in all chemically treated plots, relative to the control plots. There are no observed differences in biomass between the shaded and unshaded plots as yet.

Chromolaena (Siam weed): quantification of eradication effort

Baseline data on all individuals (approx 1000 adults), along with soil seed bank samples, were collected in July 2003. Efficacy of kill/re-treatment is being recorded, and seed bank sampling is continuing. Survey and control of significant numbers of newly found individuals, both seedlings and older plants, is still occurring, adding to the overall cost of control.

Miconia: timing of flowering and fruit maturity

Flowering episodes were recorded once a year in February 2005 and 2006, with flower buds maturing to fruit in a minimum of 60 days. An average of 300 fruits per panicle (range 13–1141) was removed as the first fruits approached maturity. The mesh bags were found to be strong and secure, and no seed escape was recorded or suspected. The seeds that matured after the panicles were removed may now be used for other purposes such as viability testing.

Clidemia: seedling survival and age to reproduction

Whilst potted plants in a shadehouse started flowering after nine months, field-grown plants have yet to flower after 12 months, even though they are of a similar size. Seedling survival in both cases is close to 100%. Seeds collected will be utilised for further experimentation, such as determination of viability and germination requirements.

Mikania: eradicating an infestation

Standard control techniques were applied in December 2005, after initial baseline data had been collected. A monitoring visit three months later found approximately 1 m^2 of regeneration. None of the potted plants have flowered after nine months.

Funding

Rainforest CRC

Weeds of National Significance funding

Four Tropical Weeds Eradication Project

Queensland Government funding

Logistical support

Rainforest CRC

CRC for Australian Weed Management

Weeds of National Significance funding

Four Tropical Weeds (Federal)

Queensland Government funding

Expected completion

The project is ongoing, with different experiments expected to require between 1 and 12 years to complete.

Clidemia hirta which is only known at one location in Australia—Julatten inland from Port Douglas.

Limnocharis flava is an aquatic herb, and eradication target, this specimen was found at Feluga near Tully.

Miconia calvescens flowers.

Miconia calvescens seedling tip.

Miconia calvescens is a small tropical tree with purple underside of leaves which regularly grow 70 cm–1 m.

Miconia calvescens can display a drooping habit.

Siam weed photo collected from a site near Ross River.

Siam weed in flower (location near the Ross River).

Environmental weed ecology

Objective

To generate ecological research outcomes that better inform environmental weed management and biological control research.

Staff

Gabrielle Vivian-Smith (Leader), Tanya Grimshaw, Graeme Hastwell, Dane Panetta, Natasha McKenzie (AFRS)

Methods

Experiments are designed to provide ecological information on propagule dispersal, seed bank dynamics and seed persistence of high impact weedy vines and other environmental weeds. Study species include cat's claw creeper (*Macfadyena unguis-cati*), balloon vine (*Cardiospermum grandiflorum*), and Madeira vine (*Anredera cordifolia*). Work is now completed for Senegal tea (*Gymnocoronis spilanthoides*) and moth vine (*Araujia sericifera*).

A major component of the project assesses the importance of riparian corridors for weed dispersal and will provide input to catchment-based weed management strategies. Dispersal studies of high impact weedy vines use seed traps, placed in-stream and along the riparian zone, to measure seed rain along creek corridors. Field and laboratory experiments evaluate the species' seed bank dynamics (germination requirements, emergence, seed persistence, and in situ seed bank densities).

Freshly harvested seeds are sown on the soil surface or buried in emergence and longevity studies. Emerging seedlings are monitored and the viability of remaining seeds is determined at intervals of 6–12 months for up to five years. Seed germination experiments in laboratory growth cabinets test responses to different light and temperature environments.

A new study has evaluated how potential biocontrol agents may affect Madeira vine by testing different types of tissue damage and removal via a simulated herbivory experiment.

Progress

Cat's claw creeper (*Macfadyena unguis-cati*)

Field work for this component of the project was completed in 2006, with data analysis and interpretation underway.

Balloon vine (*Cardiospermum grandiflorum*)

Field work for this component of the project was completed in June 2006, with assessment of the four-year seed bank persistence studies being undertaken.

Madeira vine (*Anredera cordifolia*)

Field work for the tuber deposition and tuber bank persistence components of the project was completed in 2005, with data analysis and interpretation underway. A review paper, with external collaborators, on the biology of Madeira vine has been completed (Vivian-Smith et al., in press, *Plant Protection Quarterly*).

The simulated herbivory experiment indicated that effects of tissue removal upon plant growth tended to be modest, primarily altering patterns of biomass allocation between different plant organs, rather than overall plant performance. Initial analyses indicate that leaf removal treatments had a greater effect than other above- or below-ground treatments.

Funding

Queensland Government

Expected completion

Ongoing

Experimental treatments within the tuber longevity study.

Madeira vine plant within the simulated herbivory experiment.

Mimosa pigra research

Objectives

- To study the life cycle, growth rates, seedling emergence and seed bank dynamics of *Mimosa pigra* growing at the Peter Faust Dam, Proserpine, to aid in the eradication program targeting this species.
- To investigate fire and chemical options for *M. pigra* control.
- To evaluate herbicides for control of melaleuca regrowth in *M. pigra* infested areas.

Staff

Joseph Vitelli (Leader), Barbara Madigan, Kent Worsley (TWRC)

Methods

Mimosa pigra will be intensively studied at Peter Faust Dam, especially on the peninsula known as Point 10. Massive seedling germination occurred across the peninsula as the water level in the dam decreased from April 2001, when *M. pigra* was first recognised at the dam. The study will be from the 65% water storage capacity level to the middle of the creek bed. This area includes the closed canopy *M. pigra* infestations (known as the core areas) and individual *M. pigra* plants scattered across the peninsula.

Seedling emergence and seed bank

Seedling counts will be recorded along a transect line running through the core infestation and in a grid pattern across the peninsula. Soil cores will be taken annually from different areas for seed bank studies and viability of recovered seeds will be tested.

Life cycle and growth rates

Stem height, basal diameter, number of flower buds, and number of seed pods will be recorded periodically for plants from three sections of the study area. All seeds will be collected and removed from the site. All plants will be killed once this study has been completed.

Control with chemicals and fire

A cut stump treatment using metsulfuron methyl at the rate of 0.6 g L^{-1} will be applied to individual plants in three size classes (10-25, >25-45, >45 mm basal diameter) with four replicates, and also to larger plants upon completion of life cycle and growth rates study. A dense area of *M. pigra* (144 000 ± 69 000 plants ha^{-1}) with plots containing different fuel loads (0, 1000, 2000, 4000 and 16 000 kg ha^{-1}) will be burned to study the effect of fire on an infestation. Thermocouples connected to a datataker will be placed in each plot at 0 and 50 cm above ground level. Plants will be assessed for mortality at 40 and 70 days after the burn.

Control of melaeuca regrowth

The recruitment of three melaleuca species (*Melaleuca leucadendra*, *M. quinquenervia* and *M. viridiflora*) at Peter Faust Dam is impacting on the eradication of *M. pigra* by hindering its detection and control. These three species will be grown in pots at TWRC. Fourteen treatments will be applied using the spray gantry to simulate aerial application at 200 L ha^{-1} in a complete double overpass. Treatments are:

- triclopyr/picloram (Grazon* DS Herbicide) at 900/300 and 450/150 g ha^{-1}; tebuthiuron (10% formulation) at 1500 g ha^{-1}
- dicamba (Banvel® 200 Herbicide) at 1200 g ha^{-1}
- triazinone (Velpar® L herbicide) at 1500 g ha^{-1}
- 2,4-D/picloram (Tordon* 75D Herbicide) at 2250/562.5 g ha^{-1}
- glyphosate (Weedmaster® Duo) at 3240 and 1620 g ha^{-1}
- fluroxypyr (Starane* 200 Herbicide) at 600 g ha^{-1}
- metsulfuron (DuPont™ Brush-Off® brush controller) at 72 and 36 g ha^{-1}
- imazapyr (Arsenal ® Herbicide) at 750 g ha^{-1}
- a control.

Biological control

Biological control agents will be sent from the Northern Territory as part of 'Biological control of *Mimosa pigra*—insect release and evaluation' (Project Identifier 52730) funded in Round 2 (2004–05) of the Defeating the Weed Menace Program of the Australian Government. This will be to supplement eradication efforts with insects that will target young plants that may be missed during a control operation.

Progress

Seedling emergence and seed bank

Seedling counts have decreased from a maximum of 19 000 m^{-2} in 2003 to 8 m^{-2} in 2005. Seed bank decline in the core area has been ~90% from 2002–05 (Figure 2.3). Seeds from 2006 are yet to be counted.

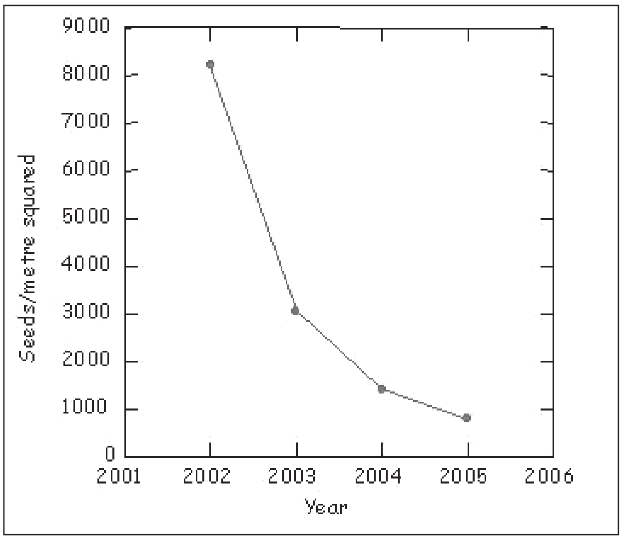


Figure 2.3: Mean *Mimosa pigra* seed density in the top 10 cm of soil cores from the core infestation area at Peter Faust Dam, Proserpine.

Life cycle and growth rates

All research on mature plants in the study area has now finished, with only a small number of *M. pigra* plants remaining within a fenced area. These plants are regularly cut back for the biocontrol agents (see photo on p. 37).

M. pigra flowered as early as 67 days after emergence (DAE), though the mean for all plants was 129 DAE (±36 SD). A plant that had died back nearly to ground level took 350 DAE to flower. Plants were found to pod from 155 to 1172 DAE (in the upper section), with a mean of 389 DAE (±204 SD) across all sections. Flowering and podding occurred year round, though numbers fluctuated. Mature plants flowering at any one time ranged from 80 to 100%, with podding plants ranging from 7.5 to 89%.

Control with chemicals and fire

Cut stump treatment on *M. pigra* was effective for nearly 100% of plants in the 10–25 mm, >25-45, >45 mm basal diameter size classes (Figure 2.4). The mortality of larger plants, which had been used for life cycle and growth rate studies, was only 80%. Basal diameter for these plants ranged from 31 to 148 mm. The length of time needed to cut these larger plants at the base, and the subsequent delay in applying the chemical, may have contributed to the lower mortality of these plants.

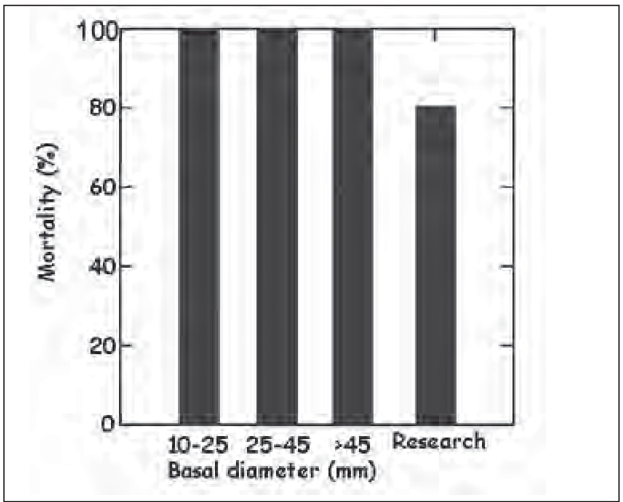


Figure 2.4: Mortality of *Mimosa pigra* plants cut to ground level with a brush cutter and treated with metsulfuron methyl applied at 0.6 g L^{-1} of active ingredient. Plants that had been used for life cycle and growth rate studies ('Research') ranged from 31 to 148 mm basal diameter, with a mean of 89 ± 33 mm.

Mortality averaged less than 10% irrespective of fuel load, with greater than 25% of plants flowering 70 days after burning (Figure 2.5).

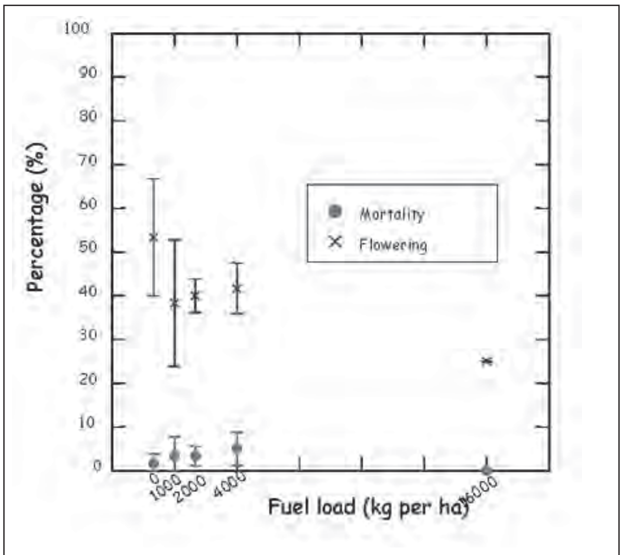


Figure 2.5: *Mimosa pigra* plant mortality and flowering 70 days after burning.

Control of melaeuca regrowth

A permit will be sought from the APVMA to register the most effective herbicide and rate for the control of melaleuca species growing at the dam.

Biological control

Three insects (*Neurostrota gunniella*, *Malacorhinus irregularis* and *Coelocephalapion pigrae*) were sent from the Northern Territory, Weed Management Branch, Department of Natural Resources, Environment and the Arts. They were released into cages made of mosquito netting in an area of dense *M. pigra* at the research site in February 2006 (see below). The area was fenced and plants within the fenced area were cut to a low level to provide food for insects and have yet to be in a condition to produce pods between visits to the site. Cages have since been opened to allow insects to travel to their plant of choice. A larva of *N. gunniella* was found in a *M. pigra* stem during June 2006, and damage consistent with this insect was also noticed in the area.

A cage used for the release of biocontrol agents for *Mimosa pigra*.

Funding and logistical support

Queensland Government

Whitsunday Natural Resource Management Group

Defeating the Weed Menace Program, Australia Government

Expected completion

2010 subject to funding availability

Weed eradication feasibility and program evaluation

Objectives

- To provide a scientifically based rationale for decision making with regard to eradication of weed incursions.
- To refine eradication methods by using ecological information.
- To monitor selected eradication programs and document associated costs.
- To develop criteria by which eradication progress can be assessed.

Staff

Dane Panetta (Leader)(AFRS), Simon Brooks, Shane Campbell, Eloise Kippers (TWRC), Stephen Setter (CWTA)

Collaborators

Data for eradication case studies are provided by NRW Land Protection staff based at South Johnstone and several local government pest management officers.

Ecological studies of Class 1 weed eradication targets are conducted in conjunction with the Ecology of Wet Tropical Weeds project at South Johnstone.

Background

Early intervention is the most cost effective means for preventing weed incursions from reaching the stage of rapid expansion. Strategies designed to achieve this aim range from eradication, where the objective is to drive the incursion to extinction, to containment, which may vary from absolute to degrees of slowing spread. Recent and ongoing work to determine the feasibility of eradication and containment should contribute to formulating decision rules for determining management approaches. To make informed decisions it is essential to gather case study data to provide a basis for determining to what degree management objectives are being achieved and assess progress towards eradication.

