final report

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Biological Control of Mesquite

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ABSTRACT

Mesquites, *Prosopis* spp. are prickly trees that seriously affect rangelands in northern Australia and are declared noxious throughout mainland Australia. Two seed-feeding beetles *Algarobius bottimeri* and *Algarobius prosopis* were imported into quarantine in Australia for host specificity testing as biological control agents against mesquite. They were found to be specific to mesquite and were approved for release byAustralian authorities. The two beetles have been released in major mesquite infestations in Qld and WA. If the beetles effectively destroy a very high proportion of mesquite seed, industry will benefit through reduced spread and reinfestation by mesquite.

EXECUTIVE SUMMARY

(i) BACKGROUND TO PROJECT AND INDUSTRY CONTEXT

Mesquites (*Prosopis* spp.) are declared noxious weeds of rangelands in all mainland states and the Northern Territory. They are spiny trees that produce impenetrable thickets that injure stock, reduce carrying capacity and interfere with mustering and with water facilities. Thickets harbour vermin such as feral pigs. Mesquites produce copious amounts of pods containing long-lived seeds, dispersed by livestock, native wildlife, feral mammals and floods. Chemical and mechanical control methods are effective but are not economical for landholders in many situations and fire is too dangerous for large scale use in some country. The benefits of these techniques are short-lived. Prolonged vigilance and follow-up work are required. Biological control, if effective, should provide long term benefits.

SCA approved mesquite as a candidate weed for biological control in 1990. In 1993 the MRC approved a funding application by the Department of Agriculture, Western Australia (now Agriculture WA) and the Department of Lands (now Department of Natural Resources), Queensland, to import, test and release the North American bruchid seed beetles *Algarobius prosopis* and *Algarobius bottimeri* which had been used against mesquite in South Africa. The MRC made the Department of Lands lead agency.

(ii) OBJECTIVES

(i) To import *A. bottimeri* and *A. prosopis* from South Africa for host specificity testing, and if testing confirms their specificity, release the agents on mesquite infestations in Queensland and Western Australia. Agents would be made available to other States or Territories on request.

(ii) To reduce the risk of spread from existing mesquite infestations and reduce reinfestation of land where mesquite has already been eradicated by biologically reducing seed output.

(iii) To increase the number of species of agents available in Australia for the biological control of mesquite.

(iii) METHODOLOGY

Approval was obtained from AQIS and ANCA to import the two agents from South Africa for host specificity testing. A host-test plant list was approved. *A. bottimeri* and *A. prosopis* were imported into quarantine in Brisbane. Breeding colonies were established on mesquite pods in the quarantine insectary at AFRS. Host testing of the two beetles was conducted on the approved test plants. Following completion of tests, host specificity reports recommending release of the two beetles were submitted to AQIS with applications for release permits. After AQIS and ANCA approved release of both agents, mass-rearing commenced in Queensland and Western Australia.

Release sites were selected in Queensland and Western Australia. Sites for each agent were well spaced to keep the agents apart and allow each to become established without

competition. Small areas of mesquite were fenced at selected release sites to exclude livestock and wildlife which consume mesquite pods and disperse seeds. *A. bottimeri* beetles were released on hybrid mesquite and *Prosopis pallida* mesquite in Queensland and on hybrid mesquite in Western Australia. *A. prosopis* beetles were released on *P. pallida* and *P. velutina* mesquites in Queensland and on hybrid mesquite and *P. glandulosa* in Western Australia.

In the immediate future beyond the time frame of this MRC project, Queensland DNR, and Agriculture WA will continue mass-rearing and releases of the agents. They will also monitor the agents and their effects on seed populations in the field.

(iv) SIGNIFICANT ACHIEVEMENTS

Both *A. bottimeri* and *A. prosopis* were imported early in 1994. In host specificity testing completed at the end of 1995, they were shown to be specific to plants of the genus *Prosopis.* Permits for their release were issued by AQIS and ANCA in late 1996.

Releases of beetles have been made in the major mesquite infestations in Queensland and Western Australia from late 1996 to the present. Approximately 20,500 *A. bottimeri* beetles and 27,900 *A. prosopis* beetles have been released. Several *A. prosopis* beetles emerged from pods collected at one site in Western Australia, four weeks after release of *A. prosopis* at the site. The emergence of these first field generation beetles does not mean that *A. prosopis* is established but it is an encouraging sign. Further achievements such as establishment at all release sites and any eventual impacts on seed populations are for the future.

(v) CONCLUSIONS, RECOMMENDATIONS AND IMPACT

It was concluded that the agents were specific to mesquite and it was recommended that approval be granted for their release. They were subsequently approved for release. It was concluded that releases are required on only a very small number of properties. Once established through the core areas of the large infestations, the agents will spread across property boundaries to infested neighbouring properties. Adoption on these neighbouring properties is automatic, requiring no participation by landholders. No extension effort is required to promote adoption however landholders on properties with biological control agents should be kept informed of progress.

It is recommended that:

- releases of the agents continue in the major areas of mesquite infestations until they are well established
- releases be made in isolated smaller infestations
- releases of the two agents continue to be geographically separated
- biological control of mesquite seeds with *A. bottimeri* and *A. prosopis* proceed in an integrated manner with other forms of control
- affected landholders be kept informed of progress of biological control
- agents be supplied to the Northern Territory Department of Primary Industry and Fisheries for use on the Barkly Tableland

The immediate impact on industry is negligible as the agents have not been long in the field. In five years, if the agents establish and reach and maintain high seed predation levels, the main impact on industry will be protection against future loss of production by a reduced invasion of pastures by mesquite and a reduced reinfestation of cleared areas. Savings will also accrue from avoidance of mustering difficulties, control costs and tyre damage. These benefits will be on-going. In a cost benefit analysis, maximum benefits five years after initial release of agents were estimated to be $750,000 in 1996/1997 dollars. Net realised benefits estimated for the same period are $356,000.

MRC PROJECT QDL.004 "BIOLOGICAL CONTROL OF MESQUITE" FINAL REPORT

ABSTRACT

Mesquites, *Prosopis* spp. are prickly trees that seriously affect rangelands in northern Australia and are declared noxious throughout mainland Australia. Two seed-feeding beetles *Algarobius bottimeri* and *Algarobius prosopis* were imported into quarantine in Australia for host specificity testing as biological control agents against mesquite. They were found to be specific to mesquite and were approved for release byAustralian authorities. The two beetles have been released in major mesquite infestations in Qld and WA. If the beetles effectively destroy a very high proportion of mesquite seed, industry will benefit through reduced spread and reinfestation by mesquite.

RESEARCH REPORT

(i) BACKGROUND TO PROJECT AND INDUSTRY CONTEXT

Mesquites (*Prosopis* spp.) are declared noxious weeds of rangelands in all mainland States and the NT. They are fast-growing, drought-tolerant spiny trees that produce impenetrable thickets that injure stock, reduce carrying capacity of land and interfere with mustering and with water facilities. Mesquite thickets harbour and feed vermin such as feral pigs. They produce copious amounts of pods containing long-lived seeds. Livestock, native wildlife, feral mammals and floods disperse the seeds. This weed is often associated with watercourses and floodplains, where it utilises important water resources and occupies some of the most productive soils available.

While management practices including herbicide treatments, mechanical methods, the use of fire and the integration of these techniques are effective, chemical and mechanical methods are not economical for landholders in many situations and fire is too dangerous for large scale use in Mitchell grass country. In addition the benefits of these techniques are short-lived. Prolonged vigilance and follow-up work are required. Biological control, if effective, should provide long term benefits.

Nomination of mesquite as a candidate weed for biological control was supported by all States and Territories early in 1990 through SCA. A biological control program based on the leaf-feeding psyllid, *Heteropsylla texana*, was approved by State and Commonwealth authorities. Host specificity testing of *H. texana* was completed at Alan Fletcher Research Station in 1993. Unfortunately, *H. texana* was insufficiently host specific and could not be released.

The bruchid seed beetles *Algarobius prosopis* and *Algarobius bottimeri* were introduced into South Africa from the USA in 1987 and 1990 respectively (Zimmermann, 1991). In South Africa, *A. prosopis* destroyed up to 90% of annual mesquite seed crops at some sites (Zimmermann, 1991).

In 1992, the then Department of Agriculture, Western Australia (now Agriculture WA), as lead agency, and the then Department of Lands (now Department of Natural Resources), Queensland applied to MRC for funding to import, test and release *A. bottimeri* and *A. prosopis*. Dr Jon Dodd, drafted the proposal (DAW.C93) with Queensland input from me. The MRC approved the funding in 1993 with the Department of Lands, Queensland as lead agency. I became project leader and Dr Dodd remained in charge of the Western Australian component.

The benefits to industry, in terms of protection of pastoral areas from mesquite infestation by biological reduction of mesquite seed production, are as follows:

- reduced risk of reinfestation of controlled sites where mesquite plants have been eliminated by chemical or mechanical means
- reduced risk of spread from existing infestations, since the number of seeds available to be spread to new sites will be reduced.

(ii) OBJECTIVES

(i) To import *A. bottimeri* and *A. prosopis* from South Africa for host specificity testing, and if testing confirms their specificity, release the agents on mesquite infestations in Queensland and Western Australia. Agents would be made available to other States or Territories on request.

(ii) To reduce the risk of spread from existing mesquite infestations and reduce reinfestation of land where mesquite has already been eradicated by biologically reducing seed output.

(iii) To increase the number of species of agents available in Australia for the biological control of mesquite. Because these agents have been evaluated and released elsewhere (South Africa), they can be released much sooner than if they had to be sought and evaluated *de novo*.

(iii) IMPORTATION OF AGENTS AND ESTABLISHMENT OF LABORATORY COLONIES

An application for approval to import *A. bottimeri* and *A. prosopis* from South Africa for host specificity testing was submitted to AQIS in October 1993 (Appendix 1). This application included a list of plants proposed for the host specificity tests and the rationale for selection of test plants. Attached to that application was a copy of the South African host specificity test report (Peter and Zimmermann, 1987) (Appendix 2). Permits to import the agents were granted by AQIS and Australian Nature Conservation Agency (ANCA) in February 1994. The host specificity test list was approved by AQIS and ANCA.

A consignment of *A. bottimeri* and *A. prosopis* beetles was received on 25 February 1994 from Dr John Hoffmann, Department of Zoology, University of Capetown, South Africa. This contained approximately 1,160 live and 132 dead insectary-reared *A. bottimeri* beetles and approximately 1,100 live and 106 dead insectary-reared *A. prosopis* beetles. All dead beetles and 20% of live beetles of each species were examined under a microscope for the presence of ectoparasitic pyemotid mites. One mite was found on a dead *A. prosopis* beetle. No mites were found on live beetles.

Colonies of both species were established in the quarantine insectary at Alan Fletcher Research Station. Both species were reared in plastic food storage containers and styrofoam boxes in an airconditioned room with a daily temperature range of 18°C to 26°C. Initially, pods collected from hybrid mesquite at Mardie Station, Karratha, WA were used. Pods of this mesquite were more readily obtainable at the time than pods from other sources. Beetles placed in breeding containers were fed on a mixture of honey and pollen. Containers were colour-coded to avoid accidental mixing of species. Beetles reared in breeding boxes were monitored for pyemotid mites. The colonies remained uncontaminated by the mites.

(iv) HOST SPECIFICITY TESTING

Host specificity testing of *A. bottimeri* and *A. prosopis* was conducted in the quarantine insectary at the Alan Fletcher Research Station from February 1994 to October 1995. Reports on the host specificity testing of both bruchids were completed and submitted as part of an application to AQIS for the release of the agents (Appendix 3) in January 1996. Extracts from these reports on the two agents are included below with minor editing changes to fit the context of this report.

(a) *ALGAROBIUS BOTTIMERI*

HOST SPECIFICITY OF THE BRUCHID *ALGAROBIUS BOTTIMERI* KINGSOLVER FOR THE BIOLOGICAL CONTROL OF MESQUITE, *PROSOPIS* SPP. IN AUSTRALIA

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January 1996

Introduction

Two bruchids, *Algarobius bottimeri* and *Algarobius prosopis* were imported into quarantine at the Alan Fletcher Research Station for host specificity testing as potential agents for the biocontrol of seeds of mesquites, *Prosopis* spp., in Australia. Host testing of these two insects was performed in parallel. This report covers the host specificity testing of *A. bottimeri.*

The mesquites are prickly woody weeds of mainland Australia. The major infestations are of *Prosopis pallida* in Queensland and the Northern Territory, *P. velutina* (Quilpie algarroba) in Queensland, a hybrid (*P. pallida* x ?) in Queensland and the Mardie hybrid (*P. pallida* x *? P. laevigata*) at Mardie Station, Western Australia. While these major infestations and some minor infestations of various mesquite taxa occur in the northern half of the continent, there are also minor infestations of various mesquite taxa in the southern half. Quilpie algarroba has been referred to as *P. flexuosa* (Pedley, 1977). However Burkart (1976) and Panetta (pers. comm.) consider that it is *P. velutina.*

A. bottimeri occurs naturally mainly in Texas and north-east Mexico. It has been recorded from *P. glandulosa* var. *glandulosa* and *P. reptans* var. *cinerascens* in North America (Kingsolver, 1986). It was accidentally introduced to Hawaii where it feeds on the introduced South American mesquite *P. pallida* (Kingsolver *et al*, 1977; Kingsolver, 1986).

Both *A. bottimeri* and *A. prosopis* were introduced into South Africa from the USA for the biocontrol of two mesquites, *P. velutina* and *P. glandulosa* var. *torreyana*, following host specificity testing in quarantine (Peter and Zimmermann, 1987; Zimmermann, 1991; Hoffmann *et al*, 1993). *A. bottimeri* has become established on *P. glandulosa* var. *glandulosa* at one site only (Hoffmann *et al*, 1993). Here its population is mixed with a population of *A. prosopis*. In contrast, *A. prosopis* is widely established on *Prosopis* spp. (Zimmermann, 1991: Hoffmann *et al*, 1993). In a mixed insectary culture, *A. bottimeri* was suppressed by *A. prosopis* (Peter and Zimmermann, 1987; Zimmermann, 1991). In the laboratory, Hoffmann *et al* (1993) found that *A. prosopis* larvae were more competitive than *A. bottimeri* larvae when both were placed together on seeds of *P. velutina.*

Biology

A. bottimeri and *A. prosopis* are almost identical mottled brown beetles from 2.2 to 5.0 mm long (Peter and Zimmermann, 1987). The only easily detected external difference between the two species is in the positions and shape of the pygidial sulci in the females. The males can only be separated by studying the genitalia (Kingsolver, 1986; Peter and Zimmermann, 1987).

According to Peter and Zimmermann (1987), *A. bottimeri* adults mate within 24 hours of emergence and after a short pre-oviposition period, females commence oviposition into surface cracks and crevices of mesquite pods. If there are no suitable protected sites, the female may oviposit clumps of 10-15 eggs on pod surfaces. Hoffmann *et al* (1993) found that females (n=35) could oviposit for 50 days with a cumulative mean oviposition of 300 eggs.

In nature, *A. bottimeri* adults would be expected to feed on pollen from any plants that are flowering, as noted by Kingsolver (1986) for *A. prosopis*. They would probably drink nectar. They are sustained successfully in the insectary on a paste made of honey and pollen. They are also sustained using a dilute sugar solution (Hoffmann *et al*, 1993).

Eggs hatch in 8-9 days at 34°C and larvae pass through four instars before pupation (Zimmermann, 1991). The first instar larvae have legs, are highly mobile (Peter and Zimmermann, 1987) and are able to tunnel through the sticky mesocarp, fibrous endocarp and hard seed coat to enter seeds. Only one larva develops through to the adult stage in each seed. Hoffmann *et al* (1993) found that full *A. bottimeri* development took from 25 to 71 days (median 33 days) in an insectary with a temperature regime of 27°±2°C for 12 hour "days" and 23°±2°C for "nights". They found the male:female sex ratio of emerged beetles to be 1:1 and that newly emerged males consistently weighed significantly more than females.

Materials and Methods.

Importation of *A. bottimeri*

A shipment of *A. bottimeri* beetles was obtained from the University of Capetown, South Africa in February 1994. In quarantine, the beetles were reared on Mardie hybrid mesquite pods in plastic food storage containers and in styrofoam boxes in an airconditioned room with a daily temperature range of 18° C to 26°C. The ovipositing beetles in rearing boxes were fed on a mixture of commercially available honey and pollen. Mardie hybrid mesquite pods were used because a good supply of them was readily available from the field.

Host Test List

The plants used in these host specificity tests are listed in Addendum 1 and are grouped into Part 1 - Mesquites and Part 2 - Test Plants.

Pods of some plants in the original test list approved by AQIS (Appendix 1) could not be obtained. Where it was possible, a substitute species from the same listed taxonomic group was used:

> Pods of *Acacia coriacea* (unidentified subspecies) were used in *Acacia* Section Plurinerves instead of *A. coriacea* spp. *sericophylla*.
>
> In *Acacia* Section Botrycephalae, *Acacia glaucocarpa* was substituted for *Acacia deanei* and *Acacia decurrens*.
>
> In Family Caesalpiniaceae, *Senna artemisioides* was substituted for *Senna barclayana*. *S. artemisioides* is a perennial that occurs naturally near mesquite infestations in

Queensland. It is used as a native ornamental in Queensland. Pods were easily obtained. *S. barclayana* is a weedy annual that may sometimes grow in mesquite infested areas.

In the genus *Acacia,* Section Aculeiferum, neither *Acacia albizzioides* nor *Acacia pennata* sub-sp. *kerrii* could be obtained. These two species occur only in remote parts of Cape York Peninsula. No alternative species were available.

