

The Biological Control Programme Against *Mimosa pigra* in Australia's Northern Territory

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An investigation into the biological control of the prickly, tropical American shrub *Mimosa pigra* (Mimosaceae) in Australia's Northern Territory commenced in 1979. To date, 6 species of insects imported from Mexico and Brazil have been released as biological control agents. Two species of seed beetle, *Acanthoscelides puniceus* and *A. quadridentatus* (Chrysomelidae), are widespread but destroy <1% of seed. The leaf beetle *Chlamisus mimosae* (Chrysomelidae) remains uncommon. The tip-boring moth *Neurostrota gunniella* (Gracillariidae), on the other hand, spread at least 160 km from release sites within 2 yrs and now infests >90% of *M. pigra* shoots. It is associated with a naturally occurring, exotic, die-back pathogen *Botryodiplodia theobromae* (Coelomycetes), but it is too early to know the long-term effects on plant populations. *Carmenta mimosa* (Sesiidae), a stem-boring moth, is very damaging to young plants but is still only established in the vicinity of release sites. Releases of the bud-feeding weevil *Apion aculeatum* (Brentidae) commenced in January 1992. Host-specificity testing of a bud- and leaf-feeding *Apion* n. sp., 2 seed-feeders which prefer immature pods, *Chalcodermus serripes* and *Sibinia fastigiata* (Curculionidae), and 2 fungal pathogens, *Phloeospora* sp. (Coelomycetes) and *Diabole cubensis* (Uredinales), is proceeding.

Introduction

Mimosa pigra L. (Mimosaceae) is a prickly, woody shrub native to tropical America, but now widespread throughout the tropics (Lonsdale *et al.* 1989). In Australia it is an aggressive, invasive weed that occurs in a 450 km arc across the coastal plains of the Northern Territory (Pitt and Miller 1988) with the largest infestations on the floodplains of the Finnis, Adelaide, Mary and East Alligator rivers (Fig. 1). Using the computer programme CLIMEX (Sutherst and Maywald 1985, Maywald and Sutherst 1991), we predict that *M. pigra* could become established throughout most of tropical Western Australia, Northern Territory and Queensland, and could extend down Australia's east coast into northern New South Wales in suitable moist habitats.

M. pigra forms dense shrubland on previously open floodplains and amongst paperbark (*Melaleuca* spp.) swamp forests, shading out the existing ground flora and preventing the establishment of native tree seedlings (Braithwaite *et al.* 1989). The dense thickets interfere with pastoral and recreational pursuits. Access to water is denied, mustering is hindered, pastures are displaced and species diversity is substantially reduced (Miller *et al.* 1981, Braithwaite *et al.* 1989).

An investigation into the biological control of *M. pigra* commenced in 1979 involving both the Northern Territory Department of Primary Industry and Fisheries (DPIF) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Division of Entomology (Miller *et al.* 1983). Beginning in 1984, the Australian Centre for International Agricultural Research (ACIAR) provided funds