Methods

A scoring system for the evaluation of progress towards the eradication objective is under development. In the current version the total score is a product of two sub scores, the delimitation and the extinction subscores. The delimitation sub score takes into account trends in cumulative infested area, the detection ratio (infested area detected/area searched) and the average distance between new infestations and known infestations. The extinction sub score is a composite of the percentage of infestations in the monitoring phase (i.e. no plants detected for at least 12 months) and the percentage of infestations eradicated.

Data on eradication resources and progress will be collated on an infestation and per visit basis for *Miconia racemosa*, *M. nervosa*, *M. calvescens*, *Limnocharis flava*, *Clidemia hirta*, *Mikania micrantha* and *Mimosa pigra* in Queensland. Data includes the geographical spread of infestations, discovery over time, labour resources, trends in infested areas, population decline and time since last detection. Data from Queensland and eradication case studies in New South Wales, Victoria and Western Australia will also be analysed using the eradication progress scoring system.

To support the local eradication efforts investigations have commenced into the age to maturity, recruitment and soil seed bank rundown for *M. calvescens* and *L. flava* under field conditions. Soil seed bank sampling at single *M. calvescens* and *L. flava* infestations was repeated in late 2005. Additional ecological data on species targeted for eradication is presented in the Ecology of Wet Tropical Weeds and *M. pigra* research projects.

Progress

The scoring system for the evaluation of progress towards eradication has been applied to the ongoing program targeting branched broomrape (*Orobanche ramose L.*) in South Australia (Figure 1). Marked fluctuation in the eradication progress score (Figure 3.1b) arose from a decrease in the delimitation sub score (Figure 3.1a), which reflected a substantial increase in the known area of infestation in year 5 of the eradication program. Current maxima for both the extinction sub score and the eradication progress score reflect the fact that no infestations can be considered to have been eradicated, since 12 years without seed set is the agreed criterion for eradication of this species.

The discovery date, location, original infested area and time of last detection for all *L. flava* (17 sites) and *M. micrantha* (13 sites) infestations is being analysed. Since 2004, no new *M. micrantha* infestations have been detected, and there have been only small increases in infested areas recorded since 2001; these increases have occurred at locations less than 1 km from known infestations. Two new *L. flava* infestations with one and three plants respectively were discovered in 2005, within 10 km of existing infestations. Previous discoveries of *L. flava*, made between 2001 and 2003, are scattered between Port Douglas and Townsville.

Progress towards the local extinction of these two species can be illustrated by the time since last detection data. In the six months to June 2006, some regeneration (1 to 22 vines) from seed or vegetative fragments was recorded at five *M. micrantha* sites (Figure 3.2a). No recruitment has been recorded in the last four to five years in two infestations that were discovered in 1998. Nine *L. flava* infestations are contained in aquatic features. There has been little or no emergence recorded since control measures commenced; in these cases the range of periods since last detection (Figure 3.2b) reflects the discovery of sites between 2001 and 2005.

The tagging of newly emerged *L. flava* seedlings has shown most seedlings flower after three months' growth; however, one seedling flowered after 23 days. On the basis of this minimum value, revisits to control recruitment at active *Limnocharis* sites have been reduced to every three weeks. At this site, near Tully, seedling emergence is still being recorded three years after control activities commenced; during this time no seeding plants have been recorded.

Growth measures and basal disk sampling of *M. calvescens* has continued in support of age to maturity studies. Four flowering *M. calvescens* stems with basal diameters between 4.1 and 5.4 cm were recorded in a new infestation near Babinda; previously flowering had only been observed on stems with basal diameters greater than 6.1 cm.

Funding

CRC for Australian Weed Management

Queensland Government

Expected completion

June 2008

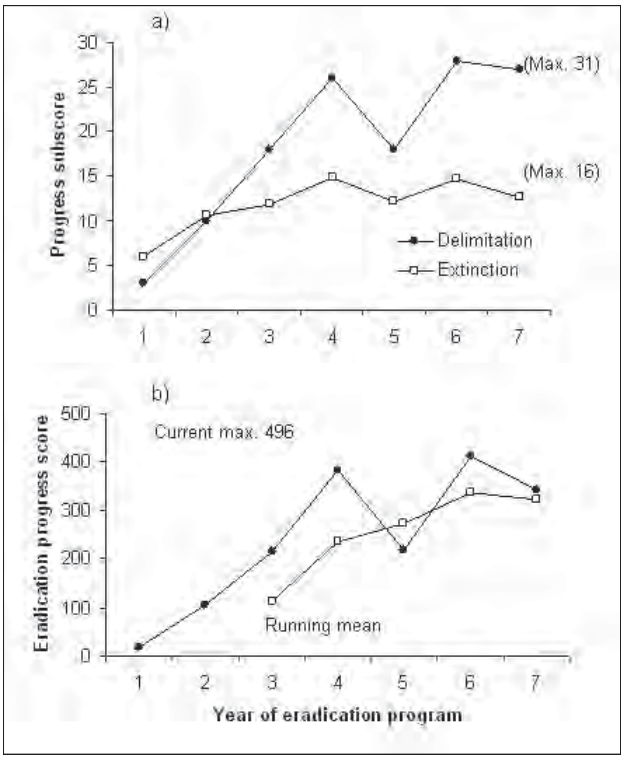


Figure 3.1: Eradication progress sub scores (a) and progress scores (b) for branched broomrape. Potential maximum values are given for both subscores and the progress scores. In addition, the three-year running mean is presented for the progress score.

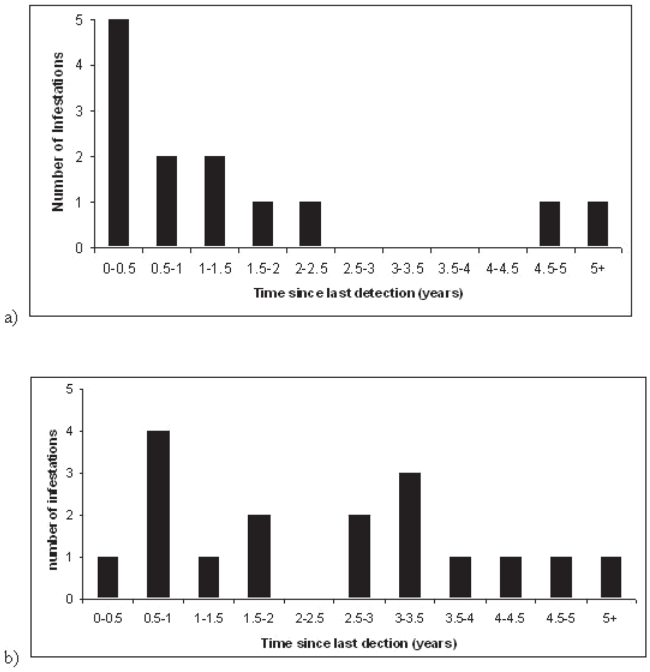


Figure 3.2: Time since last detection of plants of (a) *Mikania micrantha* and (b) *Limnocharis flava* at infestations targeted for eradication, as of 30 June 2006. Infestations enter a monitoring phase 12 months after the last detection of plants.

Chapter 3: Integrated weed management research

Integrated management of parkinsonia (*Parkinsonia aculeata*)

Objectives

- To evaluate the efficacy and cost of control methods in order to provide the technical basis for management packages.
- To better understand the ecology of parkinsonia and its implications for timing and effectiveness of control strategies.
- To promote changes in management practices that will lead to sustainable levels of production.

Staff

John McKenzie (Leader), Mike Pattison, Dannielle Brazier, Shane Campbell (TWRC)

Methods

Development of integrated control strategies

A dense parkinsonia infestation located near Duaringa in central Queensland was selected to compare the efficacy of 11 treatments. These involved the use of ground (basal bark spraying of a 1:60 Access®/Diesel mixture and spot spraying of Velpar®L) and aerially applied herbicides (Grazon* DS and Graslan*) and mechanical techniques (blade plough, Ellrott plough, stickraking, dozing and double pulling). Burning was initially included as a possible treatment in the experiment, but was later removed because of the lack of sufficient fuel to carry a fire. Secondary treatments were imposed based on initial kill rates. Primary treatments that had kill rates greater than 85% were generally supplemented by basal barking, except where residual chemical treatments had been imposed. Graslan* treated plots were left untreated and only mature plants in the Velpar® L plots were sprayed. This was done to prevent seed production, thereby enabling measurements on the soil seed bank and its depletion. Plots that were stick raked were foliar sprayed with Grazon* DS. Plots that were initially double pulled, dozed and aerially treated with Grazon *DS received supplementary treatment with the Ellrott plough.

Ecological research

As part of a Weeds CRC project, CSIRO has coordinated the establishment of five parkinsonia research sites throughout the rangelands of Australia. These areas are considered to be representative of the diversity of environmental conditions where the weed is currently found. TWRC staff collect ecological data on a monthly basis from a central Queensland site. Measurements undertaken on parkinsonia include growth and development, leaf and flower production, and seed bank density.

The effect of direction and season of burns

This study is aimed at quantifying the efficacy of fire as a control technique for parkinsonia. The experiment comprises a split plot design with season of burn (end of wet season/early dry season, late dry season, early wet season and mid wet season) allocated to main plots and direction of burning (head fire and back fire) allocated to sub plots.

The effect of camel grazing

Camels are presently being used by a small group of landholders as a control option for parkinsonia. A field study was undertaken to quantify camel impacts, with 20 mature parkinsonia plants selected from within both grazed and ungrazed paddocks on two properties. Seed production and plant biomass measurements were recorded from individual plants and 60 soil cores (4.5 cm x 5 cm) were taken beneath the canopy of each tree to assess seed bank changes over time.

Regrowth study

This study is being undertaken to determine whether seasonality of injury (simulated mechanical control) affects the rate at which regrowth approaches reproduction. Plants comprising three size classes (0 to 150, 151 to 300 and › 301 cm) are cut off 5 cm above ground at three different seasons at a site located near Charters Towers. They are then monitored on a regular basis to measure growth rates and the time it takes to reach reproduction.

Density and grass competition effects on the time to reproduction

This study will determine the effects that parkinsonia seedling density and grass competition have on the growth rate of parkinsonia and the time it takes to reach reproductive maturity. Combinations of four parkinsonia densities (0, 1100, 17 800 and 40 000 plants ha^{-1}) and three simulated grazing intensities (no grass, grass cut to 20 cm or left uncut, to simulate extreme, moderate and nil utilisation) will be applied to 9 m^2 plots. Treatments will be implemented under two moisture regimes: average and above average (10 percentile) Charters Towers rainfall. Plant growth and soil moisture content will be monitored on a regular basis.

Progress

Development of integrated control strategies

Preliminary findings indicate that the five most effective primary control methods, in terms of initial plant mortality, are blade ploughing using either front (93%) or back mounted machines (91%), basal bark spraying (97%), Graslan* DS (81%) and Velpar® L(97%). Of these, the least expensive to implement were broad scale blade ploughing, (\$126 and \$156 ha^{-1} for front mounted and back mounted ploughs, respectively) and aerially applied Graslan* (\$180 ha^{-1}). In contrast, individually applied Velpar® L and basal bark applications averaged \$270 ha^{-1} and \$412 ha^{-1}, respectively.

Final recommendations will be deferred until post-treatment seedling regrowth and pasture responses have been quantified and the most appropriate secondary control options determined. This work is completed and awaiting analysis.

Ecological research

The key finding from the ecological research to date is that the seed bank of parkinsonia appears to be relatively short-lived, with greater than 90% of the seed bank depleted within two years. This research is ongoing.

The effect of direction and season of burns

Results to date suggest that all seasonal fires and both directions of fires caused significantly higher mortality than the untreated controls. However, there was no significant difference between seasons of burn or fire direction on parkinsonia survival and recruitment levels. This work has just been completed and is undergoing analysis.

The effect of camel grazing

The field research has been completed. A paper entitled 'The effect camels have on the ability of parkinsonia (*Parkinsonia aculeata* L.) to set seed' has been written for the 15th Australian Weeds Conference.

Infestation prior to the initial basal bark treatment.

One year after application with no follow-up treatment.

Two years after initial application with no follow-up treatment, note the missed plants and seedlings.

The treatment has been done twice, photo taken two years after primary basal bark treatment and one year after secondary basal bark treatment.

Parkinsonia prior to double pulling in 2002.

Infestation is back to normal or worse after three years since being double pulled.

Plant regrowth

To date the oldest regrowth is two and a half years of age, with no plants regaining reproductive status, even though most of those remaining alive have reached their pre-treatment heights.

Density and grass competition effects on the time to reproduction

The trial has been established and monitoring is being undertaken.

Funding

Queensland Government

NHT Two Weeds of National Significance

CRC Australian Weed Management

Expected completion

June 2006

Wet Tropics weeds project: chemical trials

Objectives

The overall aim of this project is to develop herbicide control measures for various weeds of the wet tropics and improve technology for their management, containment or eradication.

Specific objectives for the 2005–06 year were to:

- evaluate chemical screening of various herbicides for the control of praxelis (*Praxelis clematidea*) growing in the field
- evaluate three herbicides applied as basal bark and cut stump sprays for the control of chromolaena (*Chromolaena odorata*) growing in the Townsville/Thuringowa region
- evaluate the effect of soil moisture on efficacy of Sempra® when applied to mature navua sedge (*Cyperus aromaticus*) growing in pots
- determine the longevity of navua sedge seeds buried at different depths
- determine effective herbicides for the control of hiptage (*Hiptage benghalensis*) growing in the Douglas Shire.

Staff

Peter van Haaren (Leader) (CWTA), Joseph Vitelli, Barbara Madigan (TWRC), and Eloise Kippers (Industrial placement student University of Queensland, Gatton Campus)

Methods

Weed control

Praxelis (*Praxelis clematidea*)

Four foliar uptake herbicides were applied at various rates to praxelis in a randomised complete block design experiment in April 2004. Each treatment was replicated three times.

Chromolaena (*Chromolaena odorata*)

A small area of a chromolaena infestation (averaging 19 700 plants ha^{-1}) in the Townsville/Thuringowa region was either basal bark sprayed or cut stumped. Treatments included fluroxypyr, triclopyr/picloram, neat diesel, a 5% picloram gel and a control. Each treatment consisted of 20 plants per plot, and was replicated three times. The height, diameter and number of stems per plant were recorded prior to herbicide application. Plant mortality was determined 119 days after application.

Navua sedge (*Cyperus aromaticus*)

There are two main areas of research associated with navua sedge: chemical control and weed ecology.

To date halosulfuron-methyl (Sempra®), a herbicide registered for the control of sedges, has controlled navua sedge poorly in screening trials. Both season of application and soil moisture have been blamed for poor herbicide performance. A glasshouse trial was established to determine the efficacy of halosulfuron-methyl when applied to nauva sedge growing in pots maintained at different soil moisture levels. The experiment was a four by three factorial. The four soil moisture levels were 16% (field capacity), 12.34%, 8.67% and 5% (near permanent wilting point), and the three halosulfuron-methyl rates were 0, 130 and 520 g ha^{-1}. All treatments were replicated four times. Each experimental unit consisted of four pots with five plants in each, giving a total of 20 plants. The moisture levels were maintained for 14 days after spraying, after which all plants were maintained at near field capacity for the remainder of the experiment.