In the Tribe Piptadeniae, pods and seeds of *Entada phaseoloides* were unavailable and no alternative to *E. phaseoloides* was available.

Mesquite Tests

These tests were conducted to determine if *A. bottimeri* would oviposit on and develop in pods of the various *Prosopis* taxa present in Australia.

In each test, four pods each of *P. pallida, P. velutina, P. glandulosa, P. juliflora* and *Prosopis* Mardie hybrid were enclosed with 100 beetles in a gauze-covered bench-top cage. The beetles used were obtained from the shipment received from South Africa after screening for parasitic mites. Two replicate cages were used. Each group of four pods was placed in a separate shallow dish on the bottom of the cage. Water and a honey and pollen mix were placed in each cage. After 10 days the beetles were removed and the pods of each mesquite taxon were placed in separate sealed plastic containers. These were stored in a controlled-temperature cabinet with a daily temperature range of 18°-32°C to await emergence of beetles. Beetle emergence was monitored and recorded.

Multiple-choice Tests

Multiple-choice tests were conducted to determine if the beetles would oviposit on and develop in test plant pods.

In these tests, five pods each of mesquite (*Prosopis* Mardie hybrid) and of four test plant species (except for the last test when only one species remained to be tested) were placed in a 3.5 L plastic food container with a petri dish of honey and pollen mixture spread on tissue paper. Three replicates were set up for each pod combination. Fifty quarantine-reared beetles were added to each test container before the containers were sealed and placed in a controlled-temperature cabinet with a daily temperature range of 18°-32°C. The beetles were removed after 14 days. Pods of each taxon tested were placed in appropriately sized and labelled sealed containers to await possible development and emergence of beetles. The containers were stored in an airconditioned quarantine room with a daily temperature range of 18°-26°C. Pods were examined for eggs after sufficient time had elapsed for them to have hatched. This timing was necessary as examination of some pods was possibly damaging to eggs. Egg numbers were recorded. Beetle emergence was monitored and recorded. At least 14 weeks after the pods were removed from the oviposition containers, the seeds were removed from the pods and examined for larval entry holes. Non-mesquite seeds with entry holes were dissected to determine the fate of the larvae. Details of this examination were recorded.

No-choice Seed Substitution Tests

Seeds of test plant species, which did not have eggs laid on their pods in the multiple-choice tests, were exposed to *A. bottimeri* larvae in no-choice seed substitution tests to determine if development would occur in them.

Pods of *Barklya syringifolia, Chamaecrista mimosoides* and *Pultenaea villosa* were the only pods to escape oviposition by *A. bottimeri* in these multiple-choice tests. In each of three replicates, 10 seeds of each of these three species were inserted into emptied endocarp capsules in excised sections of Mardie hybrid mesquite pods. For controls, 10 Mardie hybrid mesquite seeds were similarly inserted. First, a sufficient quantity of mesquite pods was exposed to oviposition by quarantine-reared *A. bottimeri* beetles for 1 week prior to the careful excision of the mesquite seeds. The seed substitutions were then made. Only pod sections on which clusters of eggs remained after seed excision were used for seed substitution. Care was taken not to damage the eggs. The sets of substituted seeds were stored in plastic food containers in a controlled-temperature cabinet with a daily temperature range of 18°-32°C. Beetle emergence was monitored and recorded. Seeds of test species were examined for larval entry holes after 7 weeks. Seeds with entry holes were kept a further 9 weeks before being dissected to determine the fate of the larvae. As all mesquite seeds produced beetles, no further examination of them was done.

Large Cage Tests

Test plant species on which either *A. bottimeri* or *A. prosopis* had successfully developed in the parallel multiple-choice tests, were used in large cage tests for each bruchid species. These were conducted to determine if the beetles would oviposit on the test pods if not in close proximity to mesquite pods. In host specificity testing in South Africa (Peter and Zimmermann, 1987; Zimmermann, 1991), the researchers noted that oviposition by both *A. bottimeri* and *A. prosopis* occurred on *Cassia didymobotrya* pods in close proximity to mesquite pods but not on *C. didymobotrya pods* in the absence of mesquite pods, and they assumed that mesquite pods provided an olfactory stimulus for oviposition.

Five pods each of Mardie hybrid mesquite and the five species in which either or both *A. bottimeri* or *A. prosopis* beetles developed in the parallel multiple-choice tests were placed out in shallow plastic trays on low benches in a large sheer nylon cloth cage (2 m x 2 m x 1.5 m) in a quarantine glasshouse. The pods were of *Petalostylis labicheoides, Acacia aneura, Neptunia gracilis* and *Arachis hypogaea* in which both bruchids had developed and *Caesalpinia decapetala,* in which only *A. prosopis* had developed. The mesquite pods were placed on the opposite side of the cage, approximately 1.5 m away from the test pods. Fifty quarantine-reared beetles were placed in the cage. There were three replicates of this test. After 1 week the beetles were removed and the pods of each species were placed separately in sealed plastic food containers. These were kept in a controlled temperature cabinet with a daily temperature range of 18°-32°C. After 2 to 4 weeks the pods were examined for eggs. When no eggs were found on any test pods, they were discarded. The beetle emergence from mesquite pods was monitored and recorded.

Results

Rearing

A. bottimeri has been reared successfully for 15 generations in quarantine on pods of *Prosopis* Mardie hybrid.

Mesquite Tests

Pods of all five mesquite taxa supported the development of *A. bottimeri* through to adult (Table 1) for three generations after which no viable seeds remained. Emergence of first generation beetles from pods of all mesquite taxa began 6 weeks after the tests were started.

Table 1. Mesquite Tests. *Algarobius bottimeri* emergence.

	P. hybrid		*P. pallida*		*P. velutina*		*P. glandulosa*		*P. juliflora*	
	R 1	R 2	R 1	R 2	R 1	R 2	R 1	R 2	R 1	R 2
Gen 1	35	31	51	23	15	23	13	12	40	34
Gen 2	26	20	42	49	36	18	37	36	22	19
Gen 3	2	1	0	5	6	2	7	1	0	4
Total	63	52	93	77	57	43	57	49	62	57

Abbreviations: *P.* hybrid = *Prosopis* Mardie hybrid, R = Replicate, Gen = Generation

Multiple-choice Tests - *A. bottimeri*

Oviposition by *A. bottimeri* occurred on pods of all test plant species except *Barklya syringifolia, Chamaecrista mimosoides* and *Pultenaea villosa.*

Beetles emerged from seeds of *Prosopis* Mardie hybrid, *Acacia aneura, Petalostylis labicheoides, Neptunia gracilis* and *Arachis hypogaea* (Table 2).

Dissected *A. aneura* seeds contained dead pupae and dead larvae of various sizes. Dissected *P. labicheoides* seeds and *A. hypogaea* seeds contained dead first instar larvae. Dissected *N. gracilis* seed contained dead beetles and dead larvae of various sizes. The causes of death of the various stages of *A. bottimeri* in these seeds were not apparent.

First instar larvae attempted to penetrate or penetrated seeds of most of the other test plant species, but only dead first instar larvae were found when these seeds were dissected. Many larval entry holes did not fully perforate the testa of some seeds. Larvae which had penetrated beyond the testa were found dead at distances of 1 mm-3 mm into the seeds. No larval entry holes were found in seeds of *Acacia monticola, Acacia glaucocarpa, Archidendropsis basaltica, Cassia brewsteri, Delonix regia* and *Hovea acutifolia.*

Table 2. *Algarobius bottimeri* emergence in multiple choice tests

Test plant species	Development time	Number of beetles emerged		
	(Weeks)	Rep 1	Rep 2	Rep 3
Prosopis Mardie hybrid	5-10	70	61	73
Acacia aneura	20	1	0	0
Prosopis Mardie hybrid	6-10	71	58	60
Petalostylis labicheoides	15	3	1	1
Neptunia gracilis	15	2	0	1
Prosopis Mardie hybrid	5-9	53	52	73
Arachis hypogaea	31	1	0	0

No-choice Seed Substitution Tests

Each mesquite seed used in these tests produced a beetle. No development beyond first instar larvae occurred in any other seeds. No larval entry holes were found in *Pultenaea villosa* seeds.

Large Cage Tests

In the separate replicates, *A. bottimeri* laid 296 eggs, 263 eggs and 217 eggs on mesquite pods but laid none on test plant pods.

Discussion

Since beetles of *A. bottimeri* developed readily in seeds of all of the *Prosopis* taxa screened in the mesquite tests (Table 1) and for many generations in Mardie hybrid mesquite seeds in rearing boxes, the failure of *A. bottimeri* to establish widely in South Africa (Hoffmann *et al*, 1993) should not be taken as an indicator of its possible performance in Australia. Some pest mesquites of Australia belong to different taxa to those of South Africa. In particular, most large Australian infestations are of *P. pallida* or *P. pallida* hybrid mesquite. As *P. pallida* has been a suitable host for *A. bottimeri* in Hawaii (Kingsolver *et al*, 1977; Kingsolver, 1986) and as *A. bottimeri* was successfully reared on Mardie hybrid mesquite pods, it should establish readily on these taxa in Australia.

The failure of larvae to penetrate through the testa or to develop beyond first instar in the majority of test plant seeds in multiple choice and no-choice seed substitution tests, indicates that those species are unsuitable as hosts for *A. bottimeri*. Southgate (1979) suggested that legume seeds may contain, in the testa or cotyledons, toxins or other substances that inhibit bruchid larval feeding or development.

The development of beetles in seeds of the test plants *A. aneura, P. labicheoides, N. gracilis* and *A. hypogaea*, followed oviposition on their pods in the close presence of mesquite pods. The extended minimum development times in these species (Table 2) indicate that they are not ideal hosts.

In large cage tests, the rejection of all pods except mesquite for oviposition supports the view of Zimmermann (1991) that *A. bottimeri* females will oviposit on non-host pods if they are in close proximity to mesquite pods but not on non-host pods that are separated from mesquite pods. There may be some places in Australia where mesquite occurs in the presence of *A. aneura* (mulga), *N. gracilis* or *P. labicheoides*. However, the pods of these plants would not be close enough to mesquite pods for oviposition to be induced on them. There are no known mesquite infestations in peanut (*A. hypogaea*) producing areas. Peanut pods are subterranean until exposed to the air post-harvest. In the field, non-host pods in the same area as mesquite will be sufficiently separated from mesquite pods to avoid oviposition by *A. bottimeri* females. If *A. bottimeri* is released in Australia it will pose no threat to these plants.

Conclusion

I submit that *A. bottimeri* is specific to plants of the genus *Prosopis* and recommend that it be released against mesquite in Australia.

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(b) *ALGAROBIUS PROSOPIS*

HOST SPECIFICITY OF THE BRUCHID *ALGAROBIUS PROSOPIS* (LE CONTE) FOR THE BIOLOGICAL CONTROL OF MESQUITE, *PROSOPIS* SPP. IN AUSTRALIA

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January 1996

Introduction

Two bruchids, *Algarobius prosopis* and *Algarobius bottimeri* were imported into quarantine at the Alan Fletcher Research Station for host specificity testing as potential agents for the biocontrol of seeds of mesquites, *Prosopis* spp., in Australia. Host testing of these two insects was performed in parallel. This report covers the host specificity testing of *A. prosopis*.

The mesquites are prickly woody weeds of mainland Australia. The major infestations are of *Prosopis pallida* in Queensland and the Northern Territory, *P. velutina* (Quilpie algarroba) in Queensland, a hybrid (*P. pallida* x ?) in Queensland and the Mardie hybrid (*P. pallida* x *? P. laevigata*) at Mardie Station, Western Australia. While these major infestations and some minor infestations of various mesquite taxa occur in the northern half of the continent, there are also minor infestations of various mesquite taxa in the southern half. Quilpie algarroba has been referred to as *P. flexuosa* (Pedley, 1977). However Burkart (1976) and Panetta (pers. comm.) consider that it is *P. velutina.*

A. prosopis occurs naturally in the south-west USA and north-west Mexico. Johnson (1983) recorded its native hosts as *P. velutina, P. glandulosa* var. *torreyana, P. pubescens* and *P. articulata.* Kingsolver (1986) adds *P. palmeri* and *P. reptans* var. *cinerascens*, but does not include *P. articulata,* and notes that *A. prosopis* has been reared in Arizona from the introduced Argentinian species, *P. alba.*

Both *A. prosopis* and *A. bottimeri* were introduced into South Africa from the USA for the biocontrol of two mesquites, *P. velutina* and *P. glandulosa* var. *torreyana*, following host specificity testing in quarantine (Peter and Zimmermann, 1987; Zimmermann, 1991; Hoffmann *et al*, 1993). *A. prosopis* is now widely established on *Prosopis* spp. in South Africa (Zimmermann, 1991: Hoffmann *et al*, 1993). Field and laboratory experience in South Africa suggests that *A. prosopis* out-competes *A. bottimeri* on the mesquite taxa in South Africa (Peter and Zimmermann, 1987; Zimmermann, 1991; Hoffmann *et al* 1993).

Biology

A. prosopis and *A. bottimeri* are almost identical mottled brown beetles from 2.2 to 5.0 mm long (Peter and Zimmermann, 1987). The only easily detected external difference between the two species is in the positions and shape of the pygidial sulci in the females. The males can only be separated by studying the genitalia (Kingsolver, 1986; Peter and Zimmermann, 1987).

According to Peter and Zimmermann (1987), *A. prosopis* adults mate within 24 hours of emergence and, after a short pre-oviposition period, females commence oviposition into surface cracks and crevices of mesquite pods. If there are no suitable protected sites, the female may oviposit clumps of 10-15 eggs on pod surfaces. Hoffmann *et al* (1993) found that females (n=35) could oviposit for 45 days with a cumulative mean oviposition of 225 eggs.

In nature, adults feed on pollen from any plants that are flowering (Kingsolver, 1986) and probably drink nectar. They are sustained successfully in the insectary on a paste made of honey and pollen. They are also sustained using a dilute sugar solution (Hoffmann *et al,* 1993).

Eggs hatch in 8-9 days at 34°C and larvae pass through four instars before pupation (Zimmermann, 1991). The first instar larvae have legs, are highly mobile (Peter and Zimmermann, 1987) and are able to tunnel through the sticky mesocarp, fibrous endocarp and hard seed coat to enter seeds. Only one larva develops through to the adult stage in each seed. Hoffmann *et al* (1993) found that full *A. prosopis* development took from 24 to 175 days (median 34 days) in an insectary with a temperature regime of 27°±2°C for 12 hour "days" and 23°±2°C for "nights". They found the male:female sex ratio of emerged beetles to be 1:1 and that newly emerged males consistently weighed significantly more than females.

Materials and Methods.

Importation of *A. prosopis*

A shipment of *A. prosopis* beetles was obtained from the University of Capetown, South Africa in February 1994. In quarantine, the beetles were reared on Mardie hybrid mesquite pods in plastic food storage containers and in styrofoam boxes in an airconditioned room with a daily temperature range of 18° C to 26°C. The ovipositing beetles in rearing boxes were fed on a mixture of commercially available honey and pollen. Mardie hybrid mesquite pods were used because a good supply of them was readily available from the field.

Host Test List

The plants used in these host specificity tests are listed in Addendum 1 and are grouped into Part 1 - Mesquites and Part 2 - Test Plants.

Pods of some plants in the original test list approved by AQIS (Appendix 1) could not be obtained. Where it was possible, a substitute species from the same listed taxonomic group was used:

Pods of *Acacia coriacea,* (unidentified subspecies) were used in *Acacia* Section Plurinerves instead of *A. coriacea* spp. *sericophylla.*

In *Acacia* Section Botrycephalae, *Acacia glaucocarpa* was substituted for *Acacia deanei* and *Acacia decurrens.*

In Family Caesalpiniaceae, *Senna artemisioides* was substituted for *Senna barclayana. S. artemisioides* is a perennial that occurs naturally near mesquite infestations in Queensland. It is used as a native ornamental in Queensland. Pods were easily

obtained. *S. barclayana* is a weedy annual that may sometimes grow in mesquite infested areas.

In the genus *Acacia*, Section Aculeiferum, neither *Acacia albizzioides* nor *Acacia pennata* sub-sp. *kerrii* could be obtained. These two species occur only in remote parts of Cape York Peninsula. No alternative species were available.

In the Tribe Piptadeniae, pods and seeds of *Entada phaseoloides* were unavailable and no alternative to *E. phaseoloides* was available.

Mesquite Tests

These tests were conducted to determine if *A. prosopis* would oviposit on and develop in pods of the various *Prosopis* taxa present in Australia.

In each test, four pods each of *P. pallida, P. velutina, P. glandulosa, P. juliflora* and *Prosopis* Mardie hybrid were enclosed with 100 beetles in a gauze-covered bench-top cage. The beetles used were obtained from the shipment received from South Africa after screening for parasitic mites. Two replicate cages used. Each group of four pods was placed in a separate shallow dish on the bottom of the cage. Water and a honey and pollen mix were placed in each cage. After 10 days the beetles were removed and the pods of each mesquite taxon were placed in separate sealed plastic containers. These were stored in a controlled-temperature cabinet with a daily temperature range of 18°-32°C to await emergence of beetles. Beetle emergence was monitored and recorded.

Multiple-choice Tests

Multiple-choice tests were conducted to determine if the beetles would oviposit on and develop in test plant pods.

