

Biological control of *Mimosa pigra* and integration with other control options

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F I N A L R E P O R T

October 2001 to December 2002



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EXECUTIVE SUMMARY

Host specificity testing of the defoliating moth *Macaria* was completed and permission to release was obtained allowing for the shipment of colonies to Darwin. A culture of the root-feeding beetle, *Syphrea bibiana*, has been reared through two generations in quarantine and specificity testing could soon commence. However, assessment of leaf-tying moth species ceased after field trials in Mexico did not enable us to predict their host ranges to an acceptable degree. Difficulties with rearing the tip weevil, *Pselaphorhynchites*, have hampered work on this species. Rearing and testing of a new agent, *Leuciris fimbriaria*, commenced in quarantine.

Mass-rearing of the seed-eating beetle *Malacorhinus irregularis* has been very successful; another 10,400 have been released this period, bringing the total now released in the Finnis and Adelaide River catchments to 12,500. Beetles have established and are obviously present at very high numbers at several sites. The moth *Macaria* has proven to be easy to rear and release - over 10,000 have been released to date. Releases of field collected *Sibinia* have continued with adults sourced from Brazil.

Evaluation of biological control has progressed from broad-scale assessment of agent distributions used to prioritize further releases, to evaluating agent impact at a reduced number of sites. Preliminary data indicates insect attack is concentrated at stand edges and on isolated plants. An experiment to estimate *Carmenta mimosa* impact indicated high densities of this agent reduced seed production by up to c. 90%. Furthermore, at sites where *Carmenta* is common the seed-feeder, *Acanthoscelides puniceus*, previously considered a failure, is now destroying up to 20% of the remaining seed. This is possibly because *Carmenta* has reduced the large seasonal peaks in seed production, enabling *Acanthoscelides* to destroy a larger proportion of the seeds. If this is so, then seed predation by *Acanthoscelides* will increase as *Carmenta* damage continues to intensify. Soil seed banks are significantly reduced in areas where the current suite of agents has been abundant for a number of years. Furthermore, sites heavily attacked by *Carmenta* are extensively defoliated with many dead stems by the end of the dry season. Reduced shading at ground level enables grasses to establish beneath stands and further reduces seedling establishment. With the establishment of *Malacorhinus*, the release of *Macaria* and imminent release of further agents under study in the host range and quarantine, prospects for further and dramatic impacts on mimosa are very promising.

The trial investigating integrating various management options was completed and the results analyzed. A manuscript has been prepared for publication. A major conclusion was, since biological control agent attack is concentrated at the edges of dense mimosa stands, control methods that break up stands increase the edge area over which agents can attack and thereby increase the impact of biological control. The most beneficial treatments were herbicide and bulldozing. A laboratory trial confirmed herbicide-treated plants die only slowly so a significant proportion of agents survived herbicide treatment. Fire was initially devastating to biological control agents, nevertheless, one year after the fire treatment all agents currently established in the NT had recolonised the site, some of these in large numbers.

This year's work has revealed further evidence that the suite of biological control agents currently in the field is having a real and significant effect on mimosa. This, combined with data that showed agent impact was enhanced by application of other control options, indicates biological control will lead to significant cost reductions in the long term management of mimosa.

PROJECT DESCRIPTION

This research and development project aims to further develop the knowledge base and methods for effective and efficient use of biological control and its integration with other control options.

The project involves the collection of insects in the native range of mimosa and conducting biology and screening studies of these agents in a quarantine facility in Brisbane. The mass rearing and release of new agents, redistribution of agents already established and ecological studies to evaluate the impact of these agents on mimosa in the Northern Territory follow this. Also included is a study into the integration of non-biological control methods with biological control. A computer model is being modified, to take into account the newly discovered spatial aspects of agent attack, which will allow the outcome of various control strategies to be predicted. In particular, the long-term impact on mimosa populations of adding biological control agents with specific activity can be assessed in advance.

This report spans the period October 01 – December 02 due to inconsistencies between the original funding agreement, and the Northern Territory regional bidding process. Such inconsistencies have made project management difficult.