Seeds of navua sedge were collected from plants growing along roadsides and degraded pastures near Babinda, far north Queensland, during November 2001. After collection, unfilled seeds were removed from the sample. Filled seeds were stored at low humidity at 5±2 °C until initiation of longevity and germination experiments one to two months later. The longevity experiment consisted of a split-plot design, with sampling time as the main plot (0 months, 3 months, 6 months, 1 yr, 2 yr, 3 yr, 5 yr, 10 yr, and 15 yr) and burial depth as the sub-plot (0 cm, 2 cm, and 10 cm). Seeds were enclosed in packets that were buried using a randomised grid design in a field site at South Johnstone. Each treatment was replicated four times. The existing ground cover (grass) at the site was initially removed manually, and then allowed to grow over the site.

Hiptage (*Hiptage benghalensis*)

Hiptage benghalensis, a native from India to the Philippines, is an invasive vine-like shrub or liana smothering native trees in the Douglas Shire of north Queensland and Manaton Park in Brisbane. Planted because of its fragrant ornamental pink-red flowers, hiptage has now become a garden escapee. Its dispersal is aided by its three-winged fruits (samaras). Hiptage is capable of growing in a variety of habitats that receive greater than 900 mm annual rainfall.

The objective of this trial is to field test the efficacy of several herbicides.

Progress

Weed control

Praxelis

Praxelis density at the start of the trial averaged 1.3 million plants ha^{-1}. A 100% kill was achieved with triclopyr/picloram at 3 L ha^{-1}. This result was not significantly different to that achieved with 2,4-D/picloram when applied at 3 L ha^{-1}. Metsulfuron-methyl at 45 g ha^{-1} controlled approximately 80% of the treated plants, whilst in previous trials metsulfuron at 100 g ha^{-1} achieved 100% control (Figure 1). A final trial involving triclopyr/picloram, 2,4-D/picloram, metsulfuron-methyl and clopyralid is scheduled for the end of 2006.

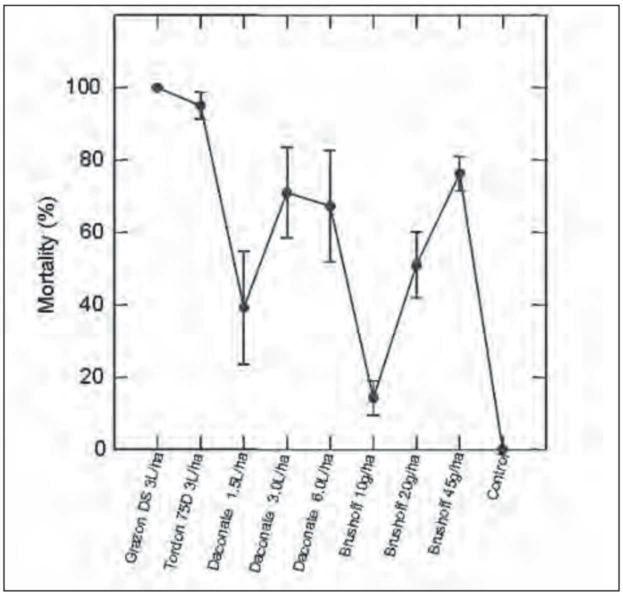


Figure 3.3: The effect of four herbicides at various rates for the control of praxelis (*Praxelis clematidea*).

Chromolaena

Mortality of chromolaena following basal bark or cut stump treatment ranged between 98 and 100%, depending on the herbicide used. Neat diesel controlled only 23% of the treated plants. This data will be used to obtain a minor use permit for the control of this weed.

Navua sedge

Mortality averaged 0, 40 and 62% for halosulfuron-methyl concentrations of 0, 130 and 520 g ha^{-1}, irrespective of soil moisture level. There was no significant difference between chemical application rates to soil moisture (P=0.123). However, average plant mortality increased with increasing soil moisture. The seed longevity study is ongoing.

Hiptage

A basal bark, cut stump and foliar application trial was recently completed. No effective foliar uptake herbicide was found for mature vines. However, triclopyr/picloram and fluroxypyr controlled 79 and 83% of the seedlings treated, respectively. The most effective herbicide for basal barking was triclopyr/picloram at an application rate of 16.7 mL L^{-1} diesel, which controlled 65% of the treated plants.

Cut stump was the most effective method for controlling hiptage, with triclopyr/picloram (16.7 mL L^{-1} diesel), fluroxypyr (33.3 mL L^{-1} diesel), glyphosate (500 mL L^{-1} water) and picloram (neat) controlling greater than 95% of the treated plants. Diesel alone controlled 3% of the plants when applied as a basal bark treatment and 60% of plants when applied as a cut stump treatment. A minor use permit will be sought in the next few months.

Funding and logistical support

Queensland Government

Expected completion

Ongoing

Integrated management of bellyache bush (*Jatropha gossypifolia*) in northern Queensland

Objectives

- To develop an integrated management strategy for bellyache bush.
- To evaluate the effects of combinations of fire, slashing, and a foliar herbicide (Brush-Off®) on survival and seedling recruitment of bellyache bush.
- To better understand the ecology of bellyache bush and the implications for timing and effectiveness of control strategies.
- To promote changes in management practices that will lead to sustainable levels of production.

Staff

Faiz Bebawi (Leader), Joe Vitelli, Shane Campbell, Kitty Davis (TWRC)

Methods

There are three areas of research associated with this project: integrated weed control, weed ecology and pasture management.

Integrated weed control

The impact of singular treatments (fire and slashing) on bellyache bush was examined at two north Queensland sites (Sandy Creek and Larkspur) near Charters Towers. A five-year integrated management trial was undertaken on riparian habitats adjacent to Sandy Creek and Southern Cross Creek at Branmore Station (formerly Almora Station) to determine the most effective combination of fire, slashing, stickraking and chemical treatments for controlling this weed. A combination of primary control techniques (including slashing, stickraking, burning and spraying) supplemented by secondary, tertiary and quaternary follow-up control techniques (including slashing, burning and spraying) was imposed.

Weed ecology

Experiments are being conducted to help fill knowledge gaps about bellyache bush seed ecology, flowering periodicity, competitive ability under different simulated grazing pressures, population dynamics, jewel bug (*Agonosoma trilineatum*) impact on seeds, and impact of integrated control treatments on pasture composition and yield. A trial was conducted in December 2000 at two sites: Riverview—rocky habitat, and Sandy Creek—heavy clay habitat, to determine bellyache bush seed bank persistence after complete removal of infestations from the sites. A trial was established at TWRC in February 2004 to determine the effects of three densities (control, low, and high) of the jewel bug on capsule abortion, seed weight, seed production, seed viability and germination.

Pasture management

A trial was established at Branmore Cattle Station during September 2002 to determine the impact of five simulated grazing intensity regimes [no grazing (uncut pasture), low (cut at 40 cm height), medium (cut at 20 cm height), high grazing (cut at 10 cm height) and no pasture (pasture removed)] on four bellyache bush densities [control (no bellyache bush), low (2 plants m^{-2}), medium (6 plants m^{-2}), and high density (12 plants m^{-2})].

Progress

Integrated weed control

Four years after treatment, bellyache bush mortality in the nil treatment (control), once off (single application without follow-up), integrated control (repeated follow-up irrespective of treatment combination), and best practice technique (four consecutive annual applications of foliar uptake herbicides) averaged 64%, 68%, 96%, and 100% respectively. For the same treatments, pasture yield increased by 184%, 221%, 219%, and 211% respectively. Results suggest that integrated control techniques were more effective in reducing bellyache bush infestations and increasing pasture yield compared with a 'do nothing' management strategy. This trial is completed.

Ecology

Seed bank persistence

Seedling emergence is still occurring 57 months later at Riverview but has ceased at Sandy Creek. The trial is ongoing.

Impact of the jewel bug

Seed fresh weight was reduced by 15% and 28% when seeds were partially and fully damaged. At low jewel bug density, mortality of partially damaged immature and mature unripe seeds (those harvested from green capsules) averaged 81% and 59%. At high jewel bug density, seed mortality averaged 96% and 84% respectively. Results suggest that irrespective of jewel bug density, immature bellyache bush seeds are relatively more vulnerable to jewel bug damage compared to mature seed, and that a high jewel bug density, irrespective of seed type, caused the greatest damage. Mortality of ripe bellyache bush seeds (those naturally released from capsules) averaged 96% and was not affected by jewel bug density.

Nymph production was significantly greater at low (4.3%) than at high (1%) jewel bug density. Nymph production peaked between December and March (wet season). Unfortunately, under our experimental conditions (31 °C and 52% RH), the nymphs never grew to adults. However, 79% of eggs from egg batches that were removed and placed in Petri dishes under lab conditions (28 °C and 100% RH) produced nymphs that grew to adults. This trial is completed.

Bellyache bush field day—controlling bellyache bush through pasture management.

Pasture management

No significant differences in pasture yield were observed between plots dominated by buffel grass (*Cenchrus ciliaris*) 45 months post-treatment, although pasture yield tended to be approximately 2% lower in plots infested with bellyache bush, compared to plots without this weed. Bellyache bush mortality differed significantly between grazing regimes, irrespective of bellyache bush density. Less than 3% of bellyache bush plants died in plots void of pasture (pasture removed). In contrast, an average of 59% mortality occurred in no grazing, low, medium and high grazing pressure treatments. The trial is ongoing.

Funding and logistical support

Queensland Government

Expected completion

June 2007

Evaluating the risk of off-target damage through the application of chemicals to control hymenachne (*Hymenachne amplexicaulis*)

Objectives

- To investigate the rates of breakdown and movement of haloxyfop applied within northern Queensland water systems, using aquarium tanks and enclosed and open water systems.
- To establish residue levels of total haloxyfop in hymenachne and in non-target organisms, including fish, clams and crayfish.

Staff

Joseph Vitelli (Leader), Barbara Madigan, Kent Worsley (TWRC), Lesley Ruddle (NRSc)

Methods

Laboratory studies

Two 100 L glass aquarium tanks will contain either buffered sterile water (pH 7) or water and sediment from a creek system (~ pH 7) in northern Queensland. The tanks will be aerated and have aquarium lights on a 12 hour light/12 hour dark setting. Hymenachne, barramundi, freshwater mussels, redclaw, rainbow fish, fork-tailed catfish and purple gudgeons will be placed in each water tank. Water parameters (temperature, salinity, dissolved oxygen, pH, turbidity, conductivity) will be taken at commencement of treatment and at intervals during longer treatments. Verdict* 520 Herbicide equivalent to 400 g haloxyfop ha^{-1} will be sprayed on all hymenachne and the water surface. Ten minutes after treatment, 500 mL of tank water will be removed for analysis. At sampling times of 1, 3, 10, 31, 100, 316, 1000 and 3163 hours, water (from both field water and sterile water tanks) and sediment samples will be taken, and aquatic organisms will be harvested and analysed for haloxyfop-R methyl ester and haloxyfop acid.

This research is being conducted under an animal ethics permit, PAEC 040501.

Field studies

In 2005 field studies will be conducted in four enclosed (e.g. dams) and three open (e.g. creeks) water systems in northern Queensland. Hymenachne, barramundi, freshwater mussels, redclaw, rainbow fish, fork-tailed catfish and purple gudgeons will be placed in floating cages in the closed water systems. Water parameters (temperature, dissolved oxygen, pH, and conductivity) will be taken before and at intervals after spraying. Verdict* 520 Herbicide equivalent to 400 g haloxyfop ha^{-1} will be sprayed on all hymenachne on the banks and the water surface in the closed systems, and on all hymenachne on the banks and the water surface for a stretch of 50 m in the open systems. In the closed systems, water (from the upper 15 cm and the lower 15 cm) and sediment samples will be taken at 1, 3, 10, 31, 100, 316, and 1000 hours after spraying. Aquatic organisms will also be harvested at those times and later analysed for haloxyfop-R methyl ester and haloxyfop acid. In the open systems, water samples will be taken at 1, 3, 10, 31, 100, 316, and 1000 hours after spraying from the sprayed section and also 100, 300 and 1000 m downstream. Water travel time will be monitored in each open water system prior to herbicide application.

Progress

Laboratory studies

This work has been completed. A summation of the results was provided in *Technical highlights 2004–05*.

Field studies

Field studies have been completed except for a final assessment. Samples are still being analysed for haloxyfop-R methyl ester and haloxyfop acid. Preliminary results for the haloxyfop concentration in water samples following herbicide application for enclosed and open water system are presented in figures 1 and 2. Haloxyfop concentration was significantly different between the upper and lower parts of the water column, with the difference becoming non-significant after 31 hours post herbicide application (Figure 3.4). Similarly, after 31 hours post herbicide application to open flowing water systems, no significant difference in haloxyfop concentration was observed at set distances along the stream, with values dropping to near zero for total haloxyfop concentration (Figure 3.5).

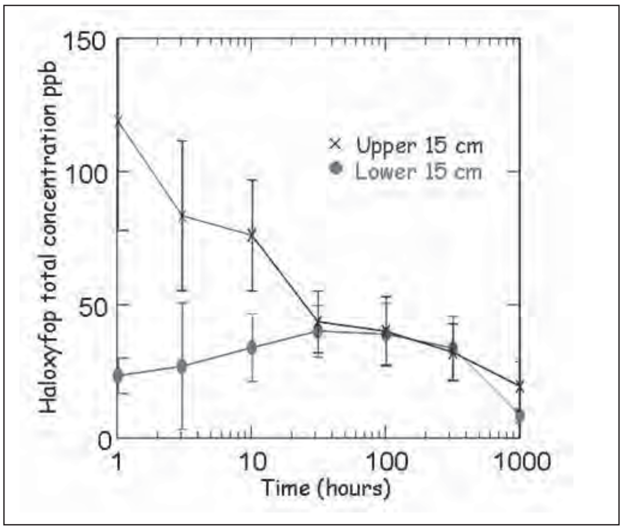


Figure 3.4: Total haloxyfop (ester plus acid) concentration measured over time at two depths in enclosed water bodies located in the Douglas and Cardwell shires. Haloxyfop was ground foliar applied to hymenachne-infested dams at a concentration of 400 g a.i. ha^{-1}.

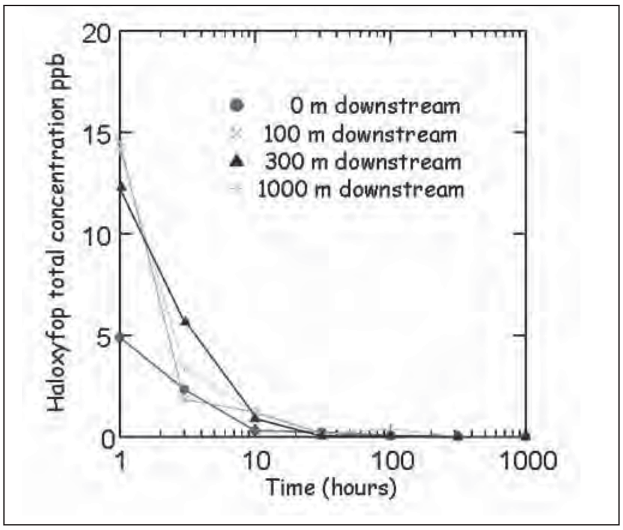


Figure 3.5: Total haloxyfop (ester plus acid) concentration measured over time at four locations in a flowing stream located in the Douglas Shire. Haloxyfop was ground foliar applied to a hymenachne-infested stream at a concentration of 400 g a.i. ha^{-1}. Haloxyfop concentration at 0 m immediately following application was ~ 115 ppb.

Funding and logistical support

Natural Heritage Trust
Queensland Government

Expected completion

November 2006

Aerial control of bellyache bush (*Jatropha gossypiifolia*)

Objectives

- To evaluate a range of herbicides and rates for aerial control of bellyache bush, leading to registration.
- To evaluate the efficacy of two herbicides for pre-emergent control of bellyache bush.