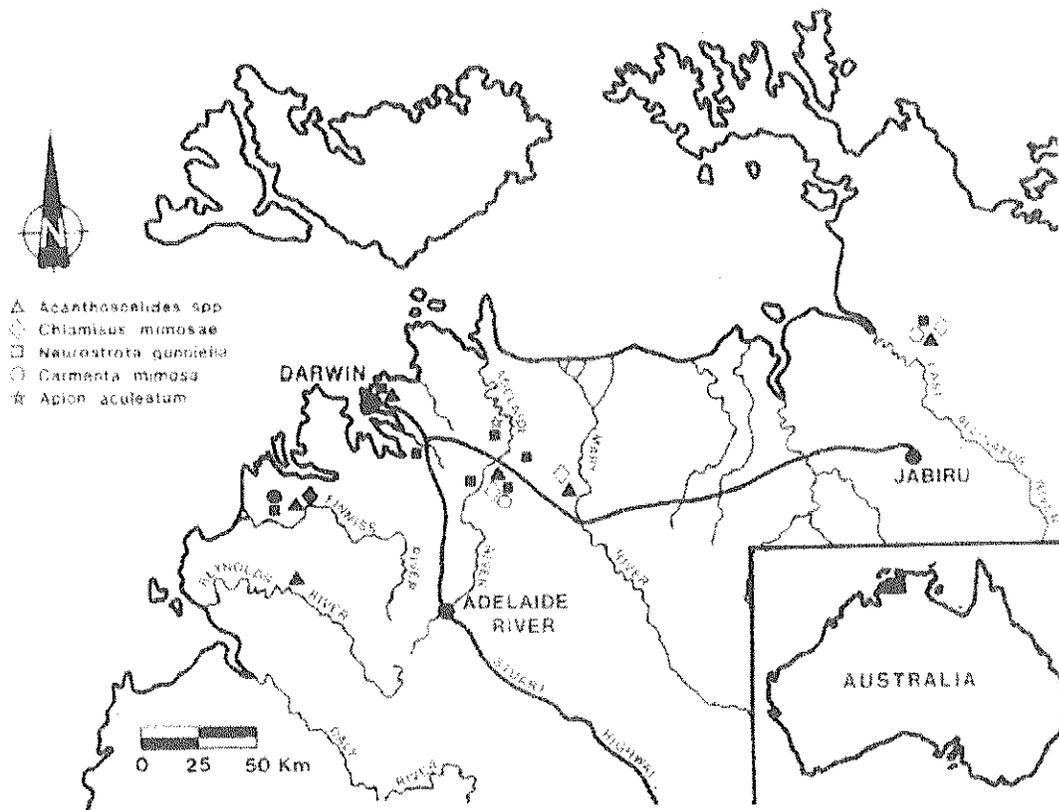


Figure 1. Sites where biological control agents have been released against *M. pigra* in the Northern Territory. Open symbols represent sites where establishment is unconfirmed; closed symbols represent sites where establishment has occurred.

During 1980-81, the search for natural enemies of *M. pigra* was centred on Brazil, with brief surveys in Mexico, southern USA and Venezuela (Harley *et al.* 1985). Since 1984 the search has concentrated on Mexico, with visits to Costa Rica, Honduras and, most recently, Venezuela.

Biological Control Agents

Lonsdale and Segura (1987) compared native populations of *M. pigra* in Mexico with introduced populations in Thailand and Australia. In its introduced range, *M. pigra* forms thickets that are more than double the biomass at a given density and with a soil seed bank 2 orders of magnitude greater. They

argue that herbivory in the native range may be largely responsible for these differences.

At least 114 insect species feed on *M. pigra* in Australia, mostly uncommon, polyphagous species feeding externally on the stems and mature foliage (Wilson *et al.* 1990). The accumulated fauna, however, is deficient in species feeding on new growth or inside the reproductive structures, and no primary pathogens have been observed. In contrast, >200 species have been collected in the native range of *M. pigra* (Harley, K.L.S. and J.D. Gillett, personal communication, 1991), but only about 10% are probably sufficiently host-specific for use as biological control agents.

Preliminary studies using test plants with taxonomic affinity to *M. pigra* were usually carried out in the native range of the insect prior

to shipment to Australia. Once in quarantine in Australia, insects were tested for host-specificity on >100 species of plants, most of which were closely related to *M. pigra*, and others which were unrelated but of economic or environmental importance.

Six insect species have been released in Australia, a number are under study in the quarantine facility in Brisbane, others are being evaluated in the native range, while a few have been rejected as not sufficiently host-specific (Forno *et al.* 1989, Forno and Harley 1991). Several fungal pathogens have been collected and 2 are under study.

Acanthoscelides puniceus Johnson and *A. quadridentatus* (Schaeffer)

Mature stands of *M. pigra* on the black cracking clays, typical of the floodplains of the Northern Territory, produce over 9,000 seeds/m²/yr (Lonsdale 1988), leading to a soil seed bank at least 2 orders of magnitude greater than beneath an equivalent stand in the native range (Lonsdale and Segura 1987). It has been estimated from aerial photographs that uncontrolled stands of *M. pigra* in Australia can double in area every year (Lonsdale *et al.* 1989). The massive production of water-dispersed seeds must be a major factor in the spread of *M. pigra* and its maintenance as dense thickets. Harley (1985) has suggested that flower- and seed-feeding insects may help to control woody weeds. The reproductive structures were thus a primary target when planning the biological control programme against *M. pigra*.