In these tests, five pods each of mesquite (*Prosopis* Mardie hybrid) and of four test plant species (except for the last test when only one species remained to be tested) were placed in a 3.5 L plastic food container with a petri dish of honey and pollen mixture spread on tissue paper. Three replicates were set up for each pod combination. Fifty quarantine-reared beetles were added to each test container before the containers were sealed and placed in a controlled-temperature cabinet with a daily temperature range of 18°-32°C. The beetles were removed after 14 days. Pods of each taxon tested were placed in appropriately sized and labelled sealed containers to await possible development and emergence of beetles. The containers were stored in an airconditioned quarantine room with a daily temperature range of 18°-26°C. Pods were examined for eggs after sufficient time had elapsed for them to have hatched. This timing was necessary as examination of some pods was possibly damaging to eggs. Egg numbers were recorded. Beetle emergence was monitored and recorded. At least 14 weeks after the pods were removed from the oviposition containers, the seeds were removed from the pods and examined for larval entry holes. Non-mesquite seeds with entry holes were dissected to determine the fate of the larvae. Details of this examination were recorded.

No-choice Seed Substitution Tests

Seeds of test plant species, which did not have eggs laid on their pods in the multiple-choice tests, were exposed to *A. prosopis* larvae in no-choice seed substitution tests to determine if development would occur in them.

Pods of *Barklya syringifolia, Chamaecrista mimosoides* and *Pultenaea villosa* were the only pods to escape oviposition by *A. prosopis* in these multiple-choice tests. In each of three replicates, 10 seeds of each of these three species were inserted into emptied seed capsules in excised sections of Mardie hybrid mesquite pods. For controls, 10 Mardie hybrid mesquite seeds were similarly inserted. First, a sufficient quantity of mesquite pods was exposed to oviposition by quarantine-reared *A. prosopis* beetles for 1 week prior to the careful excision of the mesquite seeds. The seed substitutions were then made. Only pod sections on which clusters of eggs remained after seed excision were used for seed substitution. Care was taken not to damage the eggs. The sets of substituted seeds were stored in plastic food containers in a controlled-temperature cabinet with a daily temperature range of 18°-32°C. Beetle emergence was monitored and recorded. Seeds of test species were examined for larval entry holes after 7 weeks. Seeds with entry holes were kept a further 9 weeks before being dissected to determine the fate of the larvae. As all mesquite seeds produced beetles, no further examination of them was done.

Large Cage Tests

Test plant species on which either *A. bottimeri* or *A. prosopis* had successfully developed in the parallel multiple-choice tests, were used in large cage tests for each bruchid species. These were conducted to determine if the beetles would oviposit on the test pods if not in close proximity to mesquite pods. In host specificity testing in South Africa (Peter and Zimmermann, 1987; Zimmermann, 1991), the researchers noted that oviposition by both *A. bottimeri* and *A. prosopis* occurred on *Cassia didymobotrya* pods in close proximity to mesquite pods but not on *C. didymobotrya pods* in the absence of mesquite pods, and they assumed that mesquite pods provided an olfactory stimulus for oviposition.

Five pods each of Mardie hybrid mesquite and the five species in which either or both *A. bottimeri* or *A. prosopis* beetles developed in the parallel multiple-choice tests were placed out in shallow plastic trays on low benches in a large sheer nylon cloth cage (2 m x 2 m x 1.5 m) in a quarantine glasshouse. The pods were of *Petalostylis labicheoides, Acacia aneura, Neptunia gracilis* and *Arachis hypogaea* in which both bruchids had developed and *Caesalpinia decapetala,* in which only *A. prosopis* had developed. The mesquite pods were placed on the opposite side of the cage, approximately 1.5 m away from the test pods. Fifty quarantine-reared beetles were placed in the cage. There were three replicates of this test. After 1 week the beetles were removed and the pods of each species were placed separately in sealed plastic food containers. These were kept in a controlled temperature cabinet with a daily temperature range of 18°-32°C. After 2 to 4 weeks the pods were examined for eggs. When no eggs were found on any test pods, they were discarded. The beetle emergence from mesquite pods was monitored and recorded.

Results

Rearing

A. prosopis has been reared successfully for 15 generations in quarantine on pods of *Prosopis* Mardie hybrid.

Mesquite Tests

Pods of all five mesquite taxa supported the development of *A. prosopis* through to adult (Table 3) for three generations after which no viable seeds remained. Emergence of first generation beetles from pods of all mesquite taxa began 6 weeks after the tests were started.

Table 3. Mesquite tests. *Algarobius prosopis* emergence.

	P. hybrid		*P. pallida*		*P. velutina*		*P. glandulosa*		*P. juliflora*	
	R 1	R 2	R 1	R 2	R 1	R 2	R 1	R 2	R 1	R 2
Gen 1	28	28	*	56	*	27	*	24	55	55
Gen 2	33	23	*	19	*	25	*	19	25	40
Gen 3	1	0	*	1	*	5	*	1	5	5
Total	62	51	*	76	*	57	*	44	85	100

P. hybrid = *Prosopis* Mardie hybrid, R = Replicate, Gen = Generation
* - Pods became wet and mouldy when condensate water leaked into their containers in the CT cabinet. They were autoclaved.

Multiple-choice Tests

Oviposition by *A. prosopis* occurred on pods of all test plant species except *Barklya syringifolia, Chamaecrista mimosoides* and *Pultenaea villosa.*

Beetles emerged from seeds of *Prosopis* Mardie hybrid, *Acacia aneura, Caesalpinia decapetala, Petalostylis labicheoides, Neptunia gracilis,* and *Arachis hypogaea* (Table 4).

Dissected *A. aneura* seeds contained a dead beetle and dead large larvae. Dissected *P. labicheoides* seeds and *A. hypogaea* seeds contained dead beetles, dead pupae and dead larvae of various sizes. Dissected *N. gracilis* seed contained dead beetles and dead larvae of various sizes. Dissected *C. decapetala* seeds contained dead first instar larvae. The causes of death of the various stages of *A. prosopis* in these seeds were not apparent.

First instar larvae attempted to penetrate or penetrated seeds of most of the other test plant species, but no development beyond first instar larvae was found when these seeds were dissected. Many larval entry holes did not fully perforate the testa of some seeds. Larvae which

had penetrated beyond the testa were found dead at distances of 1-3 mm into the seeds. No larval entry holes were found in seeds of *Acacia galioides, Delonix regia,* and *Hovea acutifolia.*

Table 4. *Algarobius prosopis* emergence in multiple-choice tests

Test plant species	Development time	Number of beetles emerged		
	(Weeks)	Rep 1	Rep 2	Rep 3
Prosopis Mardie hybrid	6-11	67	69	69
Acacia aneura	20-34	9	9	7
Prosopis Mardie hybrid	6-11	73	80	83
Petalostylis labicheoides	15-31	12	14	11
Neptunia gracilis	15-19	10	2	3
Prosopis Mardie hybrid	8-35	78	73	58
Arachis hypogaea	9-23	6	6	5
Prosopis Mardie hybrid	4-26	86	86	94
Caesalpinia decapetala	13	0	1	1

No-choice Seed Substitution Tests

Each mesquite seed used in these tests produced a beetle. No development beyond first instar larvae occurred in any other seeds. No larval entry holes were found in *Pultenaea villosa* seeds.

Large Cage Tests

In the separate replicates, *A. prosopis* laid 471 eggs, 370 eggs and 205 eggs on mesquite pods, but laid none on test plant pods.

Discussion

Beetles of *A. prosopis* developed readily in seeds of all of the *Prosopis* taxa screened in the mesquite tests (Table 3) and for many generations in Mardie hybrid mesquite seeds in rearing boxes. *A. prosopis* should be able to develop in seeds of these taxa in the field. *A. prosopis* established readily on *P. velutina* in South Africa (Zimmermann, 1991).

The failure of larvae to penetrate through the testa or to develop beyond first instar in the majority of test plant seeds in multiple choice and no-choice seed substitution tests, indicates

that those species are unsuitable as hosts for *A. prosopis*. Southgate (1979) suggested that legume seeds may contain, in the testa or cotyledons, toxins or other substances that inhibit bruchid larval feeding or development.

The development of beetles in seeds of the test plants *A. aneura, C. decapetala, P. labicheoides, N. gracilis* and *A. hypogaea,* followed oviposition on their pods in the close presence of mesquite pods. The extended minimum development times in these species (Table 4) indicate that they are not ideal hosts.

In large cage tests, the rejection of all pods except mesquite for oviposition supports the view of Zimmermann (1991) that *A. prosopis* females will oviposit on non-host pods if they are in close proximity to mesquite pods but not on non-host pods that are separated from mesquite pods. There may be some places in Australia where mesquite occurs in the presence of *A. aneura* (mulga), *N. gracilis* or *P. labicheoides*. However, the pods of these plants would not be close enough to mesquite pods for oviposition to be induced on them. *C. decapetala* does not grow near mesquite in Australia. There are no known mesquite infestations in peanut (*A. hypogaea*) producing areas. Peanut pods are subterranean until exposed to the air post-harvest. In the field, non-host pods in the same area as mesquite will be sufficiently separated from mesquite pods to avoid oviposition by *A. prosopis* females. If *A. prosopis* is released in Australia it will pose no threat to these plants.

Conclusion

I conclude that *A. prosopis* is specific to plants of the genus *Prosopis* and recommend that it be released against mesquite in Australia.

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APPENDIX 1

Information required for an application to import biological control agents into quarantine for host specificity testing.

Algarobius prosopis (Le Conte) and *Algarobius bottimeri* Kingsolver potential biological control agents for mesquite, *Prosopis* spp.

A. INFORMATION ON THE TARGET WEEDS.

1. Taxonomy

1.1 Scientific and Common Names

There is considerable variation within species and inter-grading between species of *Prosopis* (Pedley 1977). The taxa listed below are those named in Parsons and Cuthbertson's (1992) treatment of *Prosopis* in Australia.

Order: Fabales
Family: Mimosaceae
Tribe: Adenanthereae

Prosopis flexuosa DC. - Quilpie mesquite *	(QLD)
P. glandulosa Torrey - honey mesquite	(NSW)
P. juliflora (Sw.) DC. - mesquite	(NSW, SA, QLD)
P. pallida (Willd.) Kunth - algaroba, mesquite *	(QLD, WA, NT)
P. pallida x ? *P. laevigata* (Willd.) M.C. Johnston - mesquite *	(WA)
P. velutina Wooton - velvet mesquite	(NSW)
P. juliflora x *P. velutina*	(NSW)

* These are the targets for this application.

In the Northern Territory, *P. pallida* is known by its synonym *P. limensis* Benth..

Electrophoresis study of tropical Australian mesquite populations showed that *P. pallida* was present at Hughenden in north Queensland and at Minderoo on the north-west coast of WA, and that *P. juliflora* was present at Pallarenda near Townsville, Qld (Panetta and Carstairs 1989). It also showed that infestations at Mardie (north-west coast of WA) and Rockvale (north-west Qld) are hybrids derived, possibly, from *P. pallida*.

For the purposes of this submission, the common name mesquite is used in the generic sense.

1.2 Brief Description

The following is a brief description of *P. juliflora* after Parsons and Cuthbertson (1992).

A spiny evergreen or deciduous shrub or low tree, with one to several trunks and crooked arched branches. It takes three forms depending on its location and water supply: short, many-stemmed shrubs 1 to 3 m high on the drier soils between watercourses; large, single-stemmed trees 6 to 15 m high, with a main trunk to 1 m diameter, near permanent water; and an intermediate type, branching almost from the base and forming dense thickets 5 to 8 m high, particularly along the banks of intermittently flowing streams, and on floodplains.

2. NATIVE RANGE AND PROBABLE CENTRE OF ORIGIN.

2.1 Native Range

The genus *Prosopis* consists of 44 arid and semi-arid zone species of which one is restricted to northern Africa, three occur naturally in eastern Asia and the rest are New World natives (Burkhart and Simpson 1977). Nine of these are native to North America and 31 species are native to South America.

2.2 Centre of Origin

Burkart and Simpson (1977) suggested South America as the most likely ancestral home of the genus *Prosopis* and noted that the processes of speciation and ecological diversification have proceeded to a greater extent in extra-tropical South America than elsewhere.

3. DISTRIBUTION.

3.1 Distribution in Australia

Mesquite infestations are found in all mainland states.

In Queensland there are two major pest species, *P. pallida* in the north-west and *P. flexuosa* in the south-west of the state. The two major centres of dense *P. pallida* are the townships of Hughenden (circa 1000 ha) and Cloncurry (circa 5000 ha). A hybrid mesquite is found at Rockvale (Panetta and Carstairs 1989), near Nelia (100 ha) and near McKinlay (250 ha dense and 1000 ha moderate density)(Bolton 1989).

P. flexuosa is present at varying densities in the Quilpie district of south-west Queensland where there are 2800 ha of dense infestations (population density in the range of 600-2000 plants per hectare) and 8800 ha of scattered infestations (population density in the range of 1-9 plants per hectare) on two properties (Csurhes 1989). Odd bushes occur on adjoining properties`. The *P. juliflora* infestation at Pallarenda has

been eradicated. A small infestation of *P. glandulosa* has been reported in an industrial area at Gladstone.

In Western Australia, 120,000 ha are reported to be infested with mesquite. Most infestations occur in the pastoral areas of the north-west of the state. The major problem area is on Mardie Station in the West Pilbara between Onslow and Port Hedland where 15-20,000 ha are infested. Smaller infestations are found in the Kimberley around Derby and Broome and in the Gascoyne along the Gascoyne and Lyons Rivers. Minor isolated infestations have been found on the Fitzroy River near Fitzroy Crossing, at Nicholson Station (east of Halls Creek) and along the upper Murchison River.

In New South Wales, the total area has been estimated at about 25,000 ha. The most common species is *P. juliflora* (Parsons and Cuthbertson 1992). There are two areas with heavy infestations of *P. juliflora*, one near Tibooburra and the other near Broken Hill (Parsons and Cuthbertson 1992).

In Northern Territory, mesquite *(P. pallida*, syn. *P. limensis)* is largely confined to the Barkly Tablelands and the Alice Springs district. Most Barkly stations have mesquite. In the Alice Springs district it occurs as single trees associated with homesteads.

In South Australia there are no extensive infestations and occurrences consist mostly of single planted trees or small groups often associated with towns and habitation.

Two small infestations in Victoria are under an eradication program (Parsons and Cuthbertson 1992).

3.2 Worldwide Distribution

A few species have been introduced into other areas of the world notably India, Pakistan, South Africa, Egypt, Kuwait, Hawaii, Brazil and Australia (DeLoach 1988) and Namibia (Zimmermann 1991).

In South Africa there are at least five species (one with two sub-species) that have become naturalised. Three of these taxa are problem weeds of the north-western Cape Province with infestations exceeding 180,000 ha (Zimmermann 1991). These are *P. velutina*, *P. glandulosa* var. *torreyana* and *P. juliflora* (Peter and Zimmermann 1987).

The greatest amount of weedy mesquite occurs in the United States where it is firmly established over 28 million hectares of rangeland in Texas, New Mexico and Arizona. It is endemic in this area, but remained in a state of balance with the other vegetation until the introduction of domestic stock and other human influences which affected ecosystem balance. The result was a dramatic increase in mesquite extent and density.

4. RELATIVES NATIVE TO AUSTRALIA

There are no *Prosopis* species native to Australia. The tribe Adenanthereae contains native plants in the genera *Adenanthera* (2 species), *Neptunia* (5 species) and *Dichrostachys* (1 species). The family Mimosaceae contains the large, ecologically important genus *Acacia* (840 spp. approx.).

5. PEST STATUS

Mesquite was introduced for its perceived benefits as a coloniser of unstable arid areas, as a food and shelter tree for livestock and as a garden ornamental. It is now declared noxious in all mainland states.

In Western Australia mesquite is a declared plant in the eradication category in all parts of the State except on Mardie Station where the size of the infestation is so great that a P4 (prevention of spread) declaration applies. In South Australia all *Prosopis* species are proclaimed plants on schedule 1, obliging landholders to notify the Animal and Plant Control Commission and their local Board of any infestations and to destroy all plants. In New South Wales *Prosopis* spp are declared noxious plants for the whole state. In Queensland *P. flexuosa* is presently declared under category P2 of the Rural Lands Protection Act (1985), *P. pallida* is declared under category P3.

Little quantitative work on the costs of mesquite infestation has been done in Australia. However considerable work has been done in the USA and some relevant figures are quoted. These figures indicate the potential impact of an increase in the occurrence of mesquite in Australia. Some of these impacts are discussed below in more detail.

In America, the costs of the damage caused by mesquite far outweigh its benefits and the potential damage to rangelands is significant. DeLoach (1988) states that "total direct losses attributable to mesquite are probably US$200 - 500 million annually in the United States plus an additional unknown amount in Mexico. Soil erosion, increased desertification and loss of soil water would add greatly to these losses. Loss in total economic activity is approximately 3 times this amount or US$0.5 - 1.5 billion annually".

The USDA in 1982 determined that a total of 20.7 million ha in Texas was infested with mesquite, 8.3% in dense stands, 28.8% in moderate stands and 62.9% in light stands (DeLoach 1988).

5.1 Reduction in Carrying Capacity

Bolton (1989) states that on favourable sites *Prosopis* thickets would reduce pasture and hence productivity to near zero.

In some situations in the USA mesquite has reduced the carrying capacity from 1 sheep to 4 ha to 1 sheep to 32 ha (Milthorpe 1975).

DeLoach (1988) reports an estimated 5% to 20% loss of beef production in Texas. Stocking rates were reduced by 75% over a 45 year period in New Mexico due to brush encroachment. Lost beef production totalled $44.4 - 143.3 million annually in Texas, plus another $34 million annually in New Mexico and Arizona.

5.2 Loss of Soil Water

The basis for most of the observed association between low forage production and high density of mesquite is undoubtedly that mesquite competes strongly for the available soil water. Mesquite has roots that extend more than 15m beyond the canopy of the tree and in favourable sites the roots extend to 15m deep (DeLoach 1988).