Staff

Joseph Vitelli (Leader), Barbara Madigan, Faiz Bebawi, Carl Andersen, Kitty Davis (TWRC)

Collaborators

Fiona Barron, Deborah Eastop (Mitchell River Watershed Management Group, Inc.); Trevor Meldrum, Russell Graham (Cook Shire Council, Cape York Weeds and Feral Animal Program); Don Tudehope (Dwyer Aviation Services)

Methods

Field trial

Ten 1 ha plots along the Palmer River in northern Queensland (S15° 57', E144 ° 2') (Figure 1) were sprayed with either metsulfuron (DuPont™ Brush-Off® brush controller) at 72 g ha^{-1} or triclopyr/picloram (Grazon* DS Herbicide) at 450/150 g ha^{-1} at 200 L ha^{-1} carrier spray volume in a complete double overpass. Both treatments included Uptake* as a wetting agent at 2 L ha^{-1}. One hundred (100) bellyache bush plants in each plot were measured and tagged, with approximately one third of the plants in each of three size classes (<25, 25-50 and >50 mm basal diameter). Five permanent transects (10 m long) containing 10 permanent quadrats (50 cm x 50 cm) each were also placed within the 10 plots to determine trends in seedling recruitment and survival. Plants were assessed for mortality 200 days after treatment. Assessments were also made of seedling recruitment and survival.

Pot trial

Pots containing 50 bellyache bush seeds and a measured weight of soil at a known soil moisture content were treated with two herbicides: metsulfuron (DuPont™ Brush-Off® brush controller) at 1152, 576, 288, 144, 72 and 36 g ha^{-1}; tebuthiuron (10% formulation) at 2000, 1000 and 500 g ha^{-1} and a control). Each treatment was replicated four times. At selected days after application, each treatment was subjected to 21 simulated rainfall events to total 280 mm rainfall (average summer rainfall for Charters Towers) over a 90 day period. Gravimetric soil moisture contents of pots were recorded twice a week, emerging bellyache bush seedlings were recorded and marked, and any mortality of emerged seedlings was noted. All seedlings were then removed from the pots and any remaining seeds at the end of the experiment were retrieved and tested for viability.

Progress

Field trial

There was 100% mortality of bellyache bush plants in all plots that had been established in November 2005 at Palmer River. This cannot be attributed solely to the herbicide treatments, however, as all tagged control plants were also dead. No significant differences were detected between the controls and herbicide treatments in the recruitment and seedling survival transects. However, recruitment was 10% of the original population over all herbicide treatments. Extensive flooding of the Palmer River in March and April 2006 resulted in submersion of all bellyache bush plants for a week or more, leading to total mortality. Observations made in the different plots indicated that there was less seedling emergence in areas that had been sprayed compared to non-sprayed plots, and more grass cover in sprayed plots.

Pot trial

Mortality in all metsulfuron and tebuthiuron treatments was >80%. A further trial will be carried out to validate these findings.

Funding

Queensland Government

Weeds CRC

Logistical support

Mick Callaghan (Yambo Station)

Howard Kingsley (Mt Mulgrave Station)

Expected completion

December 2007

Bellyache bush plants growing in the Palmer River (arrows indicate bellyache bush infestations).

Herbicide screening, refinement and registration for southern Queensland

Objectives

- To investigate and assess herbicides and other methods of controlling priority weeds.
- To minimise pesticide dosages through improved application techniques and strategies.

Staff

Earl Sparkes (Leader), Paul Shortis, Trevor Armstrong, Michele Rogers (AFRS)

Methods

The herbicide screening process incorporates testing of a large number of formulations against targeted weeds. Screening may also involve the use of new herbicide application techniques. Replicated trials refine methods that were successful during the screening process. From these trials, the most effective herbicides, rates and methods of application are registered or off-label permits are sought from the APVMA. Off-target damage is minimised through improved application techniques and strategies.

Progress

This project was completed during 2005–06 and a final report for the project is provided below.

Umbrella tree (*Schefflera actinophylla*)

A third trial that further evaluated the effects of herbicides and control techniques on both large and small plants was completed on the Sunshine Coast. Results indicated that imazapyr, metsulfuron-methyl and glyphosate were active compounds for control of this weed.

Climbing asparagus (*Asparagus africanus*)

A paper describing the effects of 18 different treatments, including different techniques (mechanical, cut stump, basal bark, foliar spray and splatter gun), herbicides and application rates has been published (Armstrong et al., 2006, *Plant Protection Quarterly*). Highest mortality was achieved by removing the plant and placing it above the ground surface. Basal bark spraying of 24 g triclopyr ester (40 mL Garlon® 600) or 10 g fluroxypyr ester (50 mL Starane® 200) L^{-1} diesel and cut stump application of neat diesel or 225 g glyphosate (500 mL Glyphosate® CT) L^{-1} achieved the best chemical control.

Quilpie mesquite (*Prosopis velutina*)

A paper entitled 'Effects of plant height and water availability on response of *Prosopis velutina* to a selection of herbicides applied by the basal stem method' was presented by Earl Sparkes at the Asian Pacific Weed Science Society Conference in Vietnam and was published in the conference proceedings.

Permit renewals

Senegal tea (*Gymnocoronis spilanthoides*) Permit renewed —APVMA No: PER 8551 until 30 June 2011.

Funding

Queensland Government

Expected completion

Completed

Water weed management, WONS and Class 1 plant pests

Objective

To develop eradication strategies for cabomba (*Cabomba caroliniana*), Senegal tea plant (*Gymnocoronis spilanthoides*), hygrophila (*Hygrophila costata*) and alligator weed (*Alternanthera philoxeroides*).

Staff

Tom Anderson (Leader) Michele Rogers (AFRS)

Methods

Evaluation of potential improvements in eradication methods is undertaken. Research has focused on:

- field evaluation of carfentrazone herbicide against cabomba
- improving efficacy by developing new chemical delivery systems
- Senegal tea plant control using picloram products
- improving chemical biodegradability.

Replicated glasshouse screening trials, followed by field studies, are used to gather efficacy data. The project is a partnership between community environmental groups, local government and affected landowners.

Progress

Cabomba

Carfentrazone herbicide was effective against cabomba in glasshouse trials. Field sites were selected at Albany Creek, Brisbane and Little Springs, Noosa. These field tests indicate that carfentrazone is very effective at controlling cabomba with one application.

A glasshouse trial investigating the use of commercial bacteria for herbicide breakdown confirmed that carfentrazone has a very short half life in water.

Senegal tea plant

A glasshouse trial examined the efficacy of triclopyr and picloram herbicides against Senegal tea plant, hygrophila and alligator weed. Alligator weed proved to be the most difficult to control, with triclopyr not as effective as picloram. Combinations of triclopyr and picloram were no better against this weed. Hygrophila was susceptible to triclopyr but several plants survived picloram applications. None of the 168 Senegal tea plants used survived triclopyr, picloram or combinations thereof.

Field trials at a Strathpine grazing property confirmed picloram to be effective against Senegal tea plant. In addition, picloram is selective towards native sedges. Twelve months after treatment, competition from healthy sedges and the residual nature of picloram has kept the trial site relatively free of this weed.

Funding

Environment Australia NHT

Queensland Government

Land Protection Fund

Logistical support

Lake Macdonald Catchment Care Group

Noosa Council

Pine Rivers Shire Council

Expected completion

Ongoing

Chapter 4: Chemical research

Monitoring impact of 1080 canid baiting on spotted-tail quolls

Objective

To assess the impacts of wild dog baiting programs on a native species, the spotted-tail quoll (*Dasyurus maculatus*)

Staff

2005–06: Peter Cremasco, Amelia Selles, Tony King

2002–05: Bob Parker, Peter Elsworth, Michael Brennan, Gina Paroz

Collaborators

Cherrabah Homestead Resort; Stephanie Myer-Gleaves (Griffith University PhD candidate); Mark Weaver (Qld EPA Parks and Wildlife Service); Geoff James (NSW Parks and Wildlife Service), Peter Fleming (NSW Department of Primary Industries)

Background

Baiting with 1080 meat baits is recognised as a major tool in controlling wild dogs and other pest species such as foxes. There is a perception that 1080 impregnated meat baits also pose a threat to native fauna such as the carnivorous marsupial, the spotted-tail quoll (*Dasyurus maculatus*). Previous research conducted elsewhere in Australia highlighted the risk posed to the quoll, and gave rise to calls to curtail the use of 1080 where native fauna was threatened.

A review revealed that key components of the previous research were possibly fundamentally flawed or incorrectly interpreted. We set out to utilise a suite of methods that would reveal more accurately the extent of risk to quolls exposed to 1080 wild dog baits.

Methods

We located suitable populations of quolls in areas where wild dog baiting programs were planned. We trapped quolls, tagged individual animals with microchips, and fitted each animal with a radio-transmitter/collar. Radio-collars enable us to locate each animal within the study area. Additionally, these radio transmitters are equipped with mortality indicators, which emit a signal if movement ceases for 8 to 12 hours.

The movement and fate of quolls is monitored throughout 1080 baiting operations, and for up to one month after baits have been deployed. Any animals that die are recovered, and sent for pesticide residue analysis. Additionally, baits are either placed on footprint plots, to allow identification of animals that interact with baits, or implanted with a radio-transmitter to allow us to follow any movements of baits by animals. Predator indices are taken before and after baiting, so that the effectiveness of baiting on target animals can be evaluated.

Approximately one month after the deployment of baits, collared animals are recaptured and collars removed. During the course of this project, we have also collected DNA samples for population genetics studies, and morphological data that contributes to a PhD project.

Progress

Monitoring of two autumn and two spring 1080 baiting campaigns has been completed for a population in southern Queensland (Figure 4.1). This population has shown no decline in the four years of monitoring and, of more than 70 animals radio-collared, only two animals succumbed to 1080. Further monitoring of an autumn baiting on a second population in the same bioregion is nearing completion. No animal mortalities due to 1080 have been discovered. Despite the fate of all animals not yet having been determined, it appears likely that 1080 baiting has had no impact on either of these quoll populations.

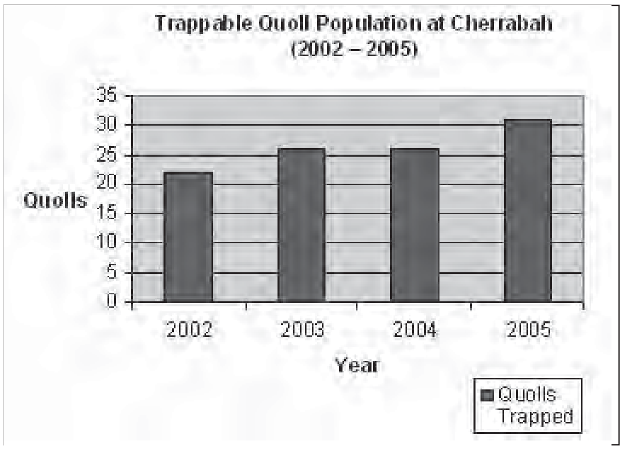


Figure 4.1: The annual number of spotted-tail quolls (*Dasyurus maculatus*) trapped

This spotted-tail quoll (*Dasyurus maculatus*) has not been affected by 1080 baiting programs in the area.

Funding

Queensland Government

Bureau of Resource Sciences, National Feral Animal Control Program

Expected completion

The project is scheduled for completion in December 2006

Effective 1080 meat baiting for feral pigs

Objectives

- To assess the amount of 1080 in meat baits required to kill feral pigs.
- To investigate the longevity of 1080 and substrate for pig meat baits.
- To undertake a field assessment of the efficacy of feral pig baiting using a quantitative biomarker to assess multiple bait uptake by feral pigs

Staff

Matt Gentle (leader), Peter Elsworth, James Speed (RWPARC), Jim Mitchell, Bill Dorney (TWRC), Bob Parker (AFRS)

Background

Baiting of feral pigs with 1080 meat baits is undertaken for broad scale reductions and is recommended in the event of an exotic disease outbreak. Much of the variation in the success of current baiting practices (31–81% population reduction) may be due to variations in bait uptake due to bait density, bait location or seasonal conditions. A low overall level of reduction may result from pigs consuming insufficient bait to receive a lethal dose. It is therefore essential to have a greater understanding of how baits are consumed by feral pigs at a particular bait and pig density. This information, when combined with the lethal dose required, will indicate whether the poor levels of reduction are due to insufficient toxin or failure of feral pigs to consume bait. Additionally, we do not know for how long meat baits with 72 mg 1080 will remain toxic. This information is required to ensure that baits that are removed by pigs still contain lethal amounts and to ensure that meat baits do not offer a long-term hazard to non-target animals.

Methods

Pen toxicity trials have been done using standard procedures. There may be differences in the susceptibility of penned feral pigs compared to free-ranging feral pigs, so field experiments with aerially applied baits have been undertaken to assess the field efficacy of 1080.

Estimating bait uptake in free-ranging pigs has been undertaken by aerially baiting with non-toxic meat baits containing a quantitative biomarker (rhodamine WT). A shot sample of the population is taken within days of bait distribution. A blood sample is removed from each individual and analysed for the presence and concentration of the biomarker, providing estimates of the proportion of the population that consumes bait, and the quantity of bait that is consumed.

To estimate the longevity of 1080 in pig baits, meat pieces with 72 mg 1080 have been presented in the field for specific periods before being collected and assayed for 1080 concentration. This has been done within a range of Queensland environments that represent areas where aerial baiting is occurring.

This is being undertaken under Animal Ethics Approval No. PAEC 040803

Progress

Toxicity trials: pen trials

Toxicity trials have been conducted on 28 adult feral pigs. Pigs consumed doses of 1080 in meat bait ranging between 2.5 and 3.5 mg kg^{-1} bodyweight. The results have confirmed that the lethal dose of 1080 to kill most feral pigs (defined here as 90%) is greater than 3.0 mg kg^{-1} bodyweight, confirming our suspicions that feral pigs require a relatively large amount of 1080 for a lethal dose. No difference was detected between the susceptibility of feral pigs maintained in pens (i.e. captive) compared to paddocks (i.e. simulated free-ranging). Furthermore, the results indicate that feral pigs are highly variable in their response to 1080. It is this natural variation in susceptibility to 1080 that will have implications for baiting practices.

Aerial field baiting trials

In September 2005 a field trial was conducted at 'Inverleigh', a cattle grazing property west of Normanton in the gulf savannah country of northern Queensland. Aerial surveys, shooting, sample collection and post-count aerial surveys were undertaken successfully. Aerial surveys indicated that our original, unmeasured estimate of pig density (4 pigs km^{-2}) was too low, with between 7.96 pigs km^{-2} (index-manipulation method) and 12.2 pigs km^{-2} (aerial count index method) present at the time of baiting. This meant that the amount of bait material available for uptake by feral pigs equated to between 2.3 and 3.6 baits per pig. Preliminary chemistry results indicate that 58% of pigs tested had consumed at least one bait, as evidenced by the presence of rhodamine WT (RWT). This level of uptake (58%) for the given bait relative to pig density is similar to the results from previous work on feral pig baiting with meat (J. Mitchell unpublished data). Results from the pen trial will used to quantify the number of baits consumed per pig.

A similar trial was undertaken near Moonie in a grain-production environment in July 2006. A density of 1.4 pigs km^{-2} was estimated from the aerial survey pre-control, declining to 0.6 pigs km^{-2} following the aerial shoot. This is a similar density to previous recorded estimates in such habitats (e.g. Goondiwindi). Preliminary chemistry results indicate that approximately 40% of pigs tested had consumed at least one bait, as evidenced by the presence of RWT.

A third trial will be undertaken at 'Inverleigh' in north Queensland, where the original aerial trial was completed in September 2005. This will replicate the original trial after 12 months, providing valuable additional information such as the response of the pig population to previous control.