PROJECT ISSUES, BACKGROUND AND OBJECTIVES

Mimosa currently occupies an area of approximately 800km² from the Phelp River in southeastern Arnhem Land to near the Fitzmaurice River, the western boundary of the Daly River/Port Keats Land Trust. Last year two outlying infestations, one at Legune Station on the Northern Territory/Western Australia border and another in a dam near Proserpine in Queensland, extended its distribution considerably. The biological control project has on-going research and development activities based in Mexico, Brisbane and Darwin and has the potential to play a substantial role in reducing the longevity, size and density of mimosa plants and their rate of spread. It is cost effective and sustainable.

The overall aims of this project are to introduce all safe and effective biological control agents and to maximize their distribution. The project is well advanced with a suite of ten insects and two pathogens released which between them attack all above ground parts of the plant. Already, the agents established are significantly reducing seed production and the soil seed bank.

There are three insects currently under study in quarantine and three biocontrol agents recently released that require a major effort to provide sufficient numbers for distribution.

Resources during 2001/2002 were allocated to the collection of biological control agents in Mexico and Brazil and the shipment of some of these agents to the CSIRO quarantine facilities in Brisbane. In addition, field-testing of biological control agents that are difficult to study in quarantine was carried out in Mexico to aid studies being done in Australia. The emphasis is on finding a suite of safe and effective insects, which will complement the action of those already released. Quarantine studies are focusing on leaf-feeding Lepidoptera and beetles and flower-feeding weevils. Several additional populations of *Malacorhinus* and *Macaria* have been processed through quarantine to aid the release program in the Northern Territory by maximizing genetic diversity.

Mass-rearing of the seed-feeding weevil *Chalcodermus serripes* was extremely successful, resulting in large numbers of beetles released. This program has since stopped allowing us to concentrate on more promising agents, such as mass rearing and release of *Malacorhinus* and *Macaria*. *Malacorhinus* has established at several sites and is present in very high numbers. Release sites of the dry season fungus have been closely monitored for symptoms of rust infection, however, this agent has not reappeared after the 1999/2000 wet season.

Experimentally monitoring the impact of biological control has been either by manipulating the numbers of insects and comparing plant performance with control plants, or by field-studies that compare plant performance at sites where the agents occur with plant performance prior to biological control, or at sites where biological control agents are still absent.

The experiment to investigate the integration of control methods has been completed. The objective of this trial is to develop a sustainable management strategy for mimosa, in which biological control is incorporated with other control options. There is a synergistic interaction between mechanical or herbicide control and biological control.

NATIVE RANGE AND QUARANTINE STUDIES

(CSIRO Mexico and Brisbane)

(1 October 2001 - 31 December 2002)

Project Milestones	Activities	Achievements	Completion Date
1. Import, rear and begin to test the specificity of the root breeding leaf beetle <i>Syphrea bibiana</i> and the tip weevil <i>Pselaphorhynchites</i> in quarantine	Import, learn to rear, and develop host-testing methodology for these potential new agents.	Two shipments of adults of <i>Syphrea bibiana</i> were imported from Mexico. Several methods of rearing were attempted and proved to be successful. Two generations have been completed. When rearing methodology is perfected, host testing can commence. Host testing will consist of using the rearing method on the roots of other plant species. <i>Pselaphorhynchites</i> has also been imported twice but no success was achieved in rearing.	Ongoing
2. If one or both of the leaf feeding Lepidoptera (<i>Aristotelia</i> and <i>Apotoforma</i>), currently under study in Mexico appears specific, resume testing in Brisbane.	Test the host specificity using the most appropriate techniques.	Work on leaf tiers ceased. Open field trials did not give a clear result because of the low level of attack. Also the trials will not provide the data needed to gain release of these insects, as it is so difficult to grow, so many species of Australian plants in the climatic conditions in Veracruz. It is not feasible to test these species with the given resources. Work has commenced on the looper caterpillar <i>Leuciris fimbriaria</i> , instead. This insect was imported into quarantine from Mexico, a thriving colony was established and methods for host testing are being developed.	
3. Assess fecundity and survival of <i>Sibinia fastigiata</i> following surface cleaning treatments. Gain permission from AQIS to modify treatments if necessary.	Conduct a series of detailed trials on the effect of chemicals and nutrition on the survival and fecundity of adults. Apply treatments to adults imported for direct release.	Trials showed that the chemical treatments used to surface-clean <i>Sibinia</i> adults had a severely detrimental impact on survival and fecundity. An application to AQIS to modify the treatments was successful and the last shipments were treated using the milder new regimen. Nutrition was also shown to be important for maintaining fecundity and enhancing survival. Providing good food for the adults is critical. Four shipments of <i>Sibinia fastigiata</i> were sent to Australia, 3 from Brazil and 1 from Mexico. A total of 651 adults were sent to Darwin for release. The shipment from Mexico had to be destroyed due to pathogens (again).	