5.3 Soil Erosion

Mesquite is generally reported to increase wind and water erosion of the soil when it replaces grasses in the more arid areas of the southwest USA.

5.4 Management Losses

(i) Dense thickets interfere with mustering and joining.
(ii) Prolific growths near windmills act as a wind shields and prevent the pumping of water.
(iii) Thorns injure the hooves of animals and puncture vehicle tyres.
(iv) The ingestion by cattle of an excess quantity of mesquite pods over a long period causes an illness characterised by anaemia, emaciation, salivation, protruding tongue and nervousness. No substantial stock losses have been reported in Australia (Meadly 1962). The green pods can also cause problems when eaten by stock due to the long stringy pod-margin forming large hard balls in the stomach (Cunningham *et al.* 1981).

5.5 Other

(i) Mesquite is a major hay fever plant in the American South West, Hawaii and South Africa. Serious allergenic problems were caused in India and Kuwait by the introduced *P. juliflora* (DeLoach 1988).
(ii) Dense thickets of mesquite harbour feral animal pests such as rabbits and pigs.
(iii) Environmental implications of replacement/invasion of natural ecosystems by an introduced species.

6. BENEFICIAL USES

In Australia, mesquites were planted around homesteads for shade and/or as ornamentals. Mesquites were also used for stabilising erosion prone areas and reclaiming mine-waste dumps.

DeLoach (1988) identified the following commercial uses, either existing or potential, for mesquite

(i) Utilisation of the wood: fuel for steam or generation of electricity, wood products, firewood, charcoal and barbecue wood, crafts and furniture and paper.
(ii) Livestock feed: some species of mesquite leaves are eaten but the ripe pods of mesquite are relished by most livestock because of the high sugar content.
(iii) Human food: the aboriginal peoples of south west North America ground the dry pods in water to make drinks or alcoholic beverages. Mesquite is one of the more valuable honey plants in the south western United States.
(iv) Chemicals, and medicines: some chemicals, alcohol, tannins and gum have been produced.
(v) Ornamentals.

The density of Australian mesquite infestations is usually insufficient to support the uses outlined above. In Western Australia there is small scale commercial use of mesquite for honey production and as firewood for barbecues.

7. OTHER CONTROL METHODS AVAILABLE

Other methods available for the control of mesquite are of a chemical and mechanical nature with some limited management actions possible to control the spread of mesquite.

7.1 Chemical Control

Basal bark and cut stump treatments of clopyralid, picloram, picloram + 2,4-D and triclopyr in diesel oil are effective (Parsons and Cuthbertson 1992). These chemicals and glyphosate as foliar sprays can be effective with best results obtained from picloram and clopyralid because of their greater rate of uptake (Parsons and Cuthbertson 1992). All herbicide treatments are best applied after rain, when plants are actively growing.

7.2 Mechanical Control

The mechanical techniques available include hand grubbing, power grubbing (use of bulldozer), chaining, heavy duty blade ploughing, root cutter or disc and roller chopper. The more intensive mechanical methods usually require a larger initial capital outlay when compared with herbicides, and retreatment is necessary in most instances to control reinfestation and plants missed by the initial operation.

In northern Queensland mechanical treatments seem more successful since they are usually a prelude to a more intensive land use at the site (Bolton 1989). Csurhes (1989) considers that dense infestations require mechanical treatment before any chemical treatment can be contemplated. The costs of large scale mechanical clearing are, however, prohibitive. The costs of control for an area of 300,000ha of *P. flexuosa* in the Quilpie district have been estimated at $914,000 using mechanical and chemical means (Csurhes 1989).

7.3 Integrated Control

It may be useful to integrate a chemical follow up treatment with mechanical methods. Parsons and Cuthbertson (1992) document the success of integrated mechanical and chemical means to control mesquite in Western Australia.

7.4 Management

Fire can be effective against *P. pallida* when there is sufficient fuel.

Where livestock, particularly cattle, are grazing mesquite-infested areas, landholders are advised to hold stock for at least 14 days in a small paddock prior to their movement to non-infested areas. These smaller paddocks as well as the non-infested areas are monitored for subsequent seedling growth which can be killed by grubbing or burning (McCormick 1989).

8 SUMMARY

8.1 Potential for Spread

The arid and semi-arid regions of Australia cover 5.3 million square kilometres or 69% of the continent. There appear to be no climatic or biological limitations to the eventual spread of *P. flexuosa* over a wide area of semi-arid Australia. Bolton (1989) considers that *Prosopis* spp. have the potential to increase in both area and density over much of Western Queensland including the south-flowing Diamantina and Cooper drainage systems.

8.2 Potential for Biological Control

Over 300 species of insect have been found to attack the 30 species of *Prosopis* native to Argentina and Paraguay (Cordo and DeLoach 1987). The most promising appear to be the seed-feeding bruchid beetles. Successful biological control of mesquite in the USA appears technically feasible with the insects known in Argentina (Cordo and DeLoach 1987).

Encouraging biocontrol results have been obtained in South Africa using the North American bruchid *Algarobius prosopis*, one of the subjects of this proposal. Within 27 months of release in one area, 92% of the seeds in a sample of pods were destroyed by *A. prosopis* (Zimmermann 1991).

B. INFORMATION ON THE AGENTS

1. SCIENTIFIC NAMES

Algarobius prosopis (LeConte) (Coleoptera: Bruchidae)
Algarobius bottimeri Kingsolver (Coleoptera: Bruchidae)

2. DESCRIPTION AND BRIEF BIOLOGY

2.1 Description

The two beetles were described by Peter and Zimmermann (1987) as follows. *A. prosopis* and *A. bottimeri* are almost identical mottled brown beetles from 2.2 to 5.0 mm long. The only detectable external difference between the two species are in the positions of the pygidial sulci of the females while the males of the two species can only be separated by studying the genitalia. The two species differ in their host preference and geographic range in the USA.

2.2 Brief Biology

The biology of the two species was described by Peter and Zimmermann (1987). A brief summary follows. The adults mate within 24 hours of emergence. Females insert eggs into surface cracks and crevices in the exocarp of the pod. If there are no cracks, females may oviposit clumps of 10-15 eggs on the outside of the pod. The first instar larva has legs and is very mobile. It burrows into the pod and eats through the mesocarp and the hard seed coat, into the seed. Once inside a seed, a larva feeds within it, moulting a few times, until it pupates about 25 days later. Larvae of both species can survive in immature seeds as well as in hard dry seeds. After about 30 days, adults emerge by eating their way out of the pods. Adults live up to 30 days. Kingsolver (1986) reported that adult *Algarobius* spp. feed on pollen.

The two species differ in their host preferences. Kingsolver (1986) lists *P. velutina*, *P. glandulosa* var. *torreyana* (L. Benson) *P. palmeri* S.Wats., *P. pubescens* Benth. and *P. reptans* var. *cinerascens* (A. Gray) as host plants of *A. prosopis* and reports that *A. prosopis* has been reared from the introduced Argentinian species *P. alba* in Arizona. *A. bottimeri* has as recorded hosts, *P. glandulosa* var. *glandulosa* and *P. reptans* var. *cinerascens* in North America and the introduced South American *P. pallida* in Hawaii (Kingsolver 1986).

3. DISTRIBUTION

3.1 Native Range

A. prosopis occurs in the south-west USA and north-west Mexico. *A. bottimeri* occurs mainly in Texas and north-east Mexico.

3.2 Introduced Range

A. prosopis was introduced into South Africa as a biocontrol agent in 1987 and into Namibia in 1988 (Zimmermann 1991). It was distributed in the mesquite infested areas of these countries. *A bottimeri* was introduced into South Africa in 1990 as a biocontrol agent. Both are established. Up to 90% of the annual seed crop at some sites has been destroyed (Zimmermann 1991).

A. bottimeri was accidentally introduced to the Hawaiian Islands with introduced *Prosopis* early this century (Kingsolver 1986).

4. RELATED SPECIES

Larvae of *Algarobius* spp. are known to feed only in seeds of *Prosopis* spp. (Johnson, 1983; Kingsolver, 1986).

5. PROPOSED SOURCES OF AGENTS

A. prosopis material will be collected in South Africa by Dr H G Zimmermann (Plant Protection Research Institute, Private Bag X134, Pretoria, Republic of South Africa). *A. bottimeri* may be collected by Dr Zimmermann or Dr J H Hoffmann (Zoology Department, University of Capetown, Rondebosch, South Africa). If *A. bottimeri* cannot be obtained from South Africa, Dr W Palmer(Queensland Lands Department North American Field Station, Temple, Texas) will collect in Texas from an area where the range of *A. bottimeri* does not overlap that of *A. prosopis.*

6. MODE OF ACTION

The larvae of *A. prosopis* and *A bottimeri* feed inside seeds of mesquite. Beetles lay eggs in cracks and holes in the pods. After they hatch, first instar larvae tunnel through pod material until they enter undamaged seeds. One larva completes its development in one seed and pupates inside. In the process it destroys the seed's food reserves and embryo. The emerging beetle makes a large exit hole in the seed and pod. There are three or four generations per year.

7. POTENTIAL FOR CONTROL OF THE TARGET

Because of the promising performance of *A. prosopis* in South Africa where destruction of up to 90% of the annual seed crop has been recorded (Zimmermann 1991), there are favourable prospects that similar results will occur in Australia. If the rate of seed destruction can be sustained at a high level the potential for further spread of the mesquites in Australia will be reduced.

8. NON TARGET ORGANISMS AT RISK

Literature and museum records, and the known host range of the two species, support the view that these are host specific insects and that it is unlikely that any other plant species will be at risk. Nevertheless, both species will be tested in quarantine against a wide range of plants related to mesquite.

9. POSSIBLE INTERACTION WITH EXISTING CONTROL PROGRAMS

There have been no other biocontrol agents released on mesquite in Australia. A leaf, flower and shoot-feeding psyllid *Heteropsylla texana* is undergoing host testing at the Alan Fletcher Research Station. If it and the bruchids are released, there should be no direct interaction with the bruchids. If *H. texana* successfully destroys flowers there may be a reduction in mesquite pods available for the bruchids.

Any interaction with chemical and mechanical programs will be positive in that the residual seed banks will be reduced.

10. PRELIMINARY TESTS

A. prosopis and *A. bottimeri* were tested on 74 species of legumes in South Africa prior to their release in South Africa and Namibia (Peter and Zimmermann 1987).

No larval feeding or development of either species occurred in any test plant seeds except those of the exotic weed *Cassia (Senna) didymobotrya*, which originated elswhere in Africa. No feeding occurred on two other species of *Cassia*. No eggs were laid on *C. didymobotrya* pods in starvation tests (Peter and Zimmermann 1987). In multiple choice tests no eggs were laid on *C. didymobotrya* unless there were *Prosopis* spp. pods in close proximity (Zimmermann 1991). Peter and Zimmermann (1987) concluded that gravid females of both species will not oviposit on *C. didymobotrya* in the absence of an olfactory stimulus associated with *Prosopis* spp.. *A. prosopis* and *A. bottimeri* were therefore regarded as host specific and safe for release in South Africa.

11. PROPOSED HOST SPECIFICITY TESTING

Oviposition preference of the two species will be tested with pods and seeds of test plant species in multiple choice tests. Seed substitution (transplant) tests as described by Peter and Zimmermann (1987) will be performed to test larval feeding.

A proposed list of plant species to be used in host specificity testing is attached as Appendix A. Plant species on this list were chosen using the centrifugal phylogenetic method with particular emphasis on Australian plants in the family Mimosaceae.

Because of the large number of species of *Acacia* native to Australia this genus is heavily represented. Where possible species occurring in areas of northern Australia where mesquite occurs have been chosen. In the genus *Acacia* we have listed species

from each section of each Australian subgenus of *Acacia* with the exception of section Alatae which is considered to be an artificial grouping of species that occur only in the southwest of Western Australia (B. Maslin, WA Herbarium, pers. comm.). Only one of the listed species in each section is to be tested. The final selection of species will be determined by availability of pods and/or seeds.

A number of plant species which may otherwise have been included in the list were cleared in host specificity testing in South Africa (Peter and Zimmermann 1987). These are Acacia cyclops, *A. longifolia, A. mearnsii, A. nilotica, A. podalyriifolia, A. saligna, Glycine max, Lablab purpureus, Leucaena leucocephala, Phaseolus vulgaris* (bush beans in South Africa), *Pisum sativus* and *Vicia faba.*

The cases of larval feeding in *C. didymobotrya* seeds in the South African tests raises the possibility of a similar result with an Australian *Cassia.* The proposed list includes *Cassia brewsteri* as well as *Chameacrista mimosoides* (= *Cassia mimosoides*) and *Senna barclayana* (=*Cassia barclayana*).

12. PROPOSED INITIAL RELEASES

Initial releases will be made on *P. flexuosa* at Quilpie and *P. pallida* at Hughenden in Queensland and on *P. pallida* x ? *P. laevigata* in Western Australia.

13. EVALUATION OF ESTABLISHMENT, DISPERSAL AND EFFECTS ON THE TARGET WEED

Staff of the departments involved in Qld and WA will monitor the agents in the field if they are released.

14. METHODS OF EVALUATION

To be developed.

15. COLLABORATIVE RESEARCH WITH OTHER DEPARTMENTS

This is a joint project involving the Queensland Lands Department and the Western Australia Department of Agriculture.

16. ASSISTANCE SOUGHT FROM OTHER DEPARTMENTS

Assistance may be sought from departments in Queensland, WA, NSW and NT to obtain various pods and seeds required for the project.

17. ASSISTANCE OFFERED TO OTHER DEPARTMENTS

If approved for release, starter colonies will be provided to all States that request them. Information on the biology and rearing techniques will be given.

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APPENDIX A

Proposed plant list for host specificity testing of *Algarobius bottimeri* and *A. prosopis* for the biological control of mesquite, *Prosopis* spp..

* Introduced species

Family Mimosaceae		
Tribe Adenanthereae		
	Adenanthera pavonina	red beantree, red sandalwood
	Neptunia gracilis	native sensitive plant
	Dichrostachys spicata	
	* *Prosopis flexuosa*	Quilpie Mesquite
	* *Prosopis glandulosa*	honey mesquite
	* *Prosopis juliflora*	mesquite
	* *Prosopis pallida*	algaroba, mesquite
	* *Prosopis pallida* x ? *P. laevigata*	mesquite
	* *Prosopis velutina*	velvet mesquite
	* *Prosopis juliflora* x *P. velutina*	mesquite
Tribe Acacieae		
Genus *Acacia*		
Sub-genus *Acacia*		
One of	*Acacia bidwillii*	corkwood wattle
or	*Acacia sutherlandii*	
Sub-genus *Aculeiferum*		
Section Aculeiferum		
One of	*Acacia albizzioides*	
or	*Acacia pennata* ssp. *kerrii*	
Sub-genus *Phyllodineae*		
Section Botrycephalae		
One of	*Acacia deanei*	green wattle
or	*Acacia decurrens*	green wattle

APPENDIX A

Proposed plant list for host specificity testing of *Algarobius bottimeri* and *A. prosopis* for the biological control of mesquite, *Prosopis* spp..

* Introduced species

	Section Phyllodineae	
One of	*Acacia ampliceps*,	
	Acacia bivenosa,	
	Acacia dictyophleba,	
	Acacia salicina,	doolan, cooba
	Acacia tetragonophylla,	
or	*Acacia victoriae*	elegant wattle, gundabluie
	Section Lycopodiifoliae	
One of	*Acacia galioides*	
or	*Acacia spondylophylla*	
	Section Pulchellae	
One of	*Acacia browniana*	
or	*Acacia pulchella*	prickly moses
	Section Plurinerves	
One of	*Acacia coriacea* ssp. *sericophylla*,	desert oak, dogwood, wirewood
	Acacia melanoxylon,	blackwood
	Acacia papyrocarpa,	
	Acacia platycarpa,	ghost wattle
	Acacia retivenia,	
or	*Acacia stenophylla*	belalie, river cooba

APPENDIX A

Proposed plant list for host specificity testing of *Algarobius bottimeri* and *A. prosopis* for the biological control of mesquite, *Prosopis* spp..

* Introduced species

	Section Juliflorae	
One of	*Acacia ancistrocarpa*,	Fitzroy wattle
	Acacia aneura,	mulga
	Acacia colei,	candelabra wattle
	Acacia cowleana,	
	Acacia lysiphloia	turpentine bush
or	*Acacia monticola*	
	Tribe Piptadeniae	
	Entada phaseoloides	matchbox bean
	Tribe Euminoseae	
	Mimosa pudica	common sensitive plant
	Tribe Ingeae	
	Archidendron lucyi	
	Archidendropsis basaltica	
	**Calliandra inaequilatera*	pom-pom tree
	Paraserianthes lophantha	
Family Caesalpiniaceae		
	Barklya syringifolia	
	Caesalpinia decapetala	
	Cassia brewsteri	Leichhardt bean
	Chamaecrista mimosoides	five-leaved cassia
	**Delonix regia*	poinciana
	Lysiphyllum hookeri	white bauhinia, pegunny
	Petalostylis labicheoides	butterfly bush
	Senna barclayana	pepper-leaved senna

APPENDIX A

Proposed plant list for host specificity testing of *Algarobius bottimeri* and *A. prosopis* for the biological control of mesquite, *Prosopis* spp..