Meat containing the biomarker Rhodamine WT has been loaded into a light aircraft in preparation for aerial bait distribution, 'Inverleigh', Normanton.

Helicopter mounted with distance-interval marked booms as used in aerial surveys for feral pigs.

Development of a quantitative biomarker

Critical to the success of the field assessment was the identification, and incorporation of a quantitative biomarker into meat bait. Iophenoxic acid has been used previously as a biomarker, but it is prohibitively expensive and may not adequately quantify bait intake. The usefulness of RWT, a derivative of rhodamine B, has been proven in trials involving mice and goats. It can be quantitatively measured in blood plasma using a fluorometer (to measure fluorescence). Pen trials on captive feral pigs indicated that RWT acts as a quantitative biomarker for up to 3–4 days (see Figure 4.2).

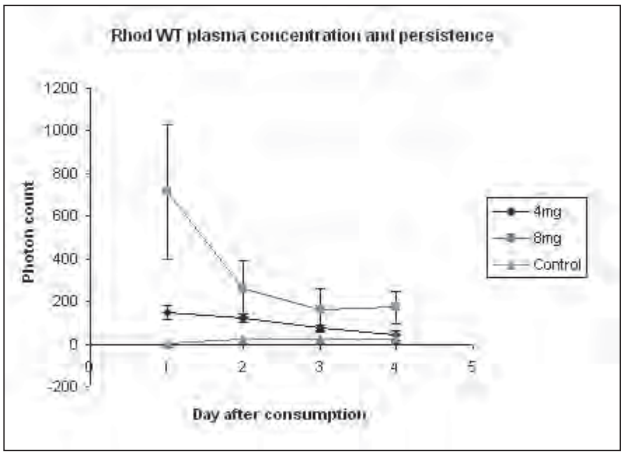


Figure 4.2: The mean photon count for pigs given 4 mg kg^{-1} (4 mg), 8 mg kg^{-1} (8 mg) Rhodamine WT and for procedural controls (Control). Error bars indicate standard deviation.

The results from the initial trials showed that at higher concentrations (i.e. 8 mg/kg), the variation in photon counts in individuals was considerable. Observations from these trials may help to explain this; baits injected with larger amounts of RWT solution showed some signs of leakage. This leakage meant that it is difficult to determine the amount that remains in the bait; some animals may have received less than the specified amount of RWT.

Leakage can be largely prevented by injecting a smaller quantity of solution. However, given the solubility of RWT, this would be impractical where higher amounts need to be injected, necessitating the injection of larger amounts of solution. As a result, direct insertion of the powder into meat was examined as a strategy to reduce leakage. An additional six pigs (3 males, 3 females) were presented with the RWT powder inserted into a gelatine capsule. After the capsule is inserted into the meat, the gelatine softens and binds to the meat, or dissolves, leaving the RWT powder to mix with the meat. Analysis of these results is pending; results will help to determine whether this technique is suitable for presentation of RWT or, in fact, other powders into meat baits.

Bait degradation trials

Bait degradation trials have been completed at Cunnamulla, south-western Queensland and South Johnstone and Lakeland Downs, northern Queensland. Preliminary analyses indicate that environmental influences result in marked differences in the rate of 1080 bait degradation. For example, pig meat baits may contain significant amounts of 1080 for periods from less than one week (South Johnstone) to several months (Cunnamulla), depending on local conditions. Detailed analyses will be completed when the results of laboratory analyses are available.

Funding and logistical support

Queensland Government funding

Bureau of Rural Sciences National Feral Animal Control Program

Expected completion

February 2007

Development of cyanide bait for rapid disease sampling and surveillance of feral pigs and foxes

Objectives

- To develop an effective formulation of cyanide for incorporation into current and likely (commercially manufactured) bait substrates for feral pig control.
- To develop an effective delivery technique.
- To demonstrate the efficacy of the bait on captive feral pigs, and if successful, undertake preliminary field trials to test efficacy.
- To conduct preliminary determinations of the delivery techniques for other species, specifically foxes.

Staff

Matt Gentle (leader), Peter Elsworth (RWPARC), Bob Parker (AFRS).

Collaborators

Duncan McMorran, Paul Aylett (Connovation Pty Ltd.), Glen Saunders, Department of Primary Industries (NSW)

Background

Feral pigs pose a significant threat to livestock producers and public health as carriers of endemic and exotic diseases. Improved techniques for feral pig control, disease surveillance and sampling would be highly beneficial for exotic disease contingency planning and managing the impacts of this serious vertebrate pest. Current toxins registered for use in Australia have long latent periods, making them unsuitable for disease surveillance purposes. The use of potassium cyanide as a feral pig toxin for such purposes appears promising; trials on captive feral pigs have shown that it is fast-acting and pigs are highly susceptible to its effects. This project aims to improve the means of cyanide delivery for feral pig control. The application of the technique will be assessed for use with other species, particularly the fox.

Methods

An effective formulation and delivery technique is being developed in collaboration with Connovation Pty Ltd, New Zealand. Connovation have developed commercially manufactured cyanide products for possums in a number of presentation mediums (pellets, paste, block and cereal matrixes). Such products may be used as a basis for developing a suitable delivery system for feral pigs. Formulations may include: 1) a cyanide powder that disperses into the pig's mouth; 2) 'sticky' or 'chewy' compounds to reduce the chance of pigs ejecting the cyanide once bitten into; 3) different capsule shapes such as rods or cylinders; and 4) a range of product types—paste or powder.

Testing of suitable products is being undertaken on captive feral pigs at RWPARC, Inglewood. Captive feral pigs are presented with each product within a suitable bait substrate and observed to determine: 1) whether the product is consumed and the nature/level of consumption; and 2) the lethality of the product.

Conditional on successful results, the best package from the pen trials will be tested on free-ranging feral pigs. The application of the technique will also be assessed for use with other species, such as the fox.

This work is being carried out under Animal Ethics Approval No. PAEC 050702.

Progress

Preliminary trials using brittle wax and gelatine capsules containing potassium cyanide were largely unsuccessful due to problems with either acceptance by pigs or delivery. These trials indicated that a means of masking the odour and/or taste of cyanide is required to deliver an adequate dose of cyanide effectively.

As a result, new prototype baits were developed and tested. In these trials, 11 individually housed feral pigs were presented with a small number of non-toxic baits containing three different flavours over three feeding sessions. The non-toxic baits were palatable to all pigs, and were extensively chewed before swallowing. The effectiveness and toxicity of potassium cyanide baits was determined in eight of these pigs by offering them a single toxic bait. Two bait types were tested: Bait A was 45 mm x 20 mm in size and contained up to 1.5 g cyanide. Bait A was presented to five pigs (four baits contained 1g cyanide and one 1.5 g cyanide). Bait B, a smaller bait (30 mm x 20 mm) was presented to three pigs (all three baits contained 1g of cyanide).

Bait A was highly effective; all five feral pigs died after chewing on the bait. The smaller sized Bait B was effective in only one pig out of three. Bait B was not chewed to the same extent as Bait A, with two of the animals chewing for a short period before rejecting the bait. This may have reduced the spread of cyanide around the animal's mouth, increasing the likelihood that the bait would be swallowed or rejected. The more concentrated cyanide formulation used in Bait B may have been easier to detect, leading to bait rejection by the pigs. Bait A appears to be a promising formulation and presentation of cyanide, and has overcome many of the issues associated with poisoning feral pigs with this toxin. Pen and field trials are needed to determine efficacy, target specificity and stability of the product.

Funding and logistical support

Queensland Government funding

Wildlife and Exotic Disease Preparedness Program

Bureau of Rural Sciences

Department of Primary Industries (NSW)

Expected completion

March 2007

Bait A, the prototype bait for delivering cyanide to feral pigs.

Rodenticide trials

Objective

To evaluate the potential of various overseas registered rodenticides for their use in Australian broadacre cropping and bulk grain storage systems.

Staff

Project Leader, Julianne Farrell, Zoologist

Peter Elsworth, District Experimentalist

Dallas Powell, Scientific Assistant

Bob Parker, Senior Chemist

Collaborators

The University of Queensland, Gatton

LaTrobe University, Melbourne

Bell Laboratories Inc.

Animal Control Technologies (Aust.)

GrainCorp Operations Limited

Grain farmers

Background

Currently, there is only one rodenticide registered for in-crop use. Grains industry stakeholders are concerned that if zinc phosphide were to be withdrawn, there would be no registered chemical to control rodents in crops.

There are several acute toxins and anticoagulants registered overseas, as well as unregistered Australian formulations that have the potential to be registered for use under Australian cropping and bulk grain storage conditions for the control of rodents.

This project was developed to evaluate each of the compounds under laboratory and field conditions for their potential for Australian registration through the APVMA (Australian Pesticides and Veterinary Medicines Authority).

Methods

Cage trials being conducted at Inglewood for each compound being evaluated include:

- Choice feed trials to assess palatability (x 20 mice, x 10 dasyurids)
- No-choice feed trials to assess toxicity (x 20 mice, x 10 dasyurids)
- Control: no treatment (x 20 mice, x 10 dasyurids)

Field trials: The number of experimental sites established will be determined by the number of compounds that prove sufficiently palatable and toxic (> 70% mortality) in cage trials. Each site will be trapped using Elliot live capture traps set in index lines, with traps set at 10 m intervals for three nights prior to baiting and three nights after baiting.

Permits

Small-scale (< 5 ha) on-farm trials—APVMA Permit No 7250.

Large-scale (> 5 ha) on-farm trials—APVMA permits pending for summer and winter crops.

Animal Ethics approvals:
PAEC No. 030605—Continued monitoring for best practice studies / plague prediction modelling.

PAEC No. 041102—Cage and field trials using diphacinone

PAEC No. 050801—Cage and field trials using bromethalin

EPA/QPWS Permit No. WISP03231205—Trap / monitor Central Qld Rat

UQAE No. SAS/047/05/GRDC—Source mice for cage trials from UQ breeding colony

UQAE pending—Field trials of bromethalin, diphacinone, cholecalciferol, zinc phosphide, bromadiolone and difenacoum

EPA/QPWS pending—Cage trials using captive-bred dasyurids

PAEC No. 060101—Encapsulated zinc phosphide, cage and field trials

PAEC No. 060602—Bromethalin and diphacinone cage trials using dasyurids

PAEC No. 060603—Field surveys of dasyurid populations in cropping areas

PAEC No. 060604 —Cage and field trials of wax block formulations of zinc phosphide, bromadiolone and difenacoum

Progress

Cage trials are ongoing and dependent on a regular supply of mice from the UQ breeding colony. The trial to assess palatability and toxicity of each compound takes 3–4 weeks to complete from the arrival of mice at the Inglewood facility.

Field trials will be started when sufficient populations of wild mice can be located, either in Queensland or interstate.

Funding

Grains Research and Development Corporation (GRDC)

Logistical support

RWPARC and AFRS staff: pot trial establishment and mice care.

Bell Laboratories, Inc and ACTA staff to assist with trapping during field trials.

Expected completion

March 2009

Infield collection of mice using Elliott live traps is ongoing.

Cage trials assessing palatability and toxicity of compounds is ongoing.

Recording mouse trait data is important for assessing the potential impacts of rodenticides.

Rodents in crops can greatly affect the yield.

Pest management chemistry

Objectives

- To provide advice on the use, impact and environmental toxicology of vertebrate pesticides and herbicides to support their effective and responsible use to manage pest animals and weeds.
- To undertake registration, manufacture and quality assurance of chemical pest control products used to manage pest animals and weeds.

- To undertake chemical ecology research and analysis.

Staff

Bob Parker, Margie Cohn, Sam Cusworth, Martin Hannan-Jones, Simon Munro, Michele Rogers, Lesley Ruddle, Alyson Weier, Jo-Anne Webster

Background

The main purpose of this project is to provide chemistry services to Pest Management Research and Land Protection business. The project maintains a laboratory at AFRS and makes use of facilities at other research stations and field sites.

Progress

Chemical ecology

Iophenoxic acid is used as a biomarker in bait consumption studies on wild animal populations. This laboratory measures the presence of iophenoxic acid either indirectly through total blood iodine or directly as an analyte in blood sera. During the year three large studies were undertaken for iodine blood markers as part of bait consumption studies on feral pigs (*Sus scrofa*).

Eco-toxicology

As part of a broader study on controlling the aquatic weed cabomba (*Cabomba caroliniana*), we conducted a study on the degradation of the herbicides 2,4-Dichlorphenoxyacetic acid and carfentrazone-ethyl in water. We investigated the effects of adding pesticide-degrading bacteria to the water to deal with herbicide contamination. This treatment enhanced the levels of decline of both herbicides, but with a greater impact on carfentrazone-ethyl.

We developed methodology to determine levels of the herbicide, haloxyfop-methyl in water, fish, crustacea, molluscs, plant material and sediment. We used this method to provide field residue data to demonstrate the fate of haloxyfop methyl in the environment. Haloxyfop-methyl is used to control hymenachne (*Hymenachne amplexicaulis*), a semi-aquatic perennial grass that is currently invading natural wetlands and land used to grow sugar cane in northern Queensland. National Association of Testing Authorities (NATA) registration is being sought for our method, which is based on solvent extraction of the herbicide and measurement using a gas chromatography-mass spectrometer system.

The group is undertaking laboratory investigations for the development of a model for the degradation of 1080 baits in the environment. Work is still progressing, with 363 environmental samples analysed this year. In addition we conducted studies on the decomposition of baits in protected areas for the NSW Department of Environment and Heritage.

Forensic toxicology

We undertook a total of 127, 49 and 13 investigations relating to suspected sodium fluoroacetate, strychnine and anticoagulant poisonings, respectively. We found only 21, or 17%, of the sodium fluoroacetate investigations to be positive. Whilst the number of investigations increased (up 40% on the previous year), the percentage of confirmations decreased. A study over the three-year period ending 2004 showed a 39% confirmation level. For strychnine and the anticoagulants we found only three for each set (6% and 23% respectively) to be positive.

Formulation chemistry and registration

The department maintains a strong testing program to ensure that sodium fluoroacetate baiting in Queensland meets agreed standards. To this end we tested 100 sodium fluoroacetate solutions and 70 fresh meat baits across the year. Pigout™ is being developed by the Invasive Animals CRC and their industry partner, Animal Control Technologies Australia, as a new sodium fluoroacetate containing bait for feral pigs. This laboratory is playing a significant part in this development, including input into the development of the formulation and testing of its performance. We also conducted studies on pindone rabbit bait formulations. A registration package is in development for the use of cyanide ejectors to control wild dogs and foxes. We submitted a data summary to the Australian Pesticides and Veterinary Medicines Authority (APVMA), requesting a ruling on what modules need to be addressed. Their response has allowed us to identify the exact detail of the submission and this is now being prepared.

Funding

Queensland Government
Bureau of Rural Sciences

Expected completion

Ongoing

Chapter 5: Animal management research

Adaptive management of rabbits

Objectives

- To improve measurement of the impact of rabbits and the effectiveness of rabbit control programs.
- To establish landholder driven, scientifically monitored rabbit control programs.
- To use these as demonstrations to promote the use of effective rabbit control.

Staff

David Berman (leader), Peter Elsworth, James Speed

Background

In 1996 rabbit haemorrhagic disease virus (RHDV) spread across Queensland and reduced rabbit numbers by at least 70%. There are signs that rabbit populations are recovering. Reports are coming from areas where rabbits have never been a problem before. Rabbits may be developing or have developed genetically based resistance to RHDV as well as myxoma virus.

Most disturbing is an increase in the number of outbreaks within the Darling Downs Moreton Rabbit Board Area, where rabbits have never been allowed to establish and where native plants and animals and agriculture have been protected from the impact of rabbits for over 100 years since rabbits arrived in Queensland.