<p>4. Release a pathogen-free culture of the looper, <i>Macaria</i> (<i>Xenoecista</i>), from quarantine, send to Darwin.</p>	<p>Complete host specificity trials, submit application for release, obtain permits, send colony to Darwin.</p>	<p>Trials were completed (including necessary unexpected trials in the native range) and the application was submitted. After extreme delays, approval from AQIS was obtained to release <i>Xenoecista</i> (now <i>Macaria</i>). Shipments were sent to Darwin to initiate colonies there.</p>	<p>Ongoing</p>
<p>5. Conduct surveys in the native range of mimosa for the seed wasp, <i>Risbecoma pigrae</i>, and for sucking bugs as potential agents.</p>	<p>Collect seeds of <i>Mimosa pigra</i>, hold in containers for adult emergence, and identify adults.</p>	<p>A total of 229 specimens of Hymenoptera that emerged from seeds were sent to a taxonomic specialist for identification. No adult <i>Risbecoma</i> were found.</p>	<p>Ongoing</p>

MASS CULTURING AND DISTRIBUTION OF BIOLOGICAL CONTROL AGENTS

**(DIPE, with support from CSIRO)
(1 October 2001 - 31 December 2002)**

Project Milestones	Activities	Achievements	Completion Date
6. Develop mass-rearing and release techniques for <i>Malacorhinus irregularis</i> and <i>Sibinia fastigiata</i> and release them throughout mimosa's range.	Protocol developed for root-feeder <i>Malacorhinus</i> .	10,300 adults released on Adelaide and Finniss catchments. Rearing protocol has been further streamlined.	Ongoing
	<i>Sibinia</i> released	No <i>Sibinia</i> were reared, South American-collected weevils were released after treatment. 621 adults released on Adelaide River.	June 02
	Rearing and releasing the leaf "looper" <i>Macaria pallidata</i> .	Deferring <i>Sibinia</i> rearing allowed us to concentrate on this more promising agent. 10,400 <i>Macaria</i> adults and larvae reared then released on Adelaide and Finniss catchments and at isolated patches near Darwin. Experiments are underway investigating optimal release strategies.	Ongoing
7. Mass-rear and release <i>Chalcodermus serripes</i> throughout mimosa's range.		927 adults released on Adelaide river. Rearing was stopped to allow us to concentrate on more promising agents <i>Malacorhinus</i> and <i>Macaria</i> .	May 02
8. Monitor <i>Malacorhinus</i> establishment and spread. Assess, and develop if applicable, aggregation pheromones to assist monitoring.	Develop techniques to monitor <i>Malacorhinus</i>	Adult <i>Malacorhinus</i> beetles have been found in litter trays set up for the Beatrice Lagoon Litter Tray study (below). This has enabled beetle numbers to be quantified over time: numbers have increased dramatically throughout 2002. An additional survey at Beatrice Lagoon found adults and larvae 65 m North of the release site, and 240 m South. We estimated that the colony exceeds 1 ha, and beetle numbers to be in the order of thousands, or even tens of thousands. Additional survey work has shown this beetle is now well established at several sites.	