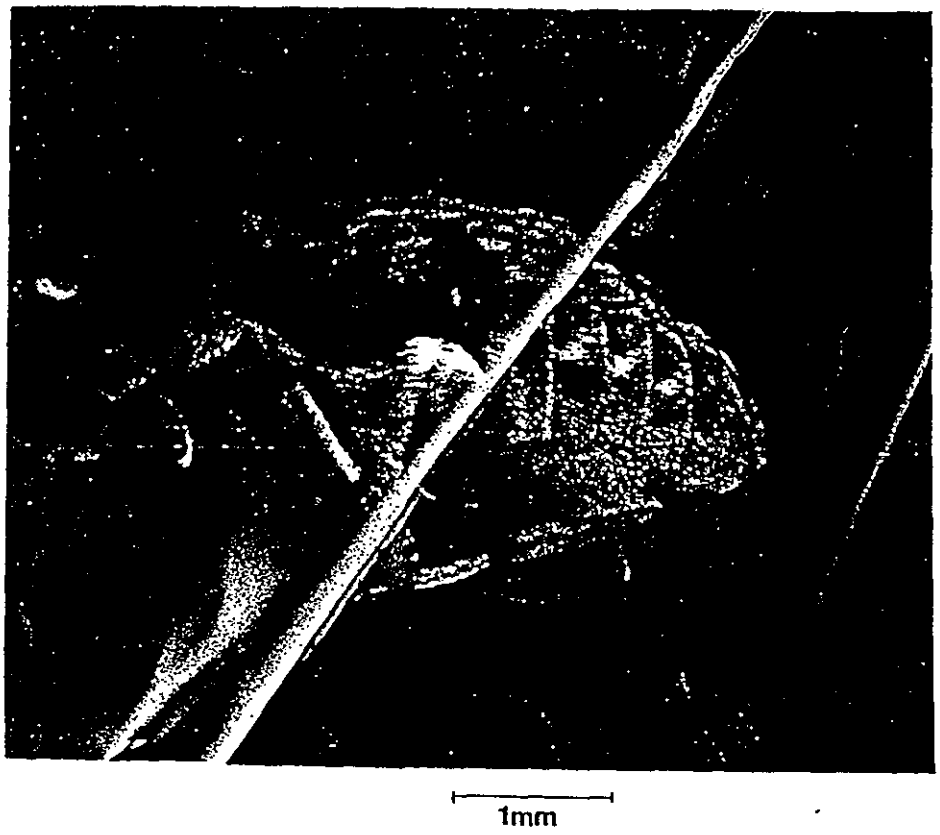
* Introduced species

Family Fabaceae

**Arachis hypogaea*	peanut
**Cajanus cajan*	pigeon pea
Clianthus formosus	Sturt's desert pea
Hardenbergia violacea	native sarsparilla
Hovea acutifolia	
**Macroptilium atropurpureum*	siratro
Pultenea villosa	
**Vigna radiata*	mung bean

APPENDIX 2

APPLICATION FOR PERMISSION TO RELEASE THE SEED-FEEDING BEETLES *ALGAROBIUS PROSOPIS* AND *ALGAROBIUS BOTTIMERI* (BRUCHIDAE) FOR THE BIOLOGICAL CONTROL OF *PROSOPIS* SPECIES IN SOUTH AFRICA.



Algarobius bottimeri

R.O.PETER AND H.G.ZIMMERMANN

1987

1. *PROSOPIS* (Mesquite)

Members of the Genus *Prosopis* (Fabaceae) were introduced into southern Africa from the U.S.A. at the end of the nineteenth century to provide shade and an alternative source of fodder for stock in the dryer parts of South Africa (Harding, 1978). While the useful properties of *Prosopis* are still recognised by some farmers, the plant has lately received considerable atention because it has become an aggressive invader of pastures on many farms, mainly in the north-western Cape. Consequently, all *Prosopis* spp have been declared invaders according to the Agricultural Conservation of Resources Act, No 43 of 1983 (Government Gazette No. 9238 of 25 May 1984).

Both mechanical and chemical control of *Prosopis* are very expensive, labour intensive and time consuming. Unsuccessful attempts at control often stimulate copice growth resulting in unmanageable and impenetrable multi-stemmed thickets. Results of a survey done by Harding during 1985 showed that most farmers see *Prosopis* as a threat which outweighs any advantages that the plant may hold for them. Before landowners are able to exploit the useful properties of this plant, the threat of further infestations of their land must be curtailed. Spread is facilitated by means of a large seed crop that is dispersed by animals eating the pods. The pods can also be carried over large distances by water.

1.1 Taxonomy of Prosopis

A review of the taxonomy of *Prosopis* is given by Harding (1987). Identification of the different *Prosopis* spp relies on specific characteristics of the leaflets, pods and spines which may vary under different climatic conditions. Present work points to the following species being present in South Africa:

P. glandulosa J. Torr var *glandulosa, P. glandulosa* J. Torr var *torreyana* (L. Benson) M.C. Johnston, *P. velutina* Wooton, *P. chilensis* (L. Mol.) Stuntz and *P. juliflora* (Swartz) DC. Of these taxa, it would appear that *P. glandulosa* var *glandulosa* and *P. chilensis* are minimally invasive and therefore of little concern. *P. velutina* is invasive in the Mafikeng area whereas in the Vanwyksvlei area the invaders are probably a mixture of *P. glandulosa* var *torreyana* and *P. velutina* (Harding, 1987). It is also likely that extensive hybridization has taken place, and it is possible that many of the infestations consist of hybrid trees that share the characteristics of two or more of the above mentioned species. The closest relatives to *Prosopis* in South Africa are the approximately forty *Acacia* spp found throughout the country (Ross, 1979).

1.2 Proposed Biological Control Agents.

Local alydid bugs have been noticed to feed on prosopis seeds in large numbers in some areas (Zimmermann pers comm). The impact of these bugs on the prosopis seed population as a whole is not significant for the following reasons:

i. The natural hosts of these bugs are the local *Acacia* spp and damage to *Prosopis* is thus limited to those areas which have a large local *Acacia* population.

ii. While fungi are probably transferred by the bugs to some of the seeds, which may kill them, others are apparently unharmed by the effects of feeding.

One local seed feeding bruchid beetle, namely *Bruchidius submaculatus* was reared from prosopis pods. This was an isolated case, and no other local bruchids are known to attack prosopis seeds in South Africa at this stage.

The seed feeding beetle *Algarobius prosopis* (Bruchidae), is the most successful predator of prosopis seeds in Arizona (U.S.A.), contributing up to 93% of all the damage done to the seeds (Swier, 1974). However the total damage caused by all seed-feeders in Arizona amounts to only 30% of the total annual seed crop produced (Swier, 1974). It is anticipated that the seed damage to *Prosopis* in South Africa after release of this beetle, will be considerably higher because the beetle may be free of specific natural parasitoids and predators. These natural enemies of *Algarobius* sp are considered to be a major limiting factor in preventing a higher seed destruction of *Prosopis* seeds in the U.S.A. (Kistler, 1985).

A. prosopis is somewhat restricted to the western half of the U.S.A. (mainly Arizona) where the climate is very hot and dry. *A. bottimeri* which is adapted to the milder climate of the eastern half of the U.S.A. (mainly Texas) (Figure 1), was also introduced. Together, these two beetle species should be able to inhabit regions with a wide climatic range in South Africa. By introducing both bruchids to South Africa, all regions invaded by *Prosopis* may be covered by the insects. Another reason for releasing both bruchid species is that they differ regarding their preferred host plant species.

A. prosopis is specific to *P. velutina* and *P. glandulosa* var *torreyana* whereas *A. bottimeri* is more specific to *P. glandulosa* var *glandulosa* (Kingsolver, 1986). Many of the infestations are considered to consist of a hybridised prosopis complex. These two bruchid species should therefore prey on a wider variety of seed types in such an infestation compared to a single beetle species. There is good reason to believe that the establishment of both bruchid beetles in South Africa could curtail the spread of *Prosopis* in this country by destroying a large proportion of its seeds.

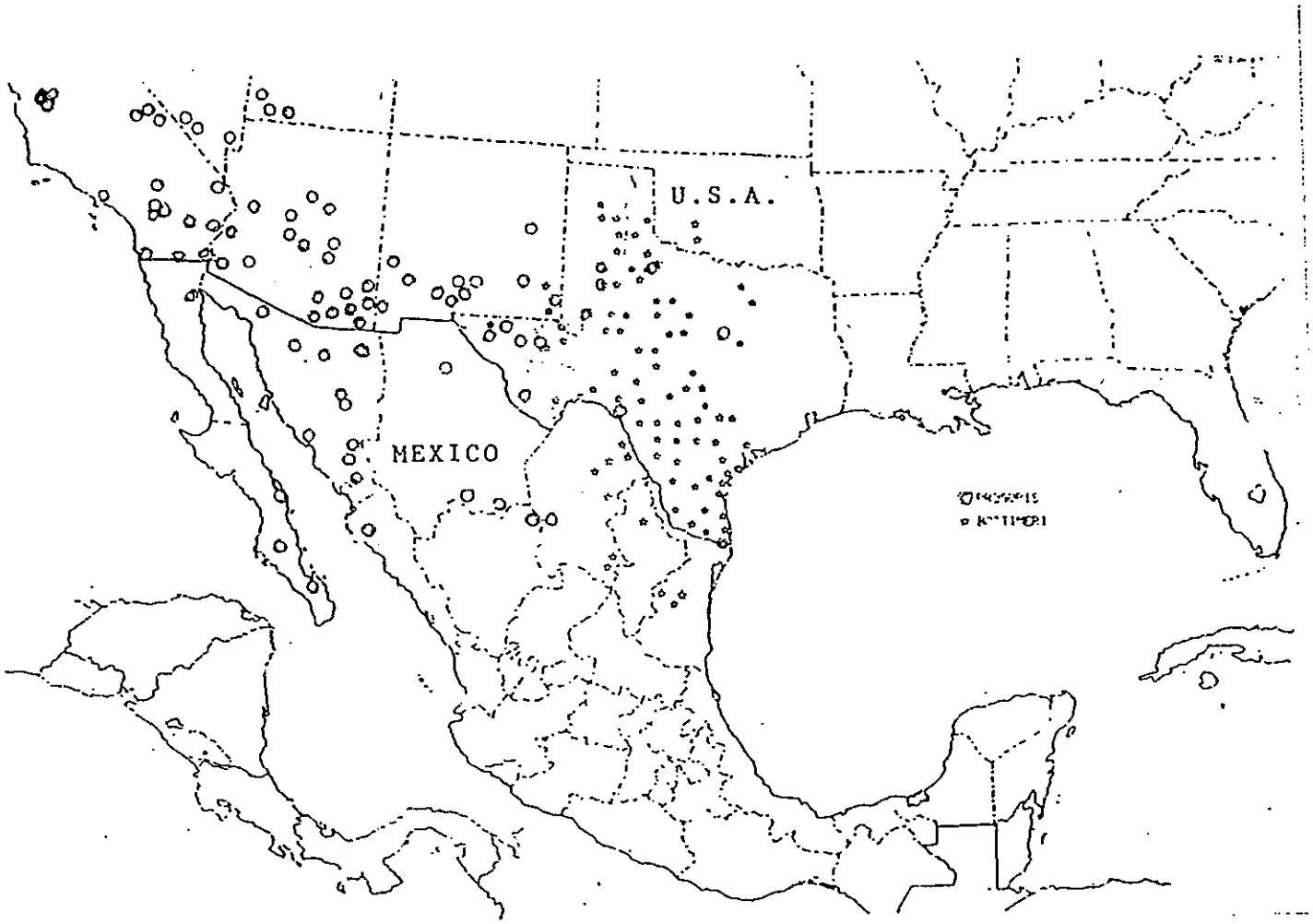


Figure 1: Distribution records of *A. prosopis* (o) and *A. bottimeri* (*)

A. bottimeri was introduced from Texas in September 1985 and *A. prosopis* from Arizona in July 1986. Both species were screened at Uitenhage for their suitability as biological control agents of *Prosopis* in South Africa. The results of these tests are presented in this report, along with other evidence to show that *A. prosopis* and *A. bottimeri* are safe and suitable for release in South Africa.

2. Description and Biology of *Algarobius prosopis* and *Algarobius bottimeri*

The *Algarobius* spp are small to medium sized, mottled brown beetles, 2,2 - 5,0 mm long. *A. prosopis* and *A. bottimeri* are almost identical in appearance. The only detectable difference between the two species are found in the pygidial sulci. These are on the face of the pygidium in the case of *A. bottimeri* females, while in *A. prosopis* females they are on the vertical face of the pygidium adjacent to the apical margin. The males of the two species are morphologically identical and can only be separated by studying the male genitalia. The two spp also differ from each other in their host preference and geographical distribution in the U.S.A. Because both species resemble each other so closely in both morphology and behaviour, a joint description of their biology is given.

2.1 Biology

Within 24 hours after emerging from *Prosopis* pods the adults mate and after a short pre-ovipositional period the females oviposit in any surface crack or crevice in the exocarp of the pod which allows access to the mesocarp. If no such break in the pod coat is present, the female may eventually oviposit on the outside of the pod in a clump consisting of 10-15 eggs. The first instar larvae have legs and are very mobile, reportedly making them competitively superior to the apodous larvae of other members of the family Bruchidae which also feed on *Prosopis* seeds in the U.S.A. (Swier, 1974). These first instar larvae make their way into the seeds by feeding through the mesocarp and the hard seed coat. They live and feed inside the seeds, moulting a few times, until they pupate approximately 25 days later. Larvae of both *Algarobius spp* can survive in immature green pods as well as in the very mature hard dry pods, thus making it possible for both spp to breed continuously throughout the year. Development is only restricted by the colder winter months. This also makes *A. prosopis* and *A. bottimeri* competitively superior to many of the other bruchid species that inhabit *Prosopis* pods in the U.S.A. which are restricted to either mature or immature pods. After approximately 30 days in

summer, the adults emerge by eating their way out of the pod leaving a characteristic emergence hole (Figure 2). The adults may live for up to 30 days. These bruchid beetles can survive entirely on *Prosopis* pods of which only the seeds are eaten, and although some feeding on pollen by adults is reported by Kingsolver (1986), no other parts of the trees are utilized.

3. Host Specificity

Bruchid beetles are, for the most part, highly host specific (Center and Johnson, 1974; Johnson and Slobodchikoff, 1979).

Figure 2: Prosopis pods showing emergence holes of bruchid beetles.

Janzen (1969) listed 31 triats of legumes that may be functional in limiting or lowering bruchid seed destruction. These include morphological, phenological and chemical triats which appear to be responsible for a legume's resistance to a specific bruchid's attacks. However, alkaloids and free amino acids are the most likely compounds that prevent most or all bruchid attack. These compounds and other potentially toxic compounds are present in most legume

species, but the co-evolved bruchids have become immune to these specific compounds (Janzen, 1969). This long standing co-evolution of legumes and bruchids has eventually led to the high degree of specificity we find today.

Van Tonder (1985) collected bruchids from a wide range of southern African *Acacia* species. Seeds of 41 indigenous *Acacia* species were collected, of which 37 yielded one or more bruchid species. These included 15 known species and 12 new species of Bruchidae. From this diverse bruchid population found on the indigenous *Acacia* species in South Africa, not one species has accepted Prosopis, as a new permanent host inspite of the fact the *Prosopis* is closely related to the South African *Acacia* spp. (Ross, 1975). Of all the native bruchids, only one local species, namely *Bruchidius submaculatus,* has been reared from *Prosopis*, in an isolated incident. This failure of the local bruchids to utilize such a large resource of seeds from a plant so closely related to their own host plants, is further evidence of the high degree of host specificity of the bruchids. After compiling a list of bruchid beetles and their hosts from 114 papers, Johnson (1981) reports that the *Algarobius* spp are totally limited to *Prosopis.* This is confirmed by Kingsolver (1977 and 1986) when he lists *A. prosopis* as being specific to *P. velutina* and *P. glandulosa* var *torreyana* and *A. bottimeri* as being specific to *P. glandulosa* var *glandulosa.*

Although the literature provides sufficient evidence that the two *Algarobius* species are host specific, extensive host specificity tests were carried out in quarantine at the Weed Laboratory near Uitenhage during 1986/1987. The purpose of these tests was to expose legume pods from economic and indigenous plants in South Africa that are not present in the U.S.A. and that could be accepted as alternative hosts.

Host specificity tests were restricted to exposure of the beetles to the pods of other legume species because of their dependance on the pods for development. They do not feed on any other parts of the plant. These tests were to establish whether the adult females would oviposit on pods and the larvae develop to maturity on any species other that *Prosopis.*

3.1 Methods of Host Specificity Testing

Three different types of tests were carried out on the beetles, namely, starvation tests, choice tests and seed transplant tests. In starvation tests, the beetles were forced to oviposit on non-host legume pods, in the absence of *Prosopis* pods. In the choice tests, *Prosopis* pods were included together with the test plant to determine if the bruchids would oviposit on pods of any other legume in the presence of their natural host. With the seed transplant tests, the larvae were forced to feed on seeds of non-host species after these have been transplanted into *Prosopis* pods to determine beyond doubt if they could develop in these seeds even if the females would not naturally choose to oviposit on pods of these legumes.

3.1.1 Host Testing: Choice and Starvation Tests

These tests were carried out in a quarantine room which was maintained at a constant temperature of approximately 27°C with a light/dark cycle of 14hrs/10hrs. Separate cultures of *A. prosopis* and *A. bottimeri* were maintained by means of providing the adults, which were kept in fabric gauze cages, with a continuous supply of mature *Prosopis* pods on which to oviposit. The pods were occasionally sprayed lightly with water and later with sugar water, but this was not essential for the survival of the beetles but probably increased their total fitness. In order to obtain freshly emerged adults of equal age, subcultures were maintained in smaller plastic containers and the emerging adults were removed on a daily basis. This ensured that any adults found in the subculture at any given time had emerged on the same day.

Between 30 and 60 newly emerged adults of both sexes were confined in perspex containers which contained pods of up to 4 different test plant species (figure 3). Approximately 5 pods of each legume test species were used in each test (figure 4).

