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Advancements in biocontrol of *Mimosa pigra* in the Northern Territory

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Summary Mimosa (*Mimosa pigra* L.) has been the focus of a biocontrol program in the Northern Territory since 1979. Fourteen agents have been released to date, with another one expected in late 2006.

Surveys to determine the abundance and distribution of six of these agents were carried out in 2004 and monthly insect surveys commenced in 2005 to monitor the fluctuation of insect numbers throughout the year. Established agents have remained widespread and new agents were found to have established. Annual vegetation monitoring surveys have also been set up to look at the long-term impact of biocontrol on mimosa. Early results already indicate a significant reduction in soil seedbanks.

Additionally, experiments have been carried out on various biocontrol agents to determine their vulnerability to predators and effectiveness against mimosa. Results suggest that recently released agents have the potential to have significant impacts on mimosa biomass and establishment.

Keywords Biocontrol, mimosa, *Malacorhinus irregularis*, *Macaria pallidata*, *Leuciris fimbriaria*.

INTRODUCTION

Mimosa is one of the worst weeds in Australia and has been declared a Weed of National Significance (a WoNS). Dense, impenetrable infestations currently cover 800 km^2 of Northern Territory floodplains.

A biological control program has been ongoing since 1979 with 14 agents released. Four of these agents; *Carmenta mimosa* Eichlin and Passoa (carmenta), *Neurostrota gunniella* Busck (neurostrota), *Coelocephalapion pigra* Kissinger (apion) and *Acanthoscelides puniceus* Johnson (acanthoscelides) (Table 1), are known to have established but their relative abundance and distribution had not been recently studied and their long term effects on mimosa populations had never been fully quantified.

Three new agents have been released on mimosa: the chrysomelid beetle, *Malacorhinus irregularis* Jacoby (malacorhinus), in 2000, whose larvae feed on roots and seedlings, and two defoliating moths *Macaria pallidata* Warren (macaria) in 2002 and *Leuciris fimbriaria* Stoll (leuciris) in 2004. Until recently it was not known whether these agents had established or become widespread. Additionally, the effects of these new agents on the target plant were unknown.

In 2004, a large-scale survey was carried out to monitor the abundance and distribution of established mimosa biocontrol agents listed in Table 1, and to determine whether the newer agents had established. In 2005, we conducted various laboratory and field experiments to predict the likely success of the newer agents at controlling mimosa. Also, in 2005 we set up a long-term monitoring program to measure the combined effects of the mimosa biocontrol program on infestations across five catchments in the Northern Territory.

This paper covers work done by the Weeds Branch, Northern Territory Department of Natural Resources, Environment and the Arts, as much of CSIRO's work has already been documented (Julien *et al.* 2004).

METHODS AND RESULTS

Rearing and releasing our newest agents The chrysomelid beetle malacorhinus was first released in the Northern Territory in October, 2000. They were reared in boxes containing large quantities of seedlings and containers of mimosa tips and were released as adults. Over 34,000 malacorhinus were released between 2000 and 2004 across the Adelaide, Mary, Finniss and Daly River catchments.

Macaria, a geometrid moth with defoliating larvae, was received in the Northern Territory in 2002. Moths were reared on potted mimosa plants in cages. Macaria were generally released as pupae as they are inert and easy to collect from the rearing cages, and because the adults are short lived. They were released in special containers hung in the field to ensure protection from predators. Between 2002 and 2004, over 37,000 macaria were released within the Adelaide, Finniss and Daly River catchments.

Leuciris, another geometrid defoliator, arrived at the Northern Territory biocontrol laboratory in December 2004. It is currently being reared and released using similar methods to those for macaria. The colony was initially slow to reproduce, but produced large numbers during the dry season (May–September) of 2005. As of March 2005, over 23,000 insects have been released across the Adelaide, Mary and Finniss River catchments.

A new agent, *Nesaecrepida infuscata* Schaeffer, is expected to arrive at the biocontrol laboratory in Darwin in October, 2006. This chrysomelid beetle is similar to malacorhinus in that the adults feed on mimosa leaves and the larvae on seedlings.