EVALUATION OF BIOLOGICAL CONTROL AGENTS

(CSIRO & DIPE, Darwin)

(1 October 2001 – 31 December 2002)

Project Milestones	Activities	Achievements	Completion Date
9. Estimate impact of <i>Carmentia mimosae</i> on seed production by monitoring seed rain at sites where <i>Carmentia</i> is present and absent.	Continue field and nursery trials to determine the impact of biological control agents on mimosa.	Litter from all but one of the sites set up in 2001 was collected in July 2002 (one site on the Adelaide River was destroyed by herbicide). In addition, 25 labeled plants were monitored at each site, to estimate survival. Random quadrats were thrown at each site to estimate population densities and percentage cover. Fifteen soil cores were taken at each site. The litter tray samples collected during the funding period are still being sorted and counted. Population density estimates and soil cores from the Adelaide River sites indicate the number of mimosa stems has significantly declined in areas where <i>Carmentia</i> is present. Seed banks are about 75% lower and seedling numbers about 95% lower at sites where <i>Carmentia</i> occurs, compared to sites where it is absent.	Ongoing
10. Repeat a pre-release litter tray study at Beatrice Lagoon during 1984-1986 to quantify differences in mimosa performance (e.g. flower and seed production) prior to and after the introduction of biological control agents and estimate the impact of <i>Coelocephalopion pigrae</i> on seed production.	Large-scale assessment of biocontrol on mimosa.	Monthly sampling has continued using litter trays that were set up at Beatrice Lagoon in January 2000, repeating a study performed from 1984 to 1986 (Lonsdale 1988), prior to the introduction of biological control agents. As for the <i>Carmentia</i> study (above), these samples indicate plant fecundity is a fraction of what it was before biological control agents were introduced, due to both fewer pods produced per inflorescence and a greater abortion rate of inflorescences. Seasonal peaks in seed production were less pronounced than in the mid-1980's, which could indicate why the proportion of seeds eaten by <i>Acanthoscelides</i> has increased, as <i>Acanthoscelides</i> is more able to keep pace with seed production.	Ongoing
11. Continue an insecticide exclusion trial to measure the combined impact of biocontrol agents on growth and survival of mimosa.	Large-scale assessment of biocontrol on mimosa.	As noted in the 2000-2001 final report, a study to use insecticides to exclude biological control agents and measure their impact of growth, fecundity and survival at Beatrice Lagoon was abandoned because both systemic insecticides tried only suppressed <i>Neurostrota</i> and had no impact on <i>Carmentia</i> abundance.	May 01

<p>12. Investigate possible non-target effects of <i>Neurostrota gunniella</i> on <i>Neptunia major</i>.</p>		<p>Monthly surveys at Beatrice Lagoon, where <i>Neptunia major</i> grows among mimosa plants indicate levels of attack by <i>Neurostrota</i> are considerably (over ten times) lower for <i>Neptunia</i> than for mimosa. A second population of <i>Neptunia</i> growing at nearby Harrison Dam, at least two kilometres from the nearest mimosa plants, had even lower levels of attack by <i>Neurostrota</i>. A population of <i>Neptunia</i> was found near Katherine, even further from the nearest mimosa, and was found to be <i>Neurostrota</i>-free.</p>	<p>Ongoing</p>
<p>13. Set up new <i>Diabole cubensis</i> stock culture and study <i>Diabole</i> establishment and persistence in low density, short growing mimosa habitats.</p>		<p>This agent does not appear to have persisted in the field. Work on this agent has been ceased following the departure of the DIPE plant pathologist, Dr Bertie Hennecke.</p>	<p>Oct 01</p>

INTEGRATED CONTROL

(DIPE and CSIRO Darwin)

(1 October 2001 – 31 December 2002)

Project Milestones	Activities	Achievements	Completion Date
13. Complete the integrated control experiment at Wagait.	Monitor the impact of various control options singly and in combination at Wagait experimental site.	This study was completed in December 2001, when the amount of regeneration following the various control options was recorded.	Dec 01
	Set up and monitor revegetation trials.	Revegetation plots were sampled in December 2002, to assess the impact of revegetation on mimosa regeneration. Samples taken indicate the mimosa seedbank in these plots is declining rapidly over time.	Ongoing
	Determine the effect of treatments on biocontrol agent abundance.	Biological control agent attack is concentrated along stand edges, so herbicides and bulldozing may not be overly detrimental to insect populations. Weed control measures can even increase the proportion of plants attacked by biological control agents, by increasing the edge area that insects can attack.	Dec 01
14. Develop a model / expert system for mimosa management.		Although a working form of the model already exists, continued collaboration with Dr Mark Rees and Yvonne Buckley (Imperial College, London) is underway to take into account the latest data we have for the impact of biological control agents, in particular the spatial aspects of agent attack.	Ongoing
15. Investigate the potential of <i>Phloeospora mimosae-pigrae</i> as a mycoherbicide.		The economic justification of this is doubtful: recent estimates indicate it would cost around \$4million to register a mycoherbicide. Work on this agent has been ceased, following the departure of the NT DIPE plant pathologist, Dr Bertie Hennecke.	Oct 01