Rabbit control using biological agents or poison, without destruction of warrens, generally provides only short-term reduction in rabbit numbers. This was demonstrated during experimental releases of RHDV on carrot bait. An isolated rabbit population at Kingaroy was wiped out in six days after releasing RHDV on carrot bait. However, the warrens were not destroyed and the rabbit population had re-established within two years. Other less isolated populations recovered within months of virus release.

This work demonstrates that rabbits recover after control unless their breeding places (e.g. warrens, holes under concrete slabs) are destroyed.

Current research

The reasons for the increase in rabbits need to be identified and a solution discovered to prevent rabbits from becoming the problem that they once were. Rabbit control needs to be as focused and efficient as possible. The importance of identification of the source of rabbits (key breeding places) and targeting control in these areas will be determined. Scientifically monitored rabbit control programmes are being established in and around the Darling Downs Moreton Rabbit Board Area. These will:

- demonstrate the importance of control activities in key breeding places.
- assess the value of genetics as a tool to identify key breeding places and
- measure the cost of eradication of small isolated rabbit populations.

The sites selected and data collected will become the foundation of a study to measure the benefits of rabbit control to biodiversity and agriculture/pastoralism in the south east of Queensland.

Establishment of scientifically monitored, landholder driven control programmes is an excellent way to demonstrate the best techniques and encourage rabbit control. These programmes will show the best techniques, the benefits of controlling rabbits and the dangers of doing nothing.

Genetics

Preliminary studies to assess the value of DNA technology as a tool for improving the efficiency of rabbit control have been completed. The method showed populations close to each other were genetically separate so that eradication may be possible without fear of re-invasion. Results also indicate that there have been some recent introductions of rabbits into the Darling Downs Moreton Rabbit Board area. Some rabbits may have been there for a long time, while others appear to be more closely related to rabbits from populations outside the rabbit proof fence. Further genetic work, testing rabbits from a greater number of sites, is required to obtain a more reliable understanding of the distribution and movement of rabbit populations.

Virus resistance

A study has commenced in the small mammal house at Inglewood to determine whether rabbits have developed genetically based resistance to RHDV. Young rabbits from all Australian states and territories are to be tested.

Bulloo Downs

On Bulloo Downs 48 000 rabbit warrens were ripped between 2000 and 2003. These warrens were ripped in the areas presumed to be refugia for rabbits during drought. Rabbits seek areas close to water during extreme drought conditions. Bulloo Downs is now into a sixth consecutive year of below average rainfall. Drought conditions and destruction of the rabbits' drought refuge have combined to reduce rabbit numbers to very low levels.

To determine the relative contribution of drought and ripping to the reduction in rabbit numbers, counts conducted at Bulloo Downs were compared with counts conducted at Coongie lakes in north-eastern South Australia (Figure 5.1). These areas are very similar in many ways. Both are suffering severe drought. Both have a combination of sand dune and clay flats subject to inundation from floodwater that falls hundreds of kilometres away. Bulloo Downs is flooded by the Bulloo River and Coongie by the Cooper Creek. The catchments of these two watercourses start in a similar part of Queensland and are influenced by similar rainfall events.

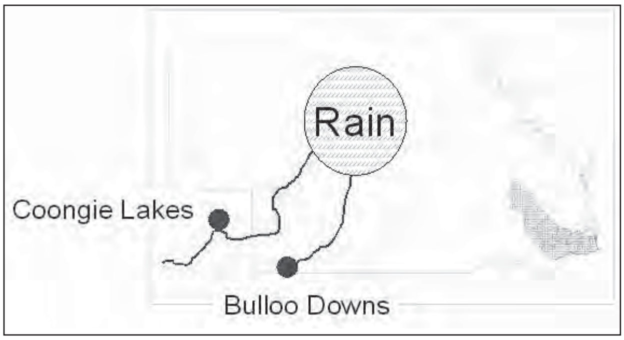


Figure 5.1: Bulloo Downs and Coongie Lakes are flooded by the same rainfall events. Both have a combination of sand dune and clay flats subject to inundation by flooding from hundreds of kilometres away.

Prior to rabbit control commencing on Bulloo Downs, rabbit numbers at Bulloo and Coongie were similar. In November 2005 there were 0.1 rabbits per kilometre of spotlight transect, while at Coongie there were 7.5 rabbits per kilometre of spotlight transect. At Coongie the drought appears to have suppressed rabbit populations by around 50%. The combination of drought and ripping at Bulloo has reduced rabbit numbers by 99% (Figure 5.2).

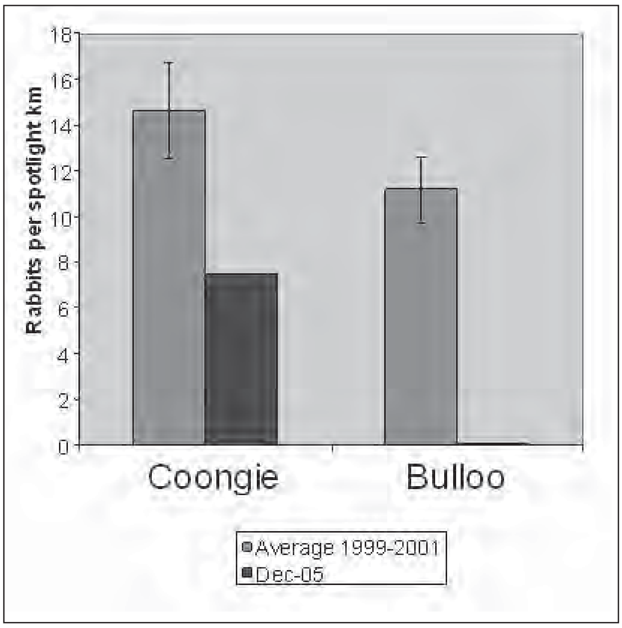


Figure 5.2: A combination of destruction of rabbit warrens in drought refuge areas and drought have suppressed rabbit numbers by 99% at Bulloo Downs. Drought alone suppressed rabbit numbers by 50% at Coongie Lakes.

This work provides more support for the belief that warren ripping is the most valuable rabbit control technique. Where there is no ripping, rabbits maintain healthy populations and will recover from biological or chemical control or drought.

It still remains to be seen whether rabbits recover from the drought on Bulloo Downs. Surveys of warren activity and spotlight counts were conducted in July 2006. There has been no reopening of ripped warrens and rabbit numbers are still very low (0.1 per km) but the active burrows found suggest that rabbits are very slowly spreading from the few isolated pockets where they survived the drought and ripping.

There is no need for landholders to suffer the damage caused by rabbits anywhere in Queensland because control methods are available. Further research is required to reduce the cost and increase the efficiency of control and to measure the cost of damage caused by rabbits so that landholders can better decide how much they can afford to spend on rabbit control.

Funding and logistical support

Land Protection Fund

Australian Wool Innovations

Invasive Animal Species CRC

Expected completion

Ongoing

Diet and trapping strategies for feral pigs in tropical rainforests

Objectives

(a) Diet

- To quantify the diet of feral pigs in the Wet Tropics World Heritage Area (WHA).
- To determine the predatory impact of feral pigs on rare and threatened species.
- To quantify the catch/effort effectiveness of hunting as a control technique.
- To quantify the potential of feral pigs to distribute weed seeds.

(b) Trapping strategy

- To enhance the effectiveness of trapping as a feral pig control technique.
- To develop a trap bait strategy package.
- To develop innovative control techniques suitable for rainforest environments.
- To integrate a trap bait strategy package with feral pig ecological information to further develop a feral pig management plan.

Staff

Jim Mitchell (Leader) (TWRC), Bill Dorney (CWTA)

Background

Diet

Feral pigs are regarded as a significant threat to the conservation values of the WHA. They are also perceived to threaten rare and endangered animal and plant species, although few quantitative data are available. This project will determine the diet of feral pigs and specifically examine their effects on threatened species. Another component will establish if the conditioned avoidance technique can be used to alter the food preference of pigs and subsequently protect rare and threatened species from predation.

Trapping strategies

Management techniques for feral pigs in rainforest environments are poorly developed and restrictive in scope. Trapping is considered the most effective technique for controlling pig populations. This project aims to enhance this control technique by increasing the capture rate, target specificity, encounter rate and envelope of control, while decreasing trapping effort and associated costs. A trapping strategy will be developed which will examine components of a trap-baiting package, such as carrier material, attractants, presentation and delivery systems.

Additional innovative control techniques are being developed. Rubbing posts are being tested as potential attractants to entice pigs into control areas or into traps. Watering systems using flavoured toxin-laced water are being investigated as a potential species-specific and low labour technique. Additional information on all aspects of feral pig ecology is being collected, as this is vital for the continued development of management plans.

Methods

Diet

Feral pigs were caught within four habitat types (rainforest, coastal swamps, sugar cane crops, and banana crops) between Cardwell and South Johnstone. For each pig captured, biological data (morphometric measurements, reproductive status, presence of parasites and diseases, age, sex and weight) was recorded and 1 L of stomach content collected. The composition of the diet of individual pigs was then determined through volumetric and frequency-of-occurrence analysis of the gut samples. Species observed to be eaten by feral pigs have been collected in the field and reference samples preserved.

Trapping strategies

Large-scale field trials tested the attractability, palatability and encounter rates of various components of the trap bait system. Population density indices and seasonal distribution patterns were also obtained.

Progress

Diet

Stomach samples from 58 feral pigs taken from four broad habitat types contained a wide range of food items. Plant material was consistently the largest component, although small animals (both vertebrates and invertebrates) were also commonly found. There were significant differences in the diet of pigs between habitats, with animals found in cropping areas (sugar and bananas) generally having a higher proportion of plant material than those in rainforest and swamp habitats. Findings from previous local, national, and international studies examining feral pig and wild hog diets are consistent with these observations. Feral pigs within the wet tropics bioregion can be defined as generalist omnivores preferring plant material. They will, however, hunt small animals (both mammals and birds) and scavenge carcasses when the opportunity arises. A final report has been completed. This discussed the implications of feral pig diet selection in the wet tropics region in relation to ecological impacts and potential for development of improved control options.

Trapping strategies

Two hundred and fifty (250) permanent bait stations were established over 200 km of transect lines in the Koombooloomba and South Johnstone State Forest areas. Field trials have determined the frequency of visitations to and palatability of 22 potential attractants. Eleven field trials have been completed. Testing of commercial feral pig baits has been completed. No attractant or new bait material was shown to have higher visitation rates or improved palatability scores relative to the base bait material (waste bananas). Trials have confirmed that non-target bait take and low visitation rates of pigs to bait stations inhibit the use of toxin baiting as a control technique in the rainforest environment. Waste fruit (bananas) is the preferred trap bait material here.

Bait stations designed to enhance pig visitation rates have been established using flavoured water and rubbing posts; research is ongoing. A field trial to test an automatic recognition trapping system is planned. This recognition system will allow only target animals (pigs) to access traps.

Funding and logistical support

Rainforest CRC

Land Protection Fund

University of Queensland

Expected completion

June 2007

Chapter 6: Animal research modelling

Refinement of a 1080 bait degradation model

Objectives

- To undertake laboratory and field experiments to investigate the effects of temperature, rainfall, soil conditions and bait age on rates of 1080 loss due to microbial breakdown, insect consumption and leaching.
- To refine the preliminary bait degradation model to incorporate relationships between bait age (and moisture content) and rates of losses.
- To validate the revised version of the model through simulation of all available field data sets, including published information as well as field experiments.

Given the success of previous objectives, the model may be packaged into a user-friendly interface to be used by operational staff and trainers to predict and assess bait longevity.

Staff

Project leaders: Matt Gentle, Joe Scanlan (RWPARC) Bob Parker (AFRS); Peter Elsworth (RWPARC)

Collaborators

Alina Barkla/Stuart Barkla, Bill Dorney, Phillip Haywood, Anne-Marie Huey/Coby Seaborn, Vic Little, Jim Mitchell, Jamie Molyneux, Rod Oliver

Background

A preliminary model has been developed to quantify the 1080 degradation rate in meat baits used in dog and fox control. This model simulates the quantity of 1080 remaining in a bait depending on the effect of bait substrate, initial 1080 dose, presentation (e.g. buried vs. surface) and environmental variables (e.g. climate, soil type). Initial runs of the preliminary model have shown that this approach is likely to be successful, but have also highlighted many deficiencies in our knowledge about the degradation response in specific environments, climatic or soil conditions. This project aims to collect experimental data to improve our ability to model the rate of 1080 degradation.

Methods

An experiment has been initiated at RWPARC Inglewood to examine the impact of temperature and humidity on the rate of 1080 breakdown. Kangaroo meat was cut into 125 g pieces and injected with 1 mL of 1080 solution, to give 6 mg per piece of meat. The baits were then lightly coated with either black soil or sand and then placed on sand in trays.

Four situations were used: a cold room, with a temperature of 13°C and humidity of 90%; room conditions (temperature of 25°C and humidity of 30%); and two ovens with temperature of 50°C and humidity of 10% and 30% respectively. Baits were collected at 0, 1, 3, 7, 14, 21 and 28 days after the commencement of the experiment. Baits were frozen when collected and will be analysed for 1080. Regular observations were made of the 'condition' of the baits.

Factorial experiments have been conducted at RWPARC, Inglewood. Baits were placed on the soil surface or buried, and samples removed after varying intervals. As the rate of breakdown is expected to vary widely, the timing has, by necessity, varied between treatments. This will help define relationships that can be incorporated into the degradation model.

Departmental land protection officers and cooperating landholders have undertaken field trials in different seasons in representative regions of Queensland. These trials have involved producing baits and placing them in the manner that is 'normal' for their situation. Baits have been collected at varying intervals, depending on the anticipated rate of breakdown. Trials throughout Queensland have been done, including at the coastal north (South Johnstone), inland north (Charters Towers, Lakeland Downs) northern central (Cloncurry), coastal central (Yeppoon), inland central (Blackall), and inland southern (Inglewood and Cunnamulla) regions.

Relationships derived from theoretical considerations (from published sources) were incorporated into the preliminary model. A sub-set of the data from laboratory and outdoor trials will be used to refine the model. Once this has been done, the model will be tested against the remaining data to see if it can be used to predict the 1080 content of meat baits under other conditions.

Progress

The majority of samples from the trials are currently being analysed by the Pest Management Chemistry group, AFRS, Sherwood. Laboratory analyses of the samples from initial trials at four sites (Inglewood, Cunnamulla, Blackall and South Johnstone) have been completed as of mid-July 2006. Little further modelling can be done until samples from more sites are analysed.

Funding

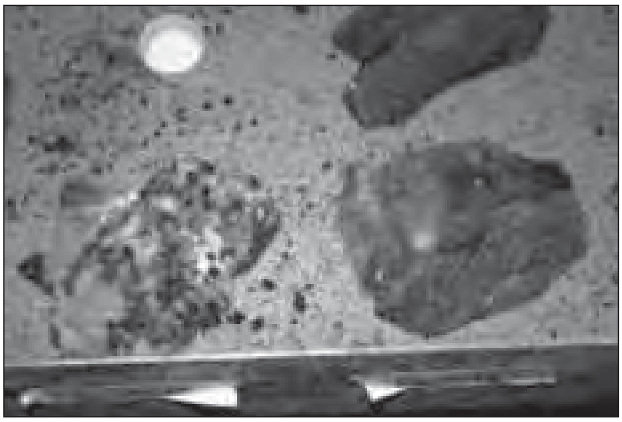
Natural Resources, Mines and Water
Bureau of Rural Sciences

Expected completion

By June 2007

Predator-proof enclosure to prevent the disturbance or removal of baits by animals and birds at Cloncurry, north-west Queensland.