The seed-feeders, *Acanthoscelides puniceus* Johnson and *A. quadridentatus* (Schaeffer) (Coleoptera: Chrysomelidae), were imported from Mexico in December 1981 (Kassulke *et al.* 1990) and were first released in the Northern Territory on 13 April 1983 at a number of sites along the Adelaide River (Fig. 1) (Wilson and Flanagan 1991). Adults of both species oviposit on mature seed pods and each larva tunnels into a seed, rendering it non-viable (Kassulke *et al.* 1990). The beetles were released, usually both species together, at 32 sites in 6 discrete *M. pigra* infestations. Since releases ceased in December 1985 both species have been recovered every year from each of the

infestations into which they were released. During that time <1% of seeds were destroyed. *A. puniceus* made up 97.8% of the beetles reared from field-collected seeds (Wilson and Flanagan 1991), an unexplained phenomenon mirrored in mixed laboratory cultures and following field releases in Thailand (Kassulke *et al.* 1990).

Wilson and Flanagan (1991) conclude that these introduced beetles are having a negligible effect on recruitment and spread of *M. pigra* in northern Australia. They are more effective in Thailand, destroying up to 10% of seed at some sites.

Chlamisus mimosae Karren

Chlamisus mimosae Karren (Coleoptera: Chrysomelidae) was collected in Brazil and shipped to Australia in November 1981. Adults feed on growing shoots and apical leaves, while larvae feed initially on petioles and pinnules, and later graze on the outer layers of green stems. It was first released in the Northern Territory on 14 November 1985 at a site near the Finniss River (Fig. 1), and subsequently at 16 sites in 4 discrete *M. pigra* infestations. The beetle has only persisted near the Finniss River, spreading at least 6.5 km from the nearest release site. *C. mimosae* has not yet had any impact on the growth of *M. pigra*, and it remains uncommon, although in small patches it is abundant.

Neurostrota gunniella (Busck)

In September 1986, stems of *M. pigra* infested with larvae of *Neurostrota gunniella* (Busck) (Lepidoptera: Gracillariidae) were shipped to Australia from Mexico. Young larvae mine leaf pinnules, and older larvae tunnel in green stems (Davis *et al.* 1991). During host-specificity trials it was established that *N. gunniella* could complete its development on 6 plant species in Australia: the introduced weeds *M. pigra* (the preferred host) and *M. pudica* L., and 4 native species of *Neptunia* (Davis *et al.* 1991). Larval mortality was high on the *Neptunia* spp. and Davis *et al.* (1991) concluded that *N. gunniella* would not cause significant damage to any plant other than the target weed, *M. pigra*.

Between 2 February 1989 and 15 February 1990, >9,000 adults and 24,000 eggs of *N. gunniella* were released at 10 sites in 5 discrete *M. pigra* infestations in the Northern Territory (Wilson and Flanagan 1990). One year after the first release on the Adelaide River plains (Fig. 1), >60% of *M. pigra* stems within 1 km of the release site were infested with *N. gunniella* larvae, and recoveries were made up to 7.5 km away (Wilson and Flanagan 1990).

N. gunniella is now present wherever *M. pigra* occurs in the Northern Territory, having spread at least 160 km from the nearest release site within 2 yrs. A survey during May 1991 of 12 sites selected from across the distribution of *M. pigra* showed that an average of over 90% of stems were infested with *N. gunniella* larvae (unpublished data). Although *Neptunia major* (Benth.) Windler can support development of *N. gunniella* (Davis *et al.* 1991), and it commonly grows around the fringes of *M. pigra* thickets on the Adelaide River plains, it has never been observed to suffer attack in the field.

It is still too early to see an effect by *N. gunniella* on populations of *M. pigra*, but an interesting phenomenon was observed during the 1990 winter dry season. Widespread dieback of *M. pigra* stems occurred where *N. gunniella* was established and abundant. Experiments identified the causal organism as *Botryodiplodia theobromae* Pat. (Wilson, C.G. and R.N. Pitkethley, unpublished data), a pathogen frequently associated with plants suffering both moisture stress and injury (Sharma *et al.* 1984, Beng *et al.* 1987). The pattern of occurrence of *B. theobromae* suggests that it enters drought-stressed *M. pigra* stems at the site of injury caused by *N. gunniella* larvae.

Carmanta mimosa Eichlin and Passoa

Stems of *M. pigra* containing larvae and pupae of *Carmanta mimosa* Eichlin and Passoa (Lepidoptera: Sesiidae) were first consigned to Australia from Mexico in April 1987. Following studies that showed *M. pigra* to be the only host plant, *C. mimosa* was released in the Northern Territory on 27 July 1989. Larvae of *C. mimosa* tunnel in the stems and sometimes the roots, frequently leading to the death of the stem

above the feeding site or causing it to snap (Forno *et al. in press*).