16. Investigate how rapidly biological control agents reinfest mimosa regrowth, following clearance by fire.		At the integrated site, populations of all established agents recolonised the plots within a year of the fire treatment, although Carmenta populations were greatly reduced by the fire treatment.	Dec 01
17. Set up grazing trials to; <ul style="list-style-type: none"> • Determine when floodplain grasses have recovered sufficiently to restock areas with cattle, following successful control. • Determine recommended stocking rates to prevent overgrazing, accounting for levels of feral animal impact • Investigate seasonal timing of grazing - when to allow cattle onto the flood plains and when to take them off to avoid excessive trampling. This will lead to development of mimosa management recommendations on grazing land.	Trials set up at Wagait to investigate how grazing can affect reinvasion after mimosa control.	Plots were set up during October/November 2002. Fencing has been completed, initial measurements taken and seedbanks analyzed.	Ongoing
18. Investigate impact of fire on potential of mimosa to reinvade cleared areas.		An experimental design has been developed. Negotiations are taking place with landholders to find a suitable field site. Most landholders are unwilling to deliberately burn their floodplains.	Ongoing
19. Mimosa management workshop.	Workshop held	Workshop held at the Northern Territory University 22 - 27 September 2002. It was attended by over 60 people including landowners, scientists and administrators from the NT, Queensland, WA and overseas.	Sept 02
20. Update the <i>A Guide to the management of Mimosa pigra</i>		Speakers at the above workshop have contributed written papers that are being compiled into an updated <i>Guide to the management of Mimosa pigra</i>	Ongoing

ACKNOWLEDGMENTS

The mimosa project is large and complex. Milestones are met through good leadership by Tim Heard, CSIRO (Exploratory and Quarantine Research), Grant Flanagan, Blair Grace, Merrilyn Paskins, DIPE (Mass rearing and distribution of insects), Grant Flanagan and Quentin Paynter, CSIRO (Integrated Management). Blair Grace and Mic Julien (CSIRO) manage the project. The high national and international standing of the project is testimony to all current and former team members. The Natural Heritage Trust funded a substantial proportion of this program.

APPENDIX

Status of natural enemies for biocontrol of *Mimosa pigra*

Weed and Agent	Plant part attacked	Status
COLEOPTERA (BEETLES)		
Bruchidae (seed beetles)		
<i>Acanthoscelides puniceus</i>	Mature hard seeds	Released Apr 1983.
<i>Acanthoscelides quadridentatus</i>	Mature hard seeds	Released Apr 1983.
Chrysomelidae (leaf beetles)		
<i>Chlamisus mimosae</i>	Leaves, stems	Released Nov 85.
<i>Cryptocephalus</i> nr <i>miserabilis</i>	Leaves	Studied 81, rejected- not specific.
<i>Lexiphanes guerini</i>	Young leaves	Studied 85/86, rejected- not specific.
<i>Diplacaspis</i> nr <i>prosternalis</i>	Stem and leaves	Studied 85/86, rejected- not specific.
<i>Syphrea bibiana</i>	Leaves, roots	Studied 84, 97, 01. Currently being reared and studied in quarantine
<i>Syphrea flavipes</i>	Leaves, roots	Studied 95-97, rejected- not specific.
<i>Genaphthona</i> prob. <i>transversicollis</i>	Leaves, roots	Studied 95-97, rejected- not specific.
<i>Paria</i> sp.	Leaves, roots	Studied 95-97, rejected- not specific.
<i>Malacorhinus irregularis</i>	Leaves, roots	Released 00.
Curculionidae (weevils)		
<i>Coelocephalopion aculeatum</i>	Flower-buds	Released Jan 92.
<i>Coelocephalopion pigrae</i>	Leaves and flower-buds	Released May 94.
<i>Chalcodermus serripes</i>	Mature green seed	Released Apr 96.
<i>Chalcodermus persimilis</i>	Mature green seed	Studied 94/95, rejected- not specific.
<i>Sibinia fastigiata</i>	Young green seed	Released Dec 97.
<i>Sibinia seminicola</i>	Young green seed	Studied in Mexico, 93-94. Rejected, normal host is <i>Mimosa asperata</i> .
<i>Sibinia ochreosa</i>	Flowers	Studied in Mexico, 97-99. Host testing 15% complete
<i>Sibinia peruana</i>	Flowers	Studied in Mexico, 97-99. Host testing 15% complete
Rynchitidae		
<i>Pselaphorhynchites debilis</i>	Young leaves and tips	In Brisbane quarantine, 98-02. Developing rearing and host-testing methodology
<i>Pselaphorhynchites</i> sp. (Venezuela)	Young leaves and tips	To be imported
Cerambycidae (longicorns)		
<i>Platyomopsis humeralis</i>	Girdles and breeds in stems	Re-distributed 97-99, damaging native insect.