2004 agent survey A broad-scale survey was conducted to monitor the abundance and distribution of established agents, and to investigate the establishment and spread of new agents.

Eighty-seven sites were surveyed across the Adelaide, Mary, Finniss, Daly and Moyle River catchments (Ostermeyer and Grace unpublished data). These sites included existing agent release sites and new sites selected from detailed mimosa distribution data collected during a large scale aerial mapping project in 2003 (Cameron Yates unpublished data). This mimosa mapping concentrated on the floodplains and associated riparian zones of seven river catchments in the Top End and mapped the density and distribution of mimosa.

The survey targeted six agents (Table 1) using a variety of different methods. Timed visual observations were carried out for carmenta frass, macaria larvae and malachorinus adults, beating samples were taken to check for the presence of apion, and seeds and mimosa tips were collected to look for acanthoscelides and neurostrota. Samples were taken back to the laboratory in Darwin for processing.

The 2004 survey showed that the four agents previously known to have established (carmenta, neurostrota, apion and acanthoscelides) had persisted and remained widespread.

Macaria was found to have established and spread widely by 2004 despite fears that it wouldn't establish due to predation of the larvae. It was even found in large numbers in the Mary River catchment, which is 50–60 km from the nearest release site on the Adelaide River.

Table 1. Mimosa biocontrol agents surveyed in 2004.

Agent	Plant part attacked
Acanthoscelides puniceus Johnson	Mature seed
Neurostrota gunniella Busck	Pinnae and tips
Carmenta mimosa Eichlin and Passoa	Large stems
Coelocephalapion pigrae Kissinger	Flower buds and leaves
Malacorhinus irregularis Jacoby	Leaves, roots and nodules
Macaria pallidata Warren	Leaves

No trace of malacorhinus was found during the 2004 survey; however, they were discovered by chance at one site while releasing another agent at night in May 2005. This led to a night survey of all sites where over 1000 malacorhinus had been released. Malacorhinus were found at five of the 14 sites surveyed, and in such high numbers at one site on the Adelaide River catchment that significant damage was visible and collection for redistribution to other areas was possible.

There has not yet been any sign that leuciris has established in the field, however large numbers of the moths are still being released onto mimosa infestations across four catchments.

Effects of defoliation by macaria Two of the newest agents, macaria and leuciris, are defoliators of mimosa. A controlled experiment was conducted in 2004 to predict their impact on mimosa (Wirf 2006). Macaria larvae and simulated herbivory were used to determine what effect different levels of defoliation had on the growth and biomass of mimosa. The experiment was conducted using young potted mimosa plants over an eight week period.

Defoliation by leaf feeders can have a detrimental impact on mimosa. Levels of 50% manual defoliation or eight larvae per young plant lead to significant reductions in growth rate, plant dimensions and biomass (Wirf 2006). It appears possible that even modest densities of macaria may be able to reduce the growth of mimosa.

Predation of macaria The two defoliating agents, macaria and leuciris, have an exposed leaf-dwelling larval stage and so may be subject to predation. A study was initiated to find out if ants and birds had an effect on macaria larval survival (and therefore establishment) in the field (Grace 2005). This controlled experiment was conducted in the field near Darwin in 2002. Ants were excluded from mimosa plants using a sticky gel ('Tac-gel', Rentokil) and birds were excluded with commercial bird netting. Macaria larvae were placed on the mimosa leaves and survival was monitored.

Macaria larvae were found to be subject to moderate levels of predation. Larval survival increased when ants were excluded from mimosa plants. Excluding birds did not appear to have a significant effect (Grace 2005).

Effects of malacorhinus seedling and root feeding Experiments were performed to determine rates of seedling consumption by malacorhinus larvae and to predict the effects of larval feeding on root nodules (Vanessa McIntyre unpublished data).

Each malacorhinus larvae can destroy more than one seedling. Larvae survived when feeding solely on root nodules, and appeared to feed on these as readily as on seedlings. In pot trials, root nodules were only produced by mimosa in low nitrogen conditions, so malacorhinus consumption of nodules should have a detrimental effect on mimosa growth under such conditions. Such impact would be very difficult to measure in the field, and preliminary nitrogen isotope studies suggest that nitrogen fixation may not be important.