Figure 3. A number of containers with beetles undergoing choice tests.

Figure 4. Pods present in a typical choice test.

In the starvation tests, *Prosopis* pods were excluded from the containers while in the choice tests they were included.

The adult bruchids were removed from the containers after 20 days, and the pods were then observed each day to determine how many beetles had emerged from each test pod and how long their larval development time was. After 70 days, the pods were dissected and the seeds examined for signs of damage by the beetles. In all these tests, the seeds were either completely destroyed, as was the case with *Prosopis*, having supported the development of the larvae, or they showed no sign of any damage.

3.1.2 Seed Transplant Tests.

These tests were carried out under the same conditions as described for the starvation and choice tests. The seeds and the fibrous endocarp were carefully dissected from the *Prosopis* pods, and were then replaced by other legume seeds. Where the *Prosopis* pod was cut open to replace the seeds, the slit was carefully sealed again with a thin strip of masking tape (figure 5).

A control was made by following the above procedure but then replacing the *Prosopis* seeds back into its own pod (some with and some without the endocarp). The bruchid females were subsequently allowed to oviposit on these *Prosopis* pods, and the larvae that entered the pods were then confronted with a non-host seed instead of a *Prosopis* seed.

This was the final test to determine beyond doubt if the beetles could develop on any of the non-host seeds offered. Seed damage was determined in the same way as for the starvation and choice tests.

Figure 5: Components of a typical seed transplant test

(a & b) - test' plant seeds

(c) - *Prosopis* seeds

More than sixty legumes were tested using one or more of the above mentioned methods. These included crop plants such as beans and peas and exotic and indigenous garden ornamentals. The native Acacia species were the best represented test plants, as they are the closest relatives to *Prosopis* in South Africa. The status of the plants tested ranged from economically important crops to weeds.

3.2 Results of Host Specificity Tests

Results of these tests are presented in Appendix 1. *A. prosopis* and *A. bottimeri* were observed to develop only in the seeds of *Prosopis* spp and on *Cassia* (*Senna*) *didymobotrya*. This occurrence of feeding on a non-host (*C. didymobotrya* was observed during both choice tests as well as in seed transplant tests, but it never occurred during starvation tests.

It is highly unlikely that this legume will ever become an alternative host for *Algarobius spp* because:

1. *A. prosopis* and *A. bottimeri* never oviposited on *C. didymobotrya* pods during starvation tests. It can therefore be assumed that the presence of *Prosopis* provided an olfactory stimulus necessary for oviposition on this non-host. In the absence of this stimulus no oviposition occurred.

2. Only a small number of beetles emerged from *C. didymobotrya* pods in the choice tests, while a large number of beetles emerged from *Prosopis* pods (Appendix 1), indicating that *Prosopis* pods are far superior hosts than *C. didymobotrya* pods.

3. Larval development of the beetles took an average of ten days longer in *C. didymobotrya* seeds.

4. Only the very mature *C. didymobotrya* pods and seeds were attacked by the beetles during choice tests. The beetles that emerged from slightly immature *C. didymobotrya* seeds during seed transplant test were only half the size of those that emerged from *Prosopis* seeds, but were able to reproduce. While *C. didymobotrya* did support development of the two *Algarobius* spp. under laboratory conditiions, it is unlikely that this exotic legume will ever be attacked by the beetles in the field or that the beetles would be able to become established on this non-host species. There is thus no reason to believe that these two bruchid species will pose a threat to any of our native, cultivated or exotic legume plants, should they be released against *Prosopis*.

4. General discussion and Conclusion

The two bruchids, *A. prosopis* and *A. bottimeri* do not pose a threat to any plants, other than *Prosopis.* It may however be argued that they do pose a threat to those farmers who utilize or may wish to utilize *Prosopis* spp in the future. The status of *Prosopis* in South Africa has been discussed by Harding (1987) who lists both useful and detrimental properties of the plant (figure 6). The possiblility of a future *Prosopis* industry should not be overlooked, and the factors for and against release of these two beetle species must be weighed against each other.

A *Prosopis* industry would involve the utilization of *Prosopis* products in several ways which are summarised in figure 7 (Harding 1987). The most important aspect of utilization would be the large scale harvesting of the nutritious pods for animal feed. This is the only part that may be affected by the envisaged biological control programme. While the beetles do not damage the pod itself, they almost entirely consume the seeds within the endocarp which constitute the largest protein source of the pod. Thus, with a large infestation of beetles, the protein value of the fodder would be reduced considerably. The carbohydrate value (mesocarp and exocarp), which constitutes the greatest value to most animals that feed on the pods in the veld, would remain largely unchanged.

This loss in seed protein may however be replaced by the protein of the contained insects should the pods be consumed by animals before the emergence of the adult beetles.

Table 1: Selected nutrient composition of prosopis seeds after Harden *et al* (1981).

	Immature whole bean	Mature whole bean	Mature seed only	Mature Pod (Pericarp) only
PROXIMATE				
Crude Protein (N X 6.25)	13.26 ± 0.19	13.35 ± 0.28	39.34 ± 0.52	7.02 ± 0.01
Crude fat (%)	2.23 ± 0.11	2.23 ± 0.03	4.91 ± 0.03	2.08 ± 0.17
Ash (%)	3.88 ± 0.00	3.40 ± 0.08	3.61 ± 0.03	3.62 ± 0.32
Sugar (%)*		30% *	3 - 5% *	
MINERALS				
Calcium (%)	0.53 ± 0.02	0.43 ± 0.00	0.26 ± 0.00	0.44 ± 0.02
Phosphorus (%)	0.11 ± 0.01	0.13 ± 0.00	0.31 ± 0.00	0.08 ± 0.00
Phytate (%)	0.156 ± 0.00	0.162 ± 0.004	1.00 ± 0.03	0.023 ± 0.00
Magnesium (%)	0.12 ± 0.00	0.09 ± 0.00	0.21 ± 0.00	0.08 ± 0.01
Potassium (%)	1.52 ± 0.12	1.99 ± 0.06	0.91 ± 0.08	2.24 ± 0.04
Sodium (ppm)	91 ± 4	82 ± 5	72 ± 3	104 ± 3
Iron (ppm)	42 ± 3	31 ± 2	156 ± 5	15 ± 2
Zinc (ppm)	26 ± 0	26 ± 1	108 ± 0	19 ± 1
AMINO ACIDS (g amino acid/16 g total N)				
Arginine	8.84	7.57	14.53	2.96
Histidine	2.98	2.46	2.98	2.17
Lysine	6.67	5.45	5.16	6.00
Methionine + Cystine	1.10	1.63	1.75	.90
Phenylalanine	4.26	3.60	4.28	3.17
Threonine	3.66	3.53	3.00	4.23
Tryptophan	0.99	0.76	0.75	0.89
Valine	5.66	5.92	4.40	7.61

Means ± SD of duplicate samples on dry weight basis.
* Value for *P. glandulosa* (Kingsolver et al 1977)

Sheep, being able to crush the seeds, may utilize up to 95% of the seeds, while most other stock types utilize very little of the seed as their chewing action does not break the tough seed coat for digestive enzymes to take effect.

These unharmed seeds are scarified as they pass through the animal's digestive system and are thus ready to germinate as soon as conditions become favourable. In order to facilitate full utilization of all the available protein in the pod by the animals, as well as to reduce the spread of the seeds, it is advisable to hammer mill the ripe pods. If done properly, the process of milling breaks up the seeds, making them a digestable component of the fodder while simultaneously destroying the bruchid larvae present in the seeds and preventing further infestation while in storage.

The storage of large quantities of unmilled pods for a long time may provide ideal breeding conditions for the two introduced Algarobius bruchids. To prevent nutritional loss, the pods may have to be fumigated, not only to prevent attack by the beetles, but also to destroy the larvae of the meal moths (*Plodia interpunctella* and *Ephestia kuehniella*) which develop in and consume the mesocarp. Thus, in the unlikely event of a conflict situation, the problem can be overcome by taking a few precautions which would most likely be necessary, irrespective of whether the beetles are released or not. Although *Algarobius* spp. destroy 30% of all *Prosopis* seeds in the U.S.A., they are not considered as pests there although *Prosopis* is utilized on a large scale. This is shown by the fact that new insects from South America are being investigated as possible biological control agents against *Prosopis* in the U.S.A. The possibility of a conflict situation arising in South Africa where *Prosopis* is at present being utilized on a very small scale, is thus minimal.

4.1 Attitude of Farmers

One of the incentives behind a postal survey on *Prosopis* in the north-western Cape during 1985, was to determine the attitude of landowners who have *Prosopis* on their properties, towards biological control of this plant.

In the survey the landowners were asked if they were in favour of:

i. entire eradication of *Prosopis;*

ii. control of *Prosopis* (implying some steps to prevent spread coupled with utilization)

iii. no change to the present *Prosopis* infestation, or

iv. a 30% reduction of the present *Prosopis infestation* or

iv. biological control, even if this would mean a 70% loss in nutritional value of the pods (this value is hypothetical).

The response from the farmers is summarized in Table 2 (data from Harding - pers comm).

It was obvious from the replies that the farmers were somewhat confused by the options presented to them. A considerable number of farmers were in favour of both eradication as well as biocontrol, which showed that they did not fully comprehend the concept of biological control. It is however, significant that most farmers voted for either eradication or biocontrol and only a small minority opted for 'no change' and these were landowners with little *Prosopis* on their properties.

At a farmers' day held on the farm "Humansdam" near Vanwyksvlei on 12 March 1987, a talk on the possibilities of biological control was presented to more than fifty farmers from the major *Prosopis* infested areas. The concept was enthusiastically received by all the farmers present, and it was obvious from discussions generated by the talk, that the farmers were only prepared to utilize Prosopis if something could be done to prevent its further spread.

Harding (1987) estimated that 60 million seeds are produced annually per hectare in a dense *Prosopis* infestation. These seeds are available for spread and re-establishment. Even if sheep were to eat all the pods and kill 95% of the seeds, this would still leave 3 million seeds per hectare. The bruchids (in the absence of their own natural enemies) have the potential to increase to very large numbers (especially in dense thickets) thereby reducing the annual seed crop significantly. The beetles have also been observed to breed through a number of generations on naked seeds under laboratory conditions. This indicates that there is also a possibility that they will attack naked seeds in the veld that have either been exposed through scarification of the pods in the soil, or that have passed through an animal's digestive system.

Table 2: Summary of farmers' attitude towards *Prosopis* spp.

Figures in brackets are percentages

REGION	KEN-HARDT	CARNAR-VON	CALVI-NIA	PRIESKA	WILLIS-TON	HOPE-TOWN	BRITS-TOWN	TOTAL
AREA OF LAND (ha)	109 944	336 540	147 032	185 563	134 267	51 228	135 344	1 099 918
AREA WITH PROSOPIS (ha)	25 666 (23.3)	79 135 (23.6)	2 910 (2.0)	14 934 (8.1)	2 646 (2.0)	13 932 (27.2)	14 970 (11,1)	154 193 (14,0)
A. Farmers FOR ERADICATION	17 (74)	55 (75)	6 (18.8)	35 (83.3)	11 (47.9)	9 (56.3)	19 (76)	152 (51.2)
B. Farmers FOR CONTROL	3 (22)	15 (20)	26 (81.3)	7 (16.7)	11 (47.8)	6 (37.5)	4 (16.0)	72 (24.2)
1: For NO CHANGE	2 (50)	2 (4.4)	5 (23.8)	2 (8.7)	5 (31.3)	- -	1 -	17 (5.7)
2: For 30% RE-REDUCTION	-	4 (8.9)	- -	4 (17.4)	- -	- -	- -	8 (2.7)
3: For BIOCONTROL	2 (50)	39 (86.8)	16 (76.2)	17 (73.9)	11 (68.8)	6 (2.0)	11 (3.7)	102 (34.3)

(% do not add up to 100 because of no responce in some cases).

In South Africa a single chemical control treatment would cost at least R300 per ha. The infested areas have land values of only half this amount (Harding, 1987). From a financial point of view, the possibility of eliminating or controlling *Prosopis* spp chemically or mechanically is limited while the feasibility of intensive utilization is very attractive. It is in this context that biological control will play a leading role. With the threat of further invasion by *Prosopis* greatly reduced by the effects of the bruchids, the existing thickets can then gradually be thinned out, as part of a utilization programme, until the status of *Prosopis* is changed entirely from a threatening invader to a useful agroforestry plant. The alternative, if biological control is ignored, may be the further loss of thousands of hectares of important pasture land or the loss of millions of rand spent trying to control this invasive plant chemically or mechanically.

The success of these two beetles as biological control agents cannot be guaranteed. It may be many years before significant results are obtained but the release of these beetles, may in time make a major contribution in curbing the *Prosopis* problem in this country.

We hereby recommend that *A. prosopis* and *A. bottimeri* be released in South Africa for the control and better management of *Prosopis* in South Africa.

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Appendix 1: List of plants tested against *Algarobius bottimeri* and *A. prosopis* in starvation, choice and seed transplant tests.

Approximately 5 pods of each test plant were used in each of the starvation and choice tests, while between 10 and 20 seeds of each test plant were used in the seed transplant tests. Between 30 and 60 beetles were used for each test.

Abreviations used: 1) Under status: E = exotic; N - native; W - weed; C - crop; O - ornamental

2) Under Bruchid: Ab = *Algarobius bottimeri* and Ap = *A. prosopis*

Test Plant	Status	Bruchid Species	No of beetles emerging from seeds				
			Starvation tests	Choice tests		Seed transplant tests	
			Test plant	Test plant	Pro-sopis	Test seeds	Prosopis seeds
Abrus precatorius	N	Ab				0	15
		Ap	0	0	0	0	18
Acacia albiba	E	Ab	-	-	-	0	15
		Ap				0	18
A. ataxacantha	N	Ab	-	-	-	0	101
		Ap	0	0		0	80
A. caffra	N	Ab	0	0	15	-	-
		Ap	0	0	10		
A. cinerea		Ap	-	0	69	-	-
A. cyclops	E/W	Ab	-	-	-	0	101
		Ab				0	80
A. erioloba	N	Ab	0	0	44	0	38
		Ap					
A. elata	N	Ab	-	-	-	0	15
		Ap				0	18
A. hebeclada	N	Ab	0	0	65	0	18
		Ap	0	0	86		
A. galpinii	N	Ab				0	9
		Ap	-	-	20	2	15

Appendix 1 (continued)

Test Plant	Status	Bruchid Species	No of beetles emerging from seeds				
			Starvation tests	Choice tests		Seed transplant tests	
			Test plant	Test plant	Pro-sopis	Test seeds	Prosopis seeds
A. karroo	N	Ab Ap	-	-	-	0 0	15 18
A. kraussiana	E	Ab Ap	-	-	-	0 0	101 80
A. longifolia	E/W	Ab Ap	-	-	-	0 0	101 80
A. mearnsii	E/W	Ab Ap	-	-	-	0 0	101 80
A. nigrescens	N	Ab Ap	-	-	-	0 0	15 18
A. nilotica	N	Ab Ab	-	0 0	29 9	0 0	9 15
A. permixta	N	Ab Ap	0 0	0 0	60 61	-	-
A. podalyriifolia	E/W	Ab Ap	-	-	-	0 0	101 80
A. polyacantha	N	Ab Ap	-	-	- -	0 0	9 15
A. robusta	N	Ab Ap	0 0	0 0	15 7	0 0	9 15
A. saligna	E/W	Ab Ap	-	-	-	0 0	15 18
A. schweinfurthii	N	Ab Ap	-	-	-	0 0	15 18
A. sieberana	N	Ab Ap	-	-	-	0 0	15 18
A. tortilis	N	Ab Ap	-	0 0	26 9	0 0	9 15
A. woodii	N	Ab Ap	0 0	0 0	45 46	-	-
Albizia harveyi	N	Ab Ap	-	-	-	0 0	9 15

Appendix 1 (continued)

Test Plant	Status	Bruchid Species	No of beetles emerging from seeds				
			Starvation tests	Choice tests		Seed transplant tests	
			Test plant	Test plant	Pro-sopis	Test seeds	Prosopis seeds
Albizia sp.		Ab Ap	0 0	0 0	25 15	-	-
Baphia racemosa	N	Ab Ap	0 0	0 0	82 71	-	-
Bauhinia galpinii	N/O	Ab Ap	0 0	0 0	60 61	-	-
B. oruamenxae	N/O	Ab Ap	0	0	3	-	-
B. tomentosa	N/O	Ab Ap		0 0	37 27	0 0	15 18
Bolusanthus speciosus	N/0	Ab Ab		0 0	23 25	0 0	9 15
Burkea africana	N	Ab Ap	0 0	0 0	82 34	0 0	9 15
Cassia didymobotrya	E/W	Ab Ap	0 0	6 8	48 61	4 7	9 15
C. laevigata	E	Ab Ap	0	0	22	-	-
Cassia sp.	O	Ab Ap	-	-	-	0 0	101 80
Calpurnia aurea	N	Ab Ap	0	0	4	-	-
Ceratonia siliqua	N	Ab Ap	-	-	-	0 0	101 80
Colophospermum mopane	N	Ab Ap	0	0	10	0 0	101 80
Crotalaria capensis	N	Ab Ap	0 0	0 0	49 33	-	-
C. juncea	E	Ab Ap	-	-	-	0 0	15 18
Enterolobium timbouva	E	Ab Ap	-	0 0	82 34	0 0	9 15

Appendix 1 (continued)