Sesiids are not an easy group to rear and *C. mimosa* is no exception. Some rearing difficulties have been overcome by the use of an artificial diet (Smith and Wilson 1992), but releases have still consisted of relatively few individuals at a time. *C. mimosa* has been released at 5 sites in 3 discrete *M. pigra* infestations. It appears to be established at a site near the Finnis River (Fig. 1).

Apion aculeatum Fall

The first shipment of the bud-feeding weevil *Apion aculeatum* Fall (Coleoptera: Brentidae) arrived in Australia from Mexico in March 1990. The adults chew through the undeveloped petals of flower buds and feed on the anthers, filaments and pistil while remaining outside the bud. Larvae feed on partially developed flower buds, destroying the reproductive parts of each bud before chewing into the peduncle (unpublished data). The first field release was at a site on the Adelaide River plains (Fig. 1) on 8 January 1992. It is far too early to predict the outcome.

Future Prospects

There are currently 3 other insects that are the subjects of biology or host-specificity studies in quarantine in Brisbane. *Chalcodermus serripes* Fahraeus and *Sibinia fastigiata* Clark (Coleoptera: Curculionidae) from Mexico are seed-feeders that prefer immature pods, and *Apion* n. sp. from Venezuela feeds on buds and leaves.

Two fungal pathogens collected from *M. pigra* in Mexico, *Phloeospora* sp. (Coelomycetes) and *Diabole cubensis* (Arth.) Arth. (Uredinales) are being host-tested at the International Institute of Biological Control in the UK.

Discussion

The search for natural enemies of *M. pigra* has been underway for 12 yrs with exploratory surveys conducted in Brazil, Mexico, Costa Rica, Honduras and Venezuela. These have

resulted in a number of potential biological control agents being found. Little was known of the ecology of the weed when the project started, but there has been rapid progress in understanding the factors which control its growth and spread. In its native Mexico, *M. pigra* is denser, smaller in stature and has a much smaller seed bank than the introduced Australian and Thai populations (Lonsdale and Segura 1987). It may be argued that herbivory is the most likely explanation for these differences as there are >200 species of insect herbivores and several fungal pathogens attacking *M. pigra* in tropical America (Harley, K.L.S. and J.D. Gillett, personal communication, 1991). Thus although this vigorous, woody shrub may seem a difficult choice for biological control, there is a large number of potential biological control agents.

One strategy to effect biological control has been to target the reproductive potential of *M. pigra*. This has been achieved by the release of the seed-feeding bruchids, *A. quadridentatus* and *A. puniceus* and the bud-feeding weevil, *A. aculeatum*, as well as the importation of several other pod- and bud-feeding beetles for host-specificity testing. However, reducing the reproductive output alone will not be sufficient to control *M. pigra* in Australia. Furthermore, seed production is highly seasonal (Lonsdale *et al.* 1988), and to be effective, insects that feed on buds, flowers or seeds must survive the long monsoonal dry season and have an extraordinarily high rate of increase when the plant flowers and seeds. It is thus important to introduce biological control agents which reduce plant vigour and longevity to complement the action of those which target the reproductive structures.

The first visible signs of plant stress have been by the introduced moth *N. gunniella*. This moth may cause long-term reduction in seedling survival, plant longevity and seed production. Preliminary field data (Lonsdale, W.M. and G.S. Farrell, personal communication, 1992) show a strong negative correlation between seed production by *M. pigra* and density of *N. gunniella* larvae, such that at the highest larval densities, seed production is reduced by 60%. The apparent association of *N. gunniella* and the die-back pathogen *B. theobromae* should add to

this effect. Another stem-boring moth, *C. mimosa*, has established and is expected to further stress the plant.

Other agents which should reduce the vigour of the plant are the leaf and bud-feeding *Apion* n. sp., and the fungal pathogens *Phloeospora* sp. and *D. cubensis*. In addition there are other stem-, leaf-, flower- and seed-feeding agents to be assessed and parts of the native range yet to be surveyed. It is accepted that biological control must be integrated with the use of fire, competitive plant species and herbicides (Miller 1988, Lonsdale *et al.* 1989) to give the best chance of destroying small infestations, reducing existing infestations and preventing spread of the weed.

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