Long-term monitoring Monthly insect surveys commenced in September 2005 across three catchments to determine if insect numbers fluctuate throughout the year. Seven insects are being surveyed for using similar methods to the 2004 survey, except that malachorinus are now being surveyed using light traps.

Annual vegetation monitoring transects have been set up across five river catchments (Adelaide, Mary, Finniss, Daly and Moyle) to assess the long-term impacts of the biocontrol program on the density and spread of mimosa populations.

Insect abundance studies are already showing results. For example, macaria were present in high numbers in the height of the wet season in 2005/06 (January–March) with many larvae found and adults being highly visible in the undergrowth around mimosa (Bron Routley pers. obs.), whilst much scarcer at the start of the survey period when it is much drier (September–December).

Although the study is in its early stages, the first year's results indicate that mimosa had a soil seedbank average of 1023 seeds m^{-2} across all five river catchments in June 2005. The average across two sites on the Adelaide River was 991 seeds m^{-2} (Table 2).

Redistribution of agents to Queensland In 2001, mimosa was found at Peter Faust Dam near Proserpine, Queensland (Chopping 2002). An eradication program was instigated and control efforts are ongoing. Re-growth at the main infestation sites is being controlled; however, some isolated plants are setting seed before being detected. In February 2006, a shipment of malacorhinus, neurostrota and apion was sent to Queensland for distribution at Peter Faust Dam. It is hoped that the insects will establish and spread to these isolated plants and help to reduce seed set and therefore, the spread of mimosa. This is one of the few instances where biocontrol is being used as part of an eradication program.

DISCUSSION

The results of the 2004 survey show that five of the six agents surveyed (carmenta, neurostrota, apion, acanthoscelides and macaria) are abundant and spreading. Subsequent night surveys have shown that malacorhinus are present in the field and appear to be causing significant damage at one site.

A particularly promising result was that macaria were found to have established widely, even spreading to the Mary River catchment where they have not been released. As there are no mimosa infestations between there and the nearest release site on the Adelaide River (50–60 km away), it is possible adult moths may have blown on the wind across to the Mary River catchment.

Even though agents are abundant and spreading, there is a fear that some of them, especially the slow-moving larvae of macaria and leuciris, may be affected by predators and parasites. A study has been initiated in 2006 to look at parasitism of macaria larvae. Larvae are being collected from the field and reared out. Any sign of parasitism is being recorded and parasitoids collected. We are also planning to look at parasitism of eggs and pupae.

Although leuciris has not yet been seen in the field, it is a similar insect to macaria, which occurs in high numbers, so hopes are high. One concern is that numbers of leuciris reared in the laboratory dropped dramatically in the hot and humid wet season build-up (October–December) suggesting that they might not be suited to these conditions. However, similar problems were encountered with macaria before their widespread establishment was observed. Releases of leuciris are continuing.

The fact that defoliation by leaf-feeders can have a detrimental effect on mimosa bodes well for the success of both macaria and leuciris. It is hoped that these agents can evade predators and parasites and build up to high enough numbers to have an effect on mimosa.

The monthly insect abundance surveys are already starting to show trends in insect numbers. However, some sites are proving difficult to access during the wet season due to flooding, and threat of crocodile attack. This will lead to gaps in the data but any trends in insect abundance should still be apparent.

The long-term vegetation monitoring study has shown that the seedbank across the Adelaide River catchment has been reduced considerably (Table 2).

Table 2. Soil seedbanks on Adelaide River, NT.

Year	Soil seedbank (seeds m^{-2})	Reference
1984–86	9,103	Lonsdale (1988)
2001	2,868	Paynter (2004)
2005	991	

Soil seedbanks are now around 10% of what they were before biocontrol commenced, leading to a reduction in the amount of follow-up treatment required after mimosa has been sprayed. This is a clear indication of how successful biocontrol of mimosa has been to date.

CONCLUSION

The biocontrol program is proving to be a successful weapon in the war against mimosa. Six agents have established and are noticeably damaging mimosa and have dramatically reduced soil seedbanks. Recent experiments have shown that the latest agents have the potential to further reduce the growth and spread of mimosa.

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