Test Plant	Status	Bruchid Species	No of beetles emerging from seeds				
			Starvation tests	Choice tests		Seed transplant tests	
			Test plant	Test plant	Pro-sopis	Test seeds	Prosopis seeds
Eriosema nutans	N	Ab Ap	-	-	-	0 0	101 80
Erythrina humeana	N/O	Ab Ap	0 0	0 0	18 12	-	-
E. lysistemon	N/O	Ab Ap	-	-	-	0 0	9 15
Gleditchiatriacanthos	E/O	Ab Ap	0 0	0 0	60 7	-	-
Glycinewightii Neonotonia weghtii	N	Ab Ap	0 0	0 0	82 71	-	-
Indigofera cylindrica	N	Ab Ab	0 0	0 0	37 27	-	-
I glomerata	N	Ab Ap	0 0	0 0	68 101	-	-
Lens culinaris	C	Ab Ap	-	0 0	21 19	0 0	15 18
Leucaena leucocephala	E	Ab Ap	-	0 0	16 08	0 0	101 80
Lonchocarpus capassa	N	Ab Ap	0	0	12 29	-	-
Millettia dura	N	Ab Ap	0 0	0 0	82 71	-	-
Mundulea sericea	N	Ab Ap	-	-	-	0 0	101 80
M. grandis	N	Ab Ap	0 0	0 0	82 71	-	-
Parkinsonia sp	W	Ab Ap	0	0	56	-	-
Peltophorum africanum	N	Ab Ap	0 0	0 0	22 43	-	-
Phaeoptilum spinosum	N	Ab Ap	-	0 0	82 34	0 0	15 18
Schotia afra	N	Ab Ap	-	0 0	60 61	-	-

Appendix 1 (continued)

Test Plant	Status	Bruchid Species	No of beetles emerging from seeds				
			Starvation tests	Choice tests		Seed transplant tests	
			Test plant	Test plant	Pro-sopis	Test seeds	Prosopis seeds
S. brachypetala	N	Ab Ap	-	0 0	68 101	-	-
Sesbania bispinosa	N	Ab Ap	-	0 0	21 9	-	-
S. punicea	E/W	Ab Ap	-	0 0	45 46	0 0	9 15
Sutherlandia frutescens	N	Ab Ap	-	-	-	0 0	101 80
Tephrosia - grandiflora	N	Ab Ap	-	- -	45 59	-	-
Tipuana tipu	E/0	Ab Ab	-	- -	45 46	-	-
Vigna unguiculatar		Ab Ap	-	-	-	- -	9 15
Virgilia oroboides	N/O	Ab Ap	-	- -	58 43	- -	15 18
Xanthocercis zambesiaca	N	Ab Ap	-	-	-	0 0	101 80
Bush beans	E C	Ab Ap	0 0	0 0	29 22	-	-
Broad beans	E C	Ab Ap	0 0	-	-	0 0	15 18
Lablab purpureus	E C	Ab Ap	0 0	-	-	0 0	15 18
Soy beans	E C	Ab Ap	0 0	0 0	25 43	0 0	9 15
Green peas	E C	Ab Ap	-	-	-	0 0	9 15
Black-eye susan peas	E C	Ab Ap	-	-	-	0 0	9 15

APPENDIX 3

PROPOSALS TO RELEASE THE SEED BEETLES *ALGAROBIUS BOTTIMERI* AND *ALGAROBIUS PROSOPIS* AS BIOLOGICAL CONTROL AGENTS AGAINST MESQUITE, *PROSOPIS* SPP.

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APPENDIX 3

PROPOSALS TO RELEASE THE SEED BEETLES *ALGAROBIUS BOTTIMERI* AND *ALGAROBIUS PROSOPIS* AS BIOLOGICAL CONTROL AGENTS AGAINST MESQUITE, *PROSOPIS* SPP.

CONTENTS

Information required for an application to release biological control agents into the field

***Algarobius bottimeri* Kingsolver and *Algarobius prosopis* (Le Conte) (Coleoptera: Bruchidae), potential biological control agents for mesquite, *Prosopis* spp.**

A. INFORMATION ON THE TARGET WEEDS

1. TAXONOMY

1.1 Scientific and Common Names

There is considerable variation within species and inter-grading between species of *Prosopis* (Pedley, 1977). With the exception of Quilpie algarroba (or mesquite), the taxa listed below are those named in Parsons and Cuthbertson's (1992) treatment of *Prosopis* in Australia.

Order: Fabales
Family: Mimosaceae
Tribe: Adenanthereae

Prosopis velutina Wooton - Quilpie algarroba, velvet mesquite *	(QLD, NSW)
P. glandulosa Torrey var. *glandulosa* - honey mesquite	(NSW, QLD)
P. juliflora (Sw.) DC. - mesquite	(NSW, SA, QLD)
P. pallida (Willd.) Kunth - algarroba, mesquite *	(QLD, WA, NT)
P. pallida x ? *P. laevigata* (Willd.) M.C. Johnston - mesquite *	(WA)
P. juliflora x *P. velutina*	(NSW)

* These are the targets for this application.

In Queensland, Quilpie algarroba has been referred to as *P. flexuosa* DC. (Pedley, 1977), however Burkart (1976) and D. Panetta (pers. comm., 1995) consider that it is *P. velutina.*

In the Northern Territory, *P. pallida* is known by its synonym *P. limensis* Benth..

Electrophoresis study of tropical Australian mesquite populations showed that *P. pallida* was present at Hughenden in north Queensland and at Minderoo on the north-west coast of WA, and that *P. juliflora* was present at Pallarenda near Townsville, Qld (Panetta and Carstairs, 1989). It also showed that infestations at Mardie (north-west coast of WA) and Rockvale (north-west Qld) are hybrids derived, possibly, from *P. pallida.*

For the purposes of this submission, the common name mesquite is used in the generic sense.

1.2 Brief Description

The following is a brief description of *P. juliflora* after Parsons and Cuthbertson (1992).

A spiny evergreen or deciduous shrub or low tree, with one to several trunks and crooked arched branches. It takes three forms depending on its location and water supply: short, many-stemmed shrubs 1 to 3 m high on the drier soils between watercourses; large, single-stemmed trees 6 to 15 m high, with a main trunk to 1 m diameter, near permanent water; and an intermediate type, branching almost from the base and forming dense thickets 5 to 8 m high, particularly along the banks of intermittently flowing streams, and on floodplains.

2. NATIVE RANGE AND PROBABLE CENTRE OF ORIGIN

2.1 Native Range

The genus *Prosopis* consists of 44 arid and semi-arid zone species of which one is restricted to northern Africa, three occur naturally in eastern Asia and the rest are New World natives (Burkart and Simpson, 1977). Nine of these are native to North America and 31 species are native to South America.

The following origins of the mesquites now found in Australia are taken from Burkart and Simpson, (1977). *P. velutina* is found in southern Arizona and adjacent California, fringing into northern Mexico. *P. glandulosa* var. *glandulosa* is found in southwestern USA in western Texas, New Mexico, eastern Arizona, Oklahoma, Nevada and Idaho, and in northeastern Mexico. *P. juliflora* is found in Baja California, coastal areas of Mexico, dry areas of southern Mexico and of Central America, islands of the West Indies, northern Venezuela and Columbia. *P. pallida* s native to the western dry parts of Columbia, Ecuador and Peru. *P. laevigata* occurs primarily across the central plateau and hillsides of northern Mexico and southern Texas. It has a disjunct distribution in Peru, Bolivia and northern Argentina. *P. flexuosa* occurs in northern Chile and in the arid regions of western Argentina.

2.2 Centre of Origin

Burkart and Simpson (1977) suggested South America as the most likely ancestral home of the genus *Prosopis* and noted that the processes of speciation and ecological diversification have proceeded to a greater extent in extra-tropical South America than elsewhere.

3. DISTRIBUTION

3.1 Distribution in Australia

Mesquite infestations are found in all mainland states.

In Queensland there are two major pest species, *P. pallida* in the north-west and *P. velutina* in the south-west of the state. The two major centres of dense *P. pallida* are the townships of Hughenden (circa 1000 ha) and Cloncurry (circa 5000 ha). A hybrid mesquite was found at Rockvale (Panetta and Carstairs, 1989), near Nelia (100 ha) and near McKinlay (250 ha dense and 1000 ha moderate density) (Bolton, 1989). The infestation at Rockvale has recently been controlled with chemicals (P. Jeffery, pers. comm., 1995)

P.velutina is present at varying densities in the Quilpie district of south-west Queensland where there are 2800 ha of dense infestations (population density in the range of 600-2000 plants per hectare) and 8800 ha of scattered infestations (population density in the range of 1-9 plants per hectare) on two properties (Csurhes, 1989). Odd bushes occur on adjoining properties`. The *P. juliflora* infestation at Pallarenda has been eradicated. A small infestation of *P. glandulosa* has been reported in an industrial area at Gladstone.

In Western Australia, 120,000 ha are reported to be infested with mesquite. Most infestations occur in the pastoral areas of the north-west of the state. The major problem area is on Mardie Station in the West Pilbara between Onslow and Karratha where 15-20,000 ha are infested. Smaller infestations are found in the Kimberley around Derby and Broome and in the Gascoyne along the Gascoyne and Lyons Rivers. Minor isolated infestations have been found on the Fitzroy River near Fitzroy Crossing, at Nicholson Station (east of Halls Creek) and along the upper Murchison River.

In New South Wales, the total area has been estimated at about 25,000 ha. The most common species is *P. juliflora* (Parsons and Cuthbertson, 1992). There are two areas with heavy infestations of *P. juliflora*, one near Tibooburra and the other near Broken Hill (Parsons and Cuthbertson, 1992).

In Northern Territory, mesquite *(P. pallida*, syn. *P. limensis)* is largely confined to the Barkly Tablelands and the Alice Springs district. Most Barkly stations have mesquite. In the Alice Springs district it occurs as single trees associated with homesteads.

In South Australia there are no extensive infestations and occurrences consist mostly of single planted trees or small groups often associated with towns and habitation.

Two small infestations in Victoria are under an eradication program (Parsons and Cuthbertson, 1992).

3.2 Worldwide Distribution

A few species have been introduced into other areas of the world notably India, Pakistan, South Africa, Egypt, Kuwait, Hawaii, Brazil and Australia (DeLoach, 1988) and Namibia (Zimmermann, 1991).

In South Africa there are at least five species (one with two sub-species) that have become naturalised. Three of these taxa are problem weeds of the north-western Cape Province with infestations exceeding 180,000 ha (Zimmermann, 1991). These are *P. velutina*, *P. glandulosa* var. *torreyana* and *P. juliflora* (Peter and Zimmermann, 1987).

The greatest amount of weedy mesquite occurs in the United States where it is firmly established over 28 million hectares of rangeland in Texas, New Mexico and Arizona. It is endemic in this area, but remained in a state of balance with the other vegetation until the introduction of domestic stock and other human influences which affected ecosystem balance. The result was a dramatic increase in mesquite extent and density.

4. RELATIVES NATIVE TO AUSTRALIA

There are no *Prosopis* species native to Australia. The tribe Adenanthereae contains native plants in the genera *Adenanthera* (2 species), *Neptunia* (5 species) and *Dichrostachys* (1 species). The family Mimosaceae contains the large, ecologically important genus *Acacia* (840 spp. approx.).

5. PEST STATUS

Mesquite was introduced for its perceived benefits as a coloniser of unstable arid areas, as a food and shelter tree for livestock and as a garden ornamental. It is now declared noxious in all mainland states.

In Western Australia mesquite is a declared plant in the eradication category in all parts of the State except on Mardie Station where the size of the infestation is so great that a P4 (prevention of spread) declaration applies. In South Australia all *Prosopis* species are proclaimed plants on Schedule 1, obliging landholders to notify the Animal and Plant Control Commission and their local Board of any infestations and to destroy all plants. In New South Wales *Prosopis* spp are declared noxious plants for the whole state. In Queensland, Quilpie algarroba is presently declared (as *P. flexuosa*) under category P2 of the Rural Lands Protection Act (1985), *P. pallida* is declared under category P3.

Little quantitative work on the costs of mesquite infestation has been done in Australia. However considerable work has been done in the USA and some relevant figures are quoted. These figures indicate the potential impact of an increase in the occurrence of mesquite in Australia. Some of these impacts are discussed below in more detail.

In America, the costs of the damage caused by mesquite far outweigh its benefits and the potential damage to rangelands is significant. DeLoach (1988) states that "total direct losses attributable to mesquite are probably US$200 - 500 million annually in the United States plus an additional unknown amount in Mexico. Soil erosion, increased desertification and loss of soil water would add greatly to these losses. Loss in total economic activity is approximately 3 times this amount or US$0.5 - 1.5 billion annually".

The USDA in 1982 determined that a total of 20.7 million ha in Texas was infested with mesquite, 8.3% in dense stands, 28.8% in moderate stands and 62.9% in light stands (DeLoach, 1988).

5.1 Reduction in Carrying Capacity

Bolton (1989) states that on favourable sites *Prosopis* thickets would reduce pasture and hence productivity to near zero.

In some situations in the USA mesquite has reduced the carrying capacity from one sheep to 4 ha to one sheep to 32 ha (Milthorpe, 1975).

DeLoach (1988) reports an estimated 5% to 20% loss of beef production in Texas. Stocking rates were reduced by 75% over a 45 year period in New Mexico due to brush encroachment. Lost beef production totalled $44.4 - 143.3 million annually in Texas, plus another $34 million annually in New Mexico and Arizona.

5.2 Loss of Soil Water

The basis for most of the observed association between low forage production and high density of mesquite is undoubtedly that mesquite competes strongly for the available soil water. Mesquite has roots that extend more than 15 m beyond the canopy of the tree and in favourable sites the roots extend to 15 m deep (DeLoach, 1988).

5.3 Soil Erosion

Mesquite is generally reported to increase wind and water erosion of the soil when it replaces grasses in the more arid areas of the southwest USA.

5.4 Management Losses

(i) Dense thickets interfere with mustering and joining.
(ii) Prolific growths near windmills act as a wind shields and prevent the pumping of water.
(iii) Thorns injure the hooves of animals and puncture vehicle tyres.
(iv) The ingestion by cattle of an excess quantity of mesquite pods over a long period causes an illness characterised by anaemia, emaciation, salivation, protruding tongue and nervousness. No substantial stock losses have been reported in Australia (Meadly, 1962). The green pods can also cause problems

when eaten by stock due to the long stringy pod-margin forming large hard balls in the stomach (Cunningham *et al.*, 1981).

5.5 Other

(i) Mesquite is a major hay fever plant in the American South West, Hawaii and South Africa. Serious allergenic problems were caused in India and Kuwait by the introduced *P. juliflora* (DeLoach, 1988).
(ii) Dense thickets of mesquite harbour feral animal pests such as rabbits and pigs.
(iii) Environmental implications of replacement/invasion of natural ecosystems by an introduced species.

6. BENEFICIAL USES

In Australia, mesquites were planted around homesteads for shade and/or as ornamentals. Mesquites were also used for stabilising erosion prone areas and reclaiming mine-waste dumps.

DeLoach (1988) identified the following commercial uses, either existing or potential, for mesquite

(i) Utilisation of the wood: fuel for steam or generation of electricity, wood products, firewood, charcoal and barbecue wood, crafts and furniture and paper.
(ii) Livestock feed: some species of mesquite leaves are eaten but the ripe pods of mesquite are relished by most livestock because of the high sugar content.
(iii) Human food: the aboriginal peoples of south west North America ground the dry pods in water to make drinks or alcoholic beverages. Mesquite is one of the more valuable honey plants in the south western United States.
(iv) Chemicals, and medicines: some chemicals, alcohol, tannins and gum have been produced.
(v) Ornamentals.

The density of Australian mesquite infestations is usually insufficient to support the uses outlined above. In Western Australia there is small scale commercial use of mesquite for honey production and as firewood for barbecues.

7. OTHER CONTROL METHODS AVAILABLE

Other methods available for the control of mesquite are of a chemical and mechanical nature with some limited management actions possible to control the spread of mesquite.

7.1 Chemical Control

Basal bark and cut stump treatments of clopyralid, picloram, picloram + 2,4-D and triclopyr in diesel oil are effective (Parsons and Cuthbertson, 1992). These chemicals and glyphosate as foliar sprays can be effective with best results obtained from

picloram and clopyralid because of their greater rate of uptake (Parsons and Cuthbertson, 1992). All herbicide treatments are best applied after rain, when plants are actively growing.

7.2 Mechanical Control

The mechanical techniques available include hand grubbing, power grubbing (use of bulldozer), chaining, heavy duty blade ploughing, root cutter or disc and roller chopper. The more intensive mechanical methods usually require a larger initial capital outlay when compared with herbicides, and retreatment is necessary in most instances to control reinfestation and plants missed by the initial operation.

In northern Queensland mechanical treatments seem more successful since they are usually a prelude to a more intensive land use at the site (Bolton, 1989). Csurhes (1989) considers that dense infestations require mechanical treatment before any chemical treatment can be contemplated. The costs of large scale mechanical clearing are, however, prohibitive. The costs of control for an area of 300,000 ha of *P. velutina* in the Quilpie district have been estimated at $914,000 using mechanical and chemical means (Csurhes, 1989).

7.3 Integrated Control

It may be useful to integrate a chemical follow up treatment with mechanical methods. Parsons and Cuthbertson (1992) document the success of integrated mechanical and chemical means to control mesquite in Western Australia.

7.4 Management

Fire can be effective against *P. pallida* when there is sufficient fuel.

Where livestock, particularly cattle, are grazing mesquite-infested areas, landholders are advised to hold stock for at least 14 days in a small paddock prior to their movement to non-infested areas. These smaller paddocks as well as the non-infested areas are monitored for subsequent seedling growth which can be killed by grubbing or burning (McCormick, 1989).