Weed and Agent	Plant part attacked	Status
LEPIDOPTERA (MOTHS)		
Gracillariidae		
<i>Neurostrota gunniella</i>	Tunnels in pinnae and small stems	Released Feb 89.
<i>Marmara</i> sp.	Tunnels under surface of stems	Studies in Mexico, c. 95. Rejected- not sufficiently damaging
Sesiidae		
<i>Carmenta mimosa</i>	Tunnels in large stems	Released Jul 89. Very damaging agent
Gelechiidae		
nr <i>Aroga</i> sp. = <i>Aristotelia</i> cf <i>howardi</i> = <i>Gelechia benitella</i> = new genus, new sp.	Leaves and stems	Studied 84-85, rejected- not specific.
<i>Aristotelia</i> sp. near <i>dasyпода</i>	Leaves	Studied in Mexico and Australia, 97-01. Rejected- unable to determine specificity
Pyralidae		
<i>Pococera gelidalis</i>	Leaves	Studied in Mexico and Australia, 97-01, rejected- not specific.
Tortricidae		
<i>Apotoforma rotundipennis</i>	Leaves	Studied in Mexico and Australia, 97-01. Rejected- unable to determine specificity
Cosmopterigidae		
<i>Ithome</i> sp.	Pods	Studied in Mexico, 97-00. Rejected- rare and not available when pods occur in Australia
Cossidae		
<i>Morpheis pyracmon</i>	Stems	Mexico and Brazil, 95-96. Rejected- insect not found.
Geometridae (loopers)		
<i>Macaria pallidata</i>	Leaves	Released Sep 02.
<i>Leuciris fimbriaria</i>	Leaves	Studied in Mexico, 98-02. Imported to Australia, 02. Colony in quarantine, developing host-testing methodology.
HEMIPTERA (BUGS)		
Pseudococcidae		
<i>Spilococcus prosopidis</i>	Young leaves	Studied in Mexico, 95-96. Rejected- not found.
Numerous other species	Young leaves	Studied in Mexico, 95-96, rejected- not specific.
Cicadellidae		
Several species	Leaves	Studied in Mexico, 96-98. Rejected- not specific, difficult to rear, larvae not found.
Coreidae		
<i>Scamurius</i> sp.	Leaf tips	Released 88. Released- did not establish (normal host is <i>M. diplotricha</i>).
HYMENOPTERA (WASPS)		
Eurytomidae		
<i>Risbecoma pigrae</i>	seeds	Attempted to collect in Mexico, 00-02. Needs further assessment.
FUNGI		
<i>Diabole cubensis</i>	Leaves	Released 95.
<i>Phloeospora mimosae-pigrae</i>	Leaves, stems and pods	Released 94.
<i>Microstroma ruizii-belinii</i>		Studied in Mexico. Rejected- not damaging in native range.
<i>Mycosphaerella mimosicola</i>		Studied in Mexico. Rejected- only on <i>M. asperata</i> .
<i>Botrydiplodia theobromae</i>	stems	Studied in Australia. Cosmopolitan fungus with broad host range, causes die-back.