Fresh kangaroo meat baits immediately after preparation.



Kangaroo meat baits showing growth of mould after 10 days at a temperature of 13 °C and 90% humidity.

1. Acronyms and other shortened forms

ACIAR	Australian Centre for International Agricultural Research
ACTA	Animal Control Technologies Australia
AFRS	Alan Fletcher Research Station, Brisbane
APVMA	Australian Pesticides and Veterinary Medicines Authority
AQIS	Australian Quarantine Inspection Service
CABI	Commonwealth Agricultural Bureau International
CCI	Cocoa and Coconut Institute
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CWTA	Centre for Wet Tropics Agriculture
DAE	days after emergence
DEH	Department of Environment and Heritage
DAFF	Department of Fisheries and Forestry
DNA	deoxyribonucleic acid
DPI&F	Department of Primary Industries and Fisheries, Queensland
EPA	Environmental Protection Agency
GRDC	Grains Research and Development Corporation
LPO	Land Protection Officer, Natural Resources and Mines
MOU	memorandum of understanding
NARI	National Agricultural Research Institute
NHT	Natural Heritage Trust
NRM	natural resource management
NRMMC	Natural Resource Management Ministerial Council
NRW	Department of Natural Resources and Water
NRSc	Natural Resource Sciences, Indooroopilly, Natural Resources and Mines
NSW	New South Wales
NZ	New Zealand
OPRA	Oil Palm Research Association
PAEC	Pest Animal Ethics Committee
PhD	Doctor of Philosophy
PNG	Papua New Guinea
ppb	parts per billion
PPRI	Plant Protection Research Institute, Pretoria, South Africa
QPWS	Queensland Parks and Wildlife Service
RHD	rabbit haemorrhagic disease
RHDV	rabbit haemorrhagic disease virus
RWPARC	Robert Wicks Pest Animal Research Centre, Inglewood and Toowoomba
RWT	Rhodamine WT
SAFS	South African Field Station, Pretoria
SPC	Secretariat for the Pacific Community
TWRC	Tropical Weeds Research Centre, Charters Towers
UK	United Kingdom
UQ	The University of Queensland
USA	United States of America
WHA	World Heritage Area
WONS	Weeds of National Significance

Symbols and units of measurements

°C	degrees Celsius
®	registered
™	trademark
pH	a measure of the concentration of hydrogen ions
g	gram
g a.i.	gram of active ingredient
mm	millimetre
cm	centimetre
m	metre
km	kilometre
L	litre
mL	millilitre
ha	hectare

2. Pesticide trade names, active ingredients and manufacturers

Name	Active ingredient(s)	Concentration	Manufacturer
Access®	triclopyr and picloram	240g/L and 120 g/L	Dow AgroSciences
Arsenal® 250A	imazapyr	250g/L	BASF
Banvel®200	dicamba	200g/L	CropCare
Brush-Off®	metsulfuron methyl	600g/kg	Du Pont
Garlon*600	triclopyr	600g/L	Dow Agrosciences
Glyphosate® CT	glyphosate	450g/L	Nufarm
Graslan*	tebuthiuron	200g/kg	Dow AgroSciences
Grazon* DS	triclopyr and picloram	300g/L and 100 g/L	Dow AgroSciences
Sempra® Herbicide	halosulfuron-methyl	750g/kg	Nufarm
Starane* 200	fluroxypyr	200g/L	Dow AgroSciences
Tordon* 75D	2,4-D and picloram	300g/L and 75g/L	Dow AgroSciences
Uptake*	paraffinic oil and alkoxylated alchohol non-ionic surfactants	582g/l and 249g/L	Dow AgroSciences
Velpar® L	hexazinone	250g/L	Du Pont
Verdict* 520	haloxyfop	520 g/L	Dow AgroSciences
Weedmaster® Duo	glyphosate	360g/L	Nufarm

3. Staff listings

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4. Publications

Books / chapters

Walton, C. 2005. Reclaiming lost provinces: a century of weed biological control in Queensland. Department of Natural Resources and Mines, Brisbane, Australia. 104 pp.

Conference / workshop proceedings

Adkins, S.W., S.C. Navie and K. Dhileepan. 2005. Parthenium Weed In Australia: Research Progress And Prospects. Proceedings of the Second International Conference on Parthenium Management. pp. 11–27. University of Agricultural Sciences, Bangalore, India.

Cremasco, P and A. King. 2005. Spotting and tracking fauna impacts. 5th DIGGARS Geospatial Information Forum. Toowoomba. 27 October.

Cremasco, P. 2005. Queensland Wild Dog Baiting: A Quoll-ity Practice. 3rd NSW Pest Animal Control Conference. Coffs Harbour. 5–8 July.

Day, M.D., W. Orapa and R. Muniappan. 2005. Two decades of weed biocontrol in the Pacific region. Proceedings of the 20th Asian-Pacific Weed Science Society Conference. pp 451–456. Agriculture Publishing House, Ho Chi Minh City.

Harvey, G. J. 2005. The uptake and distribution of acid, ester and amine salt formations of 14C-labelled 2,4-D in rubber vine (*Cryptostegia grandiflora*) with time. Proceedings of the 20th Asian-Pacific Weed Science Society Conference pp. 245–253. Agriculture Publishing House, Ho Chi Minh City.

Setter, M.J, M. Bradford, W. Dorney, B. Lynes, J. Mitchell, S. Setter and D. Westcott. 2005. Animal dispersal of pond apple, a weed of tropical Australian wetlands. Fourth International Symposium/Workshop on Frugivores and Seed Dispersal. Brisbane,Queensland, Australia. 9–16 July.

Sparkes, E.C. and D.J. Midmore. 2005. Effects of plant height and water availability on response of *Prosopis velutina* to a selection of herbicides applied by the basal stem method. Proceedings of the 20th Asian-Pacific Weed Science Society Conference. pp 413–418. Agriculture Publishing House, Ho Chi Minh City.

Journal publications

Armstrong, T.R., R.C. Breaden and D. Hinchliffe. 2006. The control of climbing asparagus (*Asparagus africanus* Lam.) in remnant Brigalow scrub in south-east Queensland. Plant Protection Quarterly 21(3): 134–136.

Bebawi, F.F., R.J. Mayer and S.D. Campbell. 2005. Flowering and capsule production of bellyache bush (*Jatropha gossypiifolia* L.). Plant Protection Quarterly 20: 129–132.

Breaden, R.C., T.R. Armstrong and D. Hinchliffe. 2006. The chemical control of the environmental, weed basket asparagus (*Asparagus aethiopicus* L. cv. Sprengeri) in Queensland. Plant Protection Quarterly 21(3): 131–133.

Buckley, Y.M., S. Anderson, C.P. Catterall, R.T. Corlett, T. Engel, C.R. Gosper, R. Nathan, D.M. Richardson, M.J. Setter, O. Spiegel, G. Vivian-Smith, F.A. Voight, J.E.S. Weir, D.A. Westcott. 2006. Management of plant invasions mediated by frugivore interactions. Journal of Applied Ecology 43(5): 848–857.

Dhileepan, K., B.J. Croft, A. Ridley, A.P. James and S. Raghu. 2006. Susceptibility of source plants to Sugarcane Fiji disease virus influences the acquisition and transmission of the virus by the planthopper vector *Perkinsiella Saccharicida*. Journal of Applied Entomology 130: 67–71.

Dhileepan, K., Trevino, M., and Raghu, S. 2006. Temporal patterns in incidence and abundance of *Aconophora compressa*, a biological control agent for *Lantana camara*, on target and non-target plants. Environmental Entomology 35: 1001–1012.

Dhileepan, K., M. Trevino and S. Raghu. 2005. Effect of temperature on the survival of *Aconophora compressa* (Hemiptera: Membracidae): Implications for weed biocontrol. Australian Journal of Entomology 44: 457–462.

Fleming, P.J.S., L.R. Allen, S.J. Lapidge, A. Robley, G.R. Saunders and P.C. Thomson. 2006. A strategic approach to mitigating the impacts of wild canids: proposed activities of the Invasive Animals Cooperative Research Centre. Australian Journal of Experimental Agriculture 46: 753–762.

Florentine, S. K., A. Raman and K. Dhileepan. 2005. Effects of gall induction by *Epiblemma strenuana* on gas exchange, nutrients, and energetics in *Parthenium hysterophorus*. Biocontrol 50: 787–801.

Gentle, M., G. Massei and R. Quy. 2006. Diversity of diet influences the persistence of conditioned taste aversion in rats. Applied Animal Behaviour Science 97(2-4): 303–311.

Gosper, C.R., C.D. Stansbury, G. Vivian-Smith. 2005. Seed dispersal of fleshy-fruited invasive plants by birds: contributing factors and management options. Diversity and Distributions 11: 549–558.

Gosper, C.R., G. Vivian-Smith and K. Hoad. 2006. Reproductive ecology of invasive *Ochna serrulata* (Ochnaceae) in south-eastern Queensland. Australian Journal of Botany 54: 43–52.

Hannan-Jones, M. A., A.J. Lowe, K.D. Scott, G.C. Graham, J.P. Playford and M.P. Zalucki. 2005. Isolation and characterization of microsatellite loci from mother-of-millions, *Bryophyllum delagoense* (Crassulaceae), and its hybrid with *Bryophyllum daigremontianum*, 'Houghton's hybrid'. Molecular Ecology Notes 5(4): 770–773.

Hooke, A.L., L. Allen and L.K-P. Leung. 2006. Clinical signs and duration of cyanide toxicosis delivered by the M-44 ejector in wild dogs. Wildlife Research 33: 1–5.

Liberato, J.R., I.G. Pascoe, S.D. Campbell, J.G. Wright and R.G. Shivas. 2005. *Oidium stachytarphetae* on *Stachytarpheta*, amended: new from Australia and New Caledonia. Mycotaxon 93: 145–147.

Martin, T.G., S.D. Campbell and S. Grounds. 2006. Weeds of Australian Rangelands. The Rangeland Journal 28: 3–26.

Mound, L. A., S. Nakahara and M. Day. 2005. *Frankliniella lantanae* sp. n. (Thysanoptera: Thripidae), a polymorphic alien thrips damaging Lantana leaves in Australia. Australian Journal of Entomology 44: 279–283.

Palmer, W. A. and A. McLennan. 2006. The host range of *Isturgia deerreria*, an insect considered for the biological control of *Acacia nilotica* in Australia. African Entomology 14: 141–5.

Palmer, W. A., M.P. Vitelli and G.P. Donnelly. 2005. The phytophagous insect fauna associated with *Acacia nilotica* ssp. indica (Mimosaceae) in Australia. Australian Entomologist 32: 173–80.

Panetta, F. D. and R. Lawes. 2005. Evaluation of weed eradication programs: the delimitation of extent. Diversity and distributions 11: 435–442.

Raghu, S. and K. Dhileepan. 2005. The value of simulating herbivory in selecting effective weed biological control agents. Biological Control 34: 265–273.

Raghu, S., K. Dhileepan and M. Trevino. 2006. Response of an invasive liana to simulated herbivory: Implications for its biological control. Acta Oecologica 29: 335–345.

Raman, A., S. Madhaven, S.F. Singarayar and K. Dhileepan. 2006. Metabolic mobilization into the stem galls of *Parthenium hysterophorus* (Asteraceae) induced by *Epiblema strenuana* (Lepidoptera: Tortricidae) inferred from signatures of isotopic carbon and nitrogen, and total nonstructural carbohydrates. Entomologia Experimentalis et Applicata. 119:101–107.

Regan, T.J, M.A. McCarthy, P.W. Baxter, F.D. Panetta and H.P. Possingham. 2006. Optimal eradication: when to stop looking for an invasive plant? Ecology Letters 9: 759–766.

Ridley, A.W., K. Dhileepan, K.N. Johnson, P.G. Allsopp, K.A. Nutt, G.H. Walter and B.J. Croft. 2006. Is the distribution of Fiji leaf gall in Australian sugarcane explained by variation in the vector *Perkinsiella saccharicida*? Australian Plant Pathology 35: 103–112.

Scanlan, J.C. and C. Vanderwoude. 2006. Modelling the potential spread of *Solenopsis invicta* Buren (Hymenoptera: Formicidae) (red imported fire ant) in Australia. Australian Journal of Entomology 45: 1–9.

Scanlan, J.C., D.M. Berman and W.E. Grant. 2006. Population dynamics of the European rabbit (*Oryctolagus cuniculus*) in north eastern Australia: simulated responses to control. Ecological Modelling 196: 221–236.

Vitelli, J.S. and J.L. Pitt. 2006. Assessment of current weed control methods relevant to the management of the biodiversity of Australian rangelands. The Rangeland Journal 28: 37–46.

Vivian-Smith, G., C.R. Gosper, A. Wilson and K. Hoad. 2006. *Lantana camara* and the fruit- and seed-damaging fly, *Ophiomyia lantanae* (Agromyzidae): Seed predator, recruitment promoter or dispersal disrupter? Biological Control 36: 247–257.

Vivian-Smith, G., C.R. Gosper, T.Grimshaw and T. Armstrong. 2006. Ecology and management of subtropical invasive asparagus (*Asparagus africanus* Lam. and *A. aethiopicus L.*). Plant Protection Quarterly 21(3): 98.

Vivian-Smith, G., D. Hinchliffe and J. Weber. 2005. Fecundity and germination requirements of the invasive aquatic plant, *Gymnocoronis spilanthoides* (D. Don) DC. Plant Protection Quarterly 20(4): 145–147.

Wardill, T. J., G.C. Graham, M.P. Zalucki, W.A. Palmer, J. Playford and K.D. Scott. 2005. The importance of species identity in the biocontrol process: Identifying the subspecies of *Acacia nilotica* (Leguminosae: Mimosoideae) by genetic distance and their implications for biological control. Journal of Biogeography 32: 2145–2159.

Witt, A.B.R., S. Docherty and W.A. Palmer. 2005. Distribution and aspects of the biology of *Chlamisus malvernensis* Bryant (Coleoptera: Chrysomelidae) collected on *Acacia nilotica* (L.) Willd. Ex Del. Ssp. *Kraussiana* (Benth.) Brenan (Mimosaceae) in South Africa. African Entomology 13(2): 376–379.

Other

Allen, L.R. 2005. The impact of wild dog predation and wild dog control on beef cattle production, PhD Thesis. University of Queensland, St Lucia, pp. 265.

Reports

Allen, L. and J. Speed. 2005. Best practice baiting: Evaluation of large-scale, community-based 1080 campaigns, progress report to Bureau of Resource Sciences.

Allen, L.R. 2006. Progress report to Bureau of Rural Sciences on Best Practice Baiting: Evaluation of large-scale baiting programs.

Cremasco, P. and A. Selles. 2006. Results from a Survey for Spotted-Tail Quolls (*Dasyurus maculatus maculatus*) at the Spicer's Peak Property and the Total Health and Education Foundation Properties, Southern Queensland.

Day, M.D. 2006. Annual Report. ACIAR Biocontrol of Chromolaena in Papua New Guinea Project.

Palmer, W. A. 2006. Risk assessment of non-target effects associated with biocontrol agents proposed for release for mother-of-millions.

Palmer, W. A. 2006. Assessment of the costs of making applications for biological control of mother-of-millions under the *Biological Control Act 1987*.

Palmer, W. A. and K.A.D.W. Senaratne. 2006. Assessment of the prospects for success using the proposed agents, *Osphilia tenuipes* and *Alcidodes sedi*, for the biological control of mother-of-millions.

Scanlan, J.C. and B. Davis. 2005. Plan for Delimiting Survey of Yellow Crazy Ants in Queensland.

Setter, M.J, and S.D. Setter. 2006. Wet tropics weeds research. Four tropical weeds annual report.

Setter, M.J, and S.D. Setter. 2006. Wet tropics weeds research. Rainforest CRC annual report

Setter, M.J, and S.D. Setter. 2006. Siam weed research annual report.

Setter, M.J, and S.D. Setter. 2006. Pond apple and hymenachne WONS annual reports.

5. Public presentations

Conference presentations

Day, M.D., W. Orapa, and R. Muniappan. 2005. Two decades of weed biocontrol in the Pacific region. 20th Asian-Pacific Weed Science Society Conference, Ho Chi Minh City, Vietnam, November.

Gosper, C. and G. Vivian-Smith. 2005. Weeds and figbirds—dietary importance and dispersal in Brisbane. Fourth international symposium/workshop on frugivores and seed dispersal, Griffith University. Brisbane, July.

Gosper, C. and G. Vivian-Smith. 2005. Ecology and management of Bird Dispersed Weeds. International Union of Forest Research Organizations 2005 World Congress. Brisbane, August.

Gosper, C.R. and G. Vivian-Smith. 2005. An approach to selecting replacements for invasive plants for frugivores in restoration—can we do better than a guess? Ecological Society of Australia Conference. Brisbane, December.

Gosper, C.R. and G. Vivian-Smith. 2005. Opportunities for managing the dispersal by birds of fleshy-fruited invasive plants. Third biennial Australasian Ornithological Conference, Blenheim, New Zealand, December.

Palmer, W. A. and T. Armstrong. 2006. Recent developments in the biological control of weeds. 2006 North East NSW-South East Qld Weeds Forum. Tweed Heads, May.

Palmer, W.A. 2006. Quarantine insectaries and their special operating requirements. Australian Controlled Environment Working Group. Black Mountain, Canberra, June.

Raghu, S. Dhileepan, K. and Scanlan, J. 2006. Predicting risk and benefit of biological control agents for invasive plant species a priori: A systems modelling approach. North Central Branch meeting of the Entomological Society of America. Bloomington, Illinois, March.

Vivian-Smith, G., C.R. Gosper, A. Wilson and K. Hoad. 2005. The fruit- and seed-damaging fly, *Ophiomyia lantanae*: seed predator, recruitment promoter or dispersal disrupter of the invasive plant, *Lantana camara*. Fourth international symposium/workshop on frugivores and seed dispersal, Griffith University. Brisbane, Month.

Field days

Bebawi, F.F. 2006. Ecology and control of bellyache bush—Bellyache Bush Field Day. Barkla, Branmore and Millview Cattle Stations, June.

Mckenzie, J.R. 2005. Baralaba Parkinsonia ecology and control Field Day. Baralaba, December.

Palmer, W. A. 2006. Prospects for biological control of lantana and annual ragweed. Beaudesert Landcare Group Incorporated. Darlington Park, Beaudesert, March.

Pukallus, K. 2006. Biological control of bellyache bush—Bellyache Bush Field Day. Barkla, Branmore and Millview Cattle Stations, June.

Rogers, M. 2005. Florestina presentation. Landcare Conference. Barcaldine, August.

Vitelli, J.S. 2006. Herbicide control of bellyache bush—Bellyache Bush Field Day. Barkla, Branmore and Millview Cattle Stations, June.

Vogler, W.D. 2006. Spread of bellyache bush—Bellyache Bush Field Day. Barkla, Branmore and Millview Cattle Stations, June.

Forums

Allen, L.R. 2006. Pest Animal Forum. Dalby, February.

Allen, L.R. 2006. AgForce Pest control Forum, Goondiwindi, March.

Berman, D., M. Gentle, L. Allen, P Cremasco and J. Farrell, 2006. Out foxing the fox. Science Forum. Toowoomba, February.

Brooks, S.J. 2006. *Limnocharis* field studies and CRC project update. Four Tropical Weeds and Siam Weed Operational Meeting. South Johnstone, February.

Campbell, S.D. 2005. Weed control. Mingela land management forum. Mingela, August.

Cremasco, P. 2005. Wild dog baiting with 1080 fresh meat baits is compatible with spotted-tail quolls at 'Cherrabah'. Darling Downs Regional Organisation of Councils. Stanthorpe, November.

Cremasco, P. and A. Selles. 2006. 1080 Baits: Cats and Quolls. CCMA Pest Animal Forum. Dalby, February.

McKenzie, J.R. 2006. Integrated weed management - Parkinsonia project. Pest Research Forum, Brisbane, May.

Setter, M.J, S.D. Setter and B. Akacich. 2005. Wet Tropics Weeds Research Report. Far North Queensland Pest Advisory Forum (FNQPAF), Atherton, November.

Setter, M.J, S.D. Setter and B. Akacich. 2005. Wet Tropics Weeds Research Report. Far North Queensland Pest Advisory Forum (FNQPAF), Mossman, August.

Setter, M.J, S.D. Setter and B. Akacich. 2006. Wet Tropics Weeds Research Report. Far North Queensland Pest Advisory Forum (FNQPAF), Cairns, February.

van Haaren, P.E. 2006. Current research update. Far North Queensland Pest Advisory Forum (FNQPAF), Cairns, February.

van Haaren, P.E. 2005. Current research update. Far North Queensland Pest Advisory Forum (FNQPAF), Atherton, November.

van Haaren, P.E. 2005. Current research update. Far North Queensland Pest Advisory Forum (FNQPAF), Mossman, August.

Vitelli, J.S. 2006. Herbicide residue breakdown. Pest Research Forum, Brisbane, May.

Vivian-Smith, G. 2006. Invasive weeds: taking a bird's eye view. Brisbane City Council Weeds Forum. Brisbane, March.

Vivian-Smith, G. 2006. Interactions between weeds and animals: Bird dispersed weeds. Weed Society of Victoria Annual General Meeting. Melbourne, March.

Gentle, M. 2006. Feral pigs - management, issues and the future. Condamine Catchment Management Authority Pest Animal Forum, Dalby, February.

Gentle, M. 2006. Foxes. Condamine Catchment Management Authority Pest Animal Forum, Dalby, February.

Dhileepan, K. 2006. Update on biological control agents for cat's claw creeper. Community Weed Forum. Griffith University EcoCentre, Brisbane, March.

Lectures

Bebawi, F.F. 2005. Weed control. University of Queensland students. TWRC, Charters Towers, July.

Brooks, S.J. 2005. Weed eradication. Mackay area productivity services study group. TWRC, Charters Towers, October.

Campbell, S. D. 2005. Weed management. James Cook University, Botany students. TWRC, Charters Towers, July.

Campbell, S.D. 2005. Pest Management. Delegation of US Senators, Charters Towers, October.

Madigan, B. 2006. Hymenachne/haloyfop residue research, All Souls St Gabriels School, Geography students. Charters Towers, May.

Mitchell, J. 2005. Feral pigs. James Cook University, Botany students. TWRC, Charters Towers, July.

Mitchell, J. 2005. Feral pigs. University of Queensland students. TWRC, Charters Towers, July.

Palmer, W. A. 2005. Weeds and their biological control in Queensland. Western Suburbs Garden Society, Graceville, October.

Vitelli, J.S. 2005. Weed control. University of Queensland students. TWRC, Charters Towers, July.

Vivian-Smith, G. 2005. Education Queensland Presentation - Spotlight on Science: Weed Research at NRSc. NRSc, Indooroopilly, July.

Vogler, W.D and Pukallus, K. 2006. Weed Control Methods. Charters Towers Central State School, May.

Vogler, W.D. 2005. Parthenium and Fire. Chinchilla and District Landcare Central Queensland Parthenium Study Tour. Clermont, October.

Vogler, W.D. 2006. Chilean Needle Grass—the local Class One Weed, Clifton Pest and Weed Show. Clifton, Queensland, March.

Dhileepan, K. 2005. The case of an invasive plant: biological control of cat's claw creeper. Distinguished Lecture Series, Natural Resource Sciences. Brisbane, September.

Lockett, C.J. and Robinson, M. 2005. Biological Control of Weeds. University of Queensland students. TWRC, Charters Towers, July.

Media

Allen, L.R. 2005. Article on cyanide ejectors. Sunday Mail, Brisbane, October.

Allen, L.R. 2006. Dispersing dingo from Yuleba state forest. Courier Mail, Brisbane, May.

Allen, L.R. 2006. Interview about the Blackall project. ABC, Longreach, March.

Allen, L.R. 2006. Ipswich report on wild dog hazards in urban areas. Ipswich, March.

Campbell, S.D. 2006. Big turnout for bellyache bush field day. Northern Miner. Townsville, June.

Campbell, S.D. 2006. Field day on bellyache bush. Northern Muster. Burdekin, June.

Campbell, S.D. 2006. Upcoming bellyache bush field day. ABC Rural Radio. June.

Gosper, C.R. and G. Vivian-Smith. 2005. Birds spreading weeds (Radio interview). 4EB, Brisbane, August.

Gosper, C. 2005. Birds egged on to do the right thing. Central Western Daily. Orange, NSW, October.

Vogler, W.D. 2006. Combating bellyache bush. ABC Rural Radio, Darwin, April.

Vogler, W.D. 2006. Weed expert visits top end. NorthernTerritory News, Darwin, May.

Gosper, C. 2005. Helping birds do the right thing. Euroa Gazette, Euroa, Victoria, November.

Gentle, M. 2006. Zoologist keen to see farmers' best feral pig traps at show. Daily News, Warwick, March.

Gentle, M. 2006. Feral pigs - damage and control. 4GR Radio, Toowoomba, March.

Newsletters

McKenzie. J.R. 2005. Parkinsonia Field day. Capricorn Pest Management Group Newsletter, Volume 4, December / January.

White, E. 2006. *Murraya paniculata* article. Weedspotters Newsletter, Queensland, June.

Allen, L.R. 2005. Update on Blackall and Fraser Island projects and where are dogs coming from? Beefy and the Beast Issue 14, November.

Selles, A and P. Cremasco. 2005. Spotted-tail quoll research in the Freestone area. Handout to local landholders, Freestone, November.

Wissmann, J., C.R. Gosper and G. Vivian-Smith. 2005. Birdwatchers join the war on weeds. Natural State, volume 5, Queensland, July.

Posters

Ellerton, K, L. Allen, A. Lisle and K.Withers. 2005. Use of pulp cavity/tooth width ratios to determine the age of adult wild dogs (*Canis lupus dingo*, and their hybrids). Australian and New Zealand Society of Comparative Physiology and Biochemistry Conference, Dunedin, December.

Rogers, M. 2005. Florestina poster, Landcare Conference, Barcaldine, August.

Seminars

Allen, L.R. 2005. Can the trend towards dingo hybridisation be reversed? Queensland Parks and Wildlife Service, Moggill, September.

Allen, L.R. 2005. Review of funding submissions, Invasive Animal CRC, Adelaide, October.

Allen, L.R. 2005. Update of research to dingo control groups, Warwick Shire. Warwick, October.

Allen, L.R. 2006. Organising demonstration sites, NSW Pastures Protection Board, Armidale, January.

Allen, L.R. 2006. Report on wild dog research. Leading Sheep Telebridge session, Toowoomba, March.

Allen, L.R. 2006. Wild dog research project update. South west and central west Queensland Wild dog meeting. Blackall, February.

Campbell, S.D. 2005. Final briefing on the 8th Queensland Weed Symposium. Weed Society of Queensland AGM, Brisbane, November.

Campbell, S.D. 2005. Research update on Parkinsonia, Mesquite and Prickly acacia. National Prickle Bush Management Meeting, Canberra, August.

Cremasco, P. 2005. The Impact of Wild Dog Baiting on a Population of Spotted-tail Quolls. Queensland Parks and Wildlife Service, Moggill, July.

Day, M.D. 2005. Biological control of *Chromolaena odorata* in PNG. Queensland Entomological Society. Brisbane, September.

Mitchell, J. 2006. Pig research. Land Protection Council. Charters Towers, May.

Vivian-Smith, G. 2005. Ecology and management of subtropical invasive asparagus, National Asparagus Weeds Management Workshop. Adelaide, November.

Vivian-Smith, G. 2005. Integrating sciences to deliver management options: impact and ecology of cat's claw creeper. Distinguished Science Seminar Series 'The Case of the Invasive Plant', NRSc, Brisbane, September.

Gentle, M. 2006. Feral pigs in Queensland, Australia: Management and the Future. Landcare Research, Lincoln, New Zealand, June.

Workshops

Allen, L.R. 2005. Trophic Cascades workshop. Adelaide, October.

Allen, L.R. 2006. Downs wild dog survey workshop. Moonie, March.

Allen, L.R. 2006. Local Government Rangers Association of Queensland 2006 Annual Training Conference. Maroochy, March.

Allen, L.R. 2006. My thoughts on baiting. Regional 1080 Trainer Workshop. Brisbane, April.

Allen, L.R. 2006. Gulf Catchments Pest Taskforce meeting. Mt Surprise, June.

Bebawi, F.F. 2005. Integrated management of weeds: Bellyache bush: a case study. Land and Water Mareeba. November.

Berman, D. 2006. Rabbits. Dalby Pest Animal Workshop. Condamine Alliance. Dalby, February.

Brooks, S.J. 2005. Controlling parthenium on roadsides. Chinchilla and District Landcare Central Queensland Parthenium Study Tour. Clermont, October.

Campbell, S.D. 2005. Ecology and control of Prickle bushes. Tennant Creek/Barkly Regional Landcare Prickle Bush Workshop, Helen Creek Station, Tenant Creek, August.

Campbell, S.D. 2005. Fire as a land management tool: weed control and hazard reduction. Fire knows no boundaries joint agency workshop. Mareeba, August.

Campbell, S.D. 2005. Research update. Dalrymple Landcare Committee annual AGM. Charters Towers, November.

Campbell, S.D. 2006. Calotrope. Dalrymple Landcare Committee Meeting. Charters Towers, February.

Campbell, S.D. 2006. Pest research overview. Land Protection Council. Charters Towers, May.

Cremasco, P. 2005. Spotted-tail quolls not affected by 1080 baiting of wild dogs at Cherrabah. Warwick Wild Dog Stakeholder's Meeting. Warwick, October.

Cremasco, P. 2006. The impact of wild dog baiting on a population of spotted-tail quolls: results of four ongoing monitoring episodes. 1080 Trainers' Workshop. Brisbane, April.

Day, M.D. 2005. NSW Lantana Taskforce Management Meeting. Port Macquarie, July.

Day, M.D. 2006. CRC Australian Weed Management Evaluation of Biocontrol Agents Workshop. Brisbane, March.

Day, M.D. 2006. CRC Australian Weed Management Release and Establishment of Biocontrol Agents Workshop. Brisbane, March.

Gosper, C.R. 2005. Ecology of bird-dispersed weeds. Moggill Creek Catchment Association, Brisbane, September.

Palmer, W. A. 2006. Mother-of-millions and the Biological Control Act. Pest Management Research Workshop. Indooroopilly, May.

Selles, A and P. Cremasco. 2006. Project overview: 1080 and quolls. Goomburra Tourist Association. Goomburra, January.

Vogler, W.D. 2006. Bellyache Bush Ecology and Management, Victoria River District Conservation Association. Willeroo Station, Katherine, April.

Vogler, W.D. 2006. Bellyache Bush Ecology and Management, Mataranka Landcare Meeting. Mataranka, April.

Vogler, W.D. 2005. Weedy Sporobolus Grasses Herbicide Screening—Preliminary Results. Tussock Terminators Workshop. Albury, November.

White, E. 2006. Assisting with weed ecology experiments. Partnership in Science Program: working with primary and secondary students and their teachers. Brisbane, February–June.

Dhileepan, K. 2006. Methodologies for effective evaluation. CRC biocontrol evaluation workshop. Brisbane, March.