8 SUMMARY

8.1 Potential for Spread

The arid and semi-arid regions of Australia cover 5.3 million square kilometres or 69% of the continent. There appear to be no climatic or biological limitations to the eventual spread of *P. velutina* over a wide area of semi-arid Australia. Bolton (1989) considers that *Prosopis* spp. have the potential to increase in both area and density over much of Western Queensland including the south-flowing Diamantina and Cooper drainage systems.

8.2 Potential for Biological Control

Over 300 species of insect have been found to attack the 30 species of *Prosopis* native to Argentina and Paraguay (Cordo and DeLoach, 1987). The most promising appear to be the seed-feeding bruchid beetles. Successful biological control of mesquite in the USA appears technically feasible with the insects known in Argentina (Cordo and DeLoach, 1987).

Encouraging biocontrol results have been obtained in South Africa using the North American bruchid *Algarobius prosopis*, one of the subjects of this proposal. Within 27 months of release in one area, 92% of the seeds in a sample of pods were destroyed by *A. prosopis* (Zimmermann, 1991).

B. INFORMATION ON THE AGENTS

1. SCIENTIFIC NAMES

Algarobius bottimeri Kingsolver (Coleoptera: Bruchidae)
Algarobius prosopis (LeConte) (Coleoptera: Bruchidae)

2. DESCRIPTION AND BRIEF BIOLOGY

2.1 Description

The two beetles were described by Peter and Zimmermann (1987) as follows. *A. bottimeri* and *A. prosopis* are almost identical mottled brown beetles from 2.2 to 5.0 mm long. The only detectable external difference between the two species are in the positions of the pygidial sulci of the females while the males of the two species can only be separated by studying the genitalia.

2.2 Brief Biology

The biology of the two species was described by Peter and Zimmermann (1987). A brief summary which applies to both species follows. The adults mate within 24 hours of emergence. Females insert eggs into surface cracks and crevices in the exocarp of the pod. If there are no cracks, females may oviposit clumps of 10-15 eggs on the outside of the pod. The first instar larva has legs and is very mobile. It burrows into the pod and eats through the mesocarp, endocarp and hard seed coat, into the seed. Once inside a seed, a larva feeds within it, moulting a few times, until it pupates about 25 days later. Larvae of both species can survive in immature seeds as well as in hard dry seeds. After about 30 days, adults emerge by eating their way out of the pods. Adults live up to 30 days. Kingsolver (1986) reported that adult *Algarobius* spp. feed on pollen.

The two species differ in their host preferences. *A. bottimeri* has as recorded hosts, *P. glandulosa* var. *glandulosa* and *P. reptans* var. *cinerascens* in North America and the introduced South American *P. pallida* in Hawaii (Kingsolver, 1986). Johnson (1983) recorded the native hosts of *A. prosopis* as *P. velutina, P. glandulosa* var. *torreyana, P. pubescens* and *P. articulata.* Kingsolver (1986) adds *P. palmeri* and *P. reptans* var. *cinerascens,* but does not include *P. articulata,* and notes that *A. prosopis* has been reared in Arizona from the introduced Argentinian species, *P. alba.*

3. DISTRIBUTION

3.1 Native Range

A. bottimeri occurs mainly in Texas and north-east Mexico. *A. prosopis* occurs in the south-west USA and north-west Mexico.

3.2 Introduced Range

A. bottimeri was accidentally introduced to the Hawaiian Islands with introduced *Prosopis* early this century (Kingsolver, 1986). *A. bottimeri* was introduced into South Africa in 1990 as a biocontrol agent (Zimmermann, 1991). It has established at only one site (Hoffmann *et al,* 1993). *A. prosopis* was introduced into South Africa as a biocontrol agent in 1987 and into Namibia in 1988 (Zimmermann ,1991). It was distributed in the mesquite infested areas of these countries and is well established at many sites. Up to 90% of the annual seed crop at some sites has been destroyed by *A. prosopis* (Zimmermann, 1991)

4. RELATED SPECIES

Larvae of the six known *Algarobius* species are known to feed only in seeds of *Prosopis* spp. (Kingsolver, 1986).

5. PROPOSED SOURCES OF AGENTS

Mass rearing of both agents will be initiated with stocks currently held in quarantine at AFRS. Both agents were imported from South Africa in 1994. They were sent by Dr John Hoffmann, Zoology Department, University of Capetown.

6. MODE OF ACTION

The larvae of *A. bottimeri* and *A. prosopis* feed inside seeds of mesquite. Beetles lay eggs in cracks and holes in the pods. After they hatch, first instar larvae tunnel through pod material until they enter undamaged seeds. One larva completes its development in one seed and pupates inside. In the process it destroys the seed's food reserves and embryo. The emerging beetle makes a large exit hole in the seed and pod. Both species have the potential for up to eight generations per year in hot climates.

7. POTENTIAL FOR CONTROL OF THE TARGET

Because of the promising performance of *A. prosopis* in South Africa where destruction of up to 90% of the annual seed crop has been recorded (Zimmermann, 1991), there are favourable prospects that similar results will occur in Australia. If the rate of seed destruction can be sustained at a high level the potential for further spread of the mesquites in Australia will be reduced.

A. bottimeri may have the potential to be more successful in Australia than in South Africa where it established at only one site and on only one taxon, *P. glandulosa* var. *glandulosa* (Hoffmann *et al,* 1993) . Some pest mesquites of Australia belong to different taxa to those of South Africa. In particular, most large Australian infestations are of *P. pallida* or *P. pallida* hybrid mesquite, whereas most south African infestations are of *P. glandulosa* var. *torreyana* or *P. velutina.* As *P. pallida* has been a suitable host for *A. bottimeri* in Hawaii (Kingsolver *et al,* 1977; Kingsolver, 1986) and as *A. bottimeri* was successfully reared on Mardie hybrid mesquite pods, it should establish readily on these taxa in Australia. Once established on these taxa in the field it should have the same potential as *A. prosopis* to control mesquite seed production.

8. NON TARGET ORGANISMS AT RISK

In host specificity tests, *A.bottimeri* developed in seeds of *Petalostylis labicheoides, Acacia aneura, Neptunia gracilis* and *Arachis hypogaea* and *A. prosopis* developed in seeds of *P. labicheoides, A. aneura, N. gracilis, A. hypogaea* and *Caesalpinia decapetala. A. bottimeri* and *A. prosopis* eggs were laid on test plant pods only when those pods were in close proximity to mesquite pods. In tests in which test plant pods were placed well apart from mesquite pods, no oviposition occurred on the test plant pods. This supported the view of Peter and Zimmermann (1987)and Zimmermann (1991) that *A. bottimeri* and *A. prosopis* are confused by olfactory stimuli from mesquite pods and will oviposit on other pods close to the mesquite pods by mistake. In the field, non-host pods in the same area as mesquite will be sufficiently separate from mesquite pods to avoid oviposition by beetles of either species. Thus these test plant species will not be at risk from either *A. bottimeri* or *A. prosopis* .

Literature and museum records, and the known host range of the two species, support the view that these are host specific insects and that it is unlikely that any other plant species will be at risk.

9. POSSIBLE INTERACTION WITH EXISTING CONTROL PROGRAMS

There have been no other biocontrol agents released on mesquite in Australia. Interaction with chemical and mechanical programs will be positive in that the residual seed banks will be reduced.

10. PRELIMINARY TESTS

A. prosopis and *A. bottimeri* were tested on 74 species of legumes in South Africa prior to their release in South Africa and Namibia (Peter and Zimmermann, 1987).

No larval feeding or development of either species occurred in any test plant seeds except those of the exotic weed *Cassia (Senna) didymobotrya*, which originated elsewhere in Africa. No feeding occurred on two other species of *Cassia*. No eggs were laid on *C. didymobotrya* pods in starvation tests (Peter and Zimmermann, 1987). In multiple choice tests no eggs were laid on *C. didymobotrya* unless there were *Prosopis* spp. pods in close proximity (Zimmermann, 1991). Peter and Zimmermann (1987) concluded that gravid females of both species will not oviposit on *C. didymobotrya* in the absence of an olfactory stimulus associated with *Prosopis* spp.. *A. prosopis* and *A. bottimeri* were therefore regarded as host specific and safe for release in South Africa.

11. HOST SPECIFICITY TESTING

Host specificity studies are described and discussed in the accompanying reports. The reports conclude that both *A. bottimeri* and *A. prosopis* are safe to release.

12. PROPOSED INITIAL RELEASES

Initial releases will be made on *P.velutina* at Quilpie, *P. pallida* at Hughenden and *P. pallida* hybrid at Mckinlay in Queensland, and on *P. pallida* x ? *P. laevigata* in Western Australia.

13. EVALUATION OF ESTABLISHMENT, DISPERSAL AND EFFECTS ON THE TARGET WEED

Staff of the departments involved in Qld and WA will monitor the agents in the field.

14. METHODS OF EVALUATION

Pod-fall traps will be set up at selected sites and the collected pods will be caged to await emergence of beetles. In addition, the total numbers of seeds in pod-fall samples and the total number of seeds destroyed by the agents in pod-fall samples will be counted and the percentage of seed destroyed calculated.

15. COLLABORATIVE RESEARCH WITH OTHER DEPARTMENTS

This is a joint project involving the Queensland Lands Department and the Western Australia Department of Agriculture.

16. ASSISTANCE SOUGHT FROM OTHER DEPARTMENTS

No assistance from other departments is required.

17. ASSISTANCE OFFERED TO OTHER DEPARTMENTS

If approved for release, starter colonies will be provided to all States that request them. Information on the biology and rearing techniques will be given.

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HOST SPECIFICITY OF THE BRUCHID *ALGAROBIUS BOTTIMERI* KINGSOLVER FOR THE BIOLOGICAL CONTROL OF MESQUITE, *PROSOPIS* SPP. IN AUSTRALIA

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Introduction

Two bruchids, *Algarobius bottimeri* and *Algarobius prosopis* were imported into quarantine at the Alan Fletcher Research Station for host specificity testing as potential agents for the biocontrol of seeds of mesquites, *Prosopis* spp., in Australia. Host testing of these two insects was performed in parallel. This report covers the host specificity testing of *A. bottimeri.*

The mesquites are prickly woody weeds of mainland Australia. The major infestations are of *Prosopis pallida* in Queensland and the Northern Territory, *P. velutina* (Quilpie algarroba) in Queensland, a hybrid (*P. pallida* x ?) in Queensland and the Mardie hybrid (*P. pallida* x *? P. laevigata*) at Mardie Station, Western Australia. While these major infestations and some minor infestations of various mesquite taxa occur in the northern half of the continent, there are also minor infestations of various mesquite taxa in the southern half. Quilpie algarroba has been referred to as *P. flexuosa* (Pedley, 1977). However Burkart (1976) and Panetta (pers. comm.) consider that it is *P. velutina.*

A. bottimeri occurs naturally mainly in Texas and north-east Mexico. It has been recorded from *P. glandulosa* var. *glandulosa* and *P. reptans* var. *cinerascens* in North America (Kingsolver, 1986). It was accidentally introduced to Hawaii where it feeds on the introduced South American mesquite *P. pallida* (Kingsolver *et al*, 1977; Kingsolver, 1986).

Both *A. bottimeri* and *A. prosopis* were introduced into South Africa from the USA for the biocontrol of two mesquites, *P. velutina* and *P. glandulosa* var. *torreyana*, following host specificity testing in quarantine (Peter and Zimmermann, 1987; Zimmermann, 1991; Hoffman *et al*, 1993). *A. bottimeri* has become established on *P. glandulosa* var. *glandulosa* at one site only (Hoffmann *et al*, 1993). Here its population is mixed with a population of *A. prosopis.* In contrast, *A. prosopis* is widely established on *Prosopis* spp. (Zimmermann, 1991: Hoffmann *et al*, 1993). In a mixed insectary culture, *A. bottimeri* was suppressed by *A. prosopis* (Peter and Zimmermann, 1987; Zimmermann, 1991). In the laboratory, Hoffmann *et al* (1993) found that *A. prosopis* larvae were more competitive than *A. bottimeri* larvae when both were placed together on seeds of *P. velutina.*

Biology

A. bottimeri and *A. prosopis* are almost identical mottled brown beetles from 2.2 to 5.0 mm long (Peter and Zimmermann, 1987). The only easily detected external difference between the two species is in the positions and shape of the pygidial sulci in the females, while the males can only be separated by studying the genitalia (Kingsolver, 1986; Peter and Zimmermann, 1987).

According to Peter and Zimmerman (1987), *A. bottimeri* adults mate within 24 hours of emergence and after a short pre-oviposition period females commence oviposition into surface cracks and crevices of mesquite pods . If there are no suitable protected sites, the female may oviposit clumps of 10-15 eggs on pod surfaces. Hoffman *et al* (1993) found that females (n=35) could oviposit for 50 days with a cumulative mean oviposition of 300 eggs.

In nature, *A. bottimeri* adults would be expected to feed on pollen from any plants that are flowering, as noted by Kingsolver (1986) for *A. prosopis*. They would probably drink nectar. They are sustained successfully in the insectary on a paste made of honey and pollen. They are also sustained using a dilute sugar solution (Hoffman *et al*, 1993).

Eggs hatch in 8-9 days at 34°C and larvae pass through four instars before pupation (Zimmermann, 1991). The first instar larvae have legs, are highly mobile (Peter and Zimmermann, 1987) and are able to tunnel through the sticky mesocarp, fibrous endocarp and hard seed coat to enter seeds. Only one larva develops through to the adult stage in each seed. Hoffman *et al* (1993) found that full *A. bottimeri* development took from 25 to 71 days (median 33 days) in an insectary with a temperature regime of 27±2°C for 12 hour "days" and 23±2°C for "nights". They found the male/female sex ratio of emerged beetles to be 1:1 and that newly emerged males consistently weighed significantly more than females.

Materials and Methods.

A shipment of *A. bottimeri* beetles was obtained from the University of Capetown, South Africa in February, 1994. In quarantine, the beetles were reared on Mardie hybrid mesquite pods in plastic food storage containers and in styrofoam boxes in an airconditioned room with a daily temperature range of from 18° C to 26°C. The ovipositing beetles in rearing boxes were fed on a mixture of commercially available honey and pollen. Mardie hybrid mesquite pods were used because a good supply of them was readily available from the field.

Host Specificity Test Plants

The plants used in these host specificity tests are listed in Appendix A and are grouped into Part 1 - Mesquites and Part 2 - Test Plants.

Pods of the following plants in the original test list approved by AQIS could not be obtained. Where possible a substitute species from the same listed taxonomic group was used:

Pods of *Acacia coriacea*, (unidentified subspecies) were used in Section Plurinerves of the genus *Acacia* instead of *A. coriacea* ssp. *sericophylla*.

In Section Botrycephalae of the genus *Acacia*, *Acacia glaucocarpa*,was substituted for *Acacia deanei* and *Acacia decurrens*.

In Family Caesalpiniaceae, *Senna artemisioides* was substituted for *Senna barclayana*. *S. artemisioides* is a perennial that occurs naturally near mesquite infestations in Queensland. It is used as a native ornamental in Queensland. Pods were easily obtained. *S. barclayana* is a weedy annual that may sometimes grow in mesquite infested areas.

In the genus *Acacia*, Section Aculeiferum, neither *Acacia albizzioides* nor *Acacia pennata* sub-sp. *kerrii* could be obtained. These two species occur only in remote parts of Cape York Peninsula. No alternative species were available.

In the Tribe Piptadeniae, pods or seeds of *Entada phaseoloides* were unavailable and no alternative to *E. phaseoloides* was available.

Mesquite Tests

These tests were conducted to determine if *A. bottimeri* would oviposit on and develop in pods of the various *Prosopis* taxa present in Australia.

In each test, four pods each of *P. pallida, P. velutina* (Quilpie algarroba), *P. glandulosa, P. juliflora* and *Prosopis* Mardie hybrid were enclosed with 100 beetles in a gauze-covered bench-top cage. The beetles used were obtained from the shipment received from South Africa after screening for parasitic mites. Two replicate cages were set up. Each group of four pods was placed in a separate shallow dish on the bottom of the cage. Water and a honey and pollen mix were placed in each cage. After 10 days the beetles were removed and the pods of each mesquite taxon were placed in separate sealed plastic containers. These were stored in a controlled-temperature cabinet with a daily temperature range of 18°-32°C to await emergence of beetles. Beetle emergence was monitored and recorded.

Multiple-choice Tests

Multiple-choice tests were conducted to determine if the bruchids would oviposit on and develop in test plant pods.

In these tests, five pods each of mesquite (*Prosopis* Mardie hybrid) and of four test plant species (except for the last test when only one species remained to be tested) were placed in a 3.5 L plastic food container with a petri dish of honey and pollen mixture spread on

tissue paper. Three replicates were set up for each pod combination. Fifty quarantine-reared beetles were added to each test container before the containers were sealed and placed in a controlled-temperature cabinet with a daily temperature range of from 18°-32°C. The beetles were removed after 14 days. Pods of each taxon tested were placed in appropriately sized and labelled sealed containers to await possible development and emergence of beetles. The containers were stored in an airconditioned quarantine room with a daily temperature range of from 18°-26°C. Pods were examined for eggs after sufficient time had elapsed for them to have hatched. This timing was necessary as examination of some pods was possibly damaging to eggs. Egg numbers were recorded. Beetle emergence was monitored and recorded. At least 14 weeks after the pods were removed from the oviposition containers, the seeds were removed from the pods and examined for larval entry holes. Non-mesquite seeds with entry holes were dissected to determine the fate of the larvae. Details of this examination were recorded.

No-choice Seed Substitution Tests

Seeds of test plant species, which did not have eggs laid on their pods in the multiple-choice tests, were exposed to *A. bottimeri* larvae in no-choice seed substitution tests to determine if development would occur in them.

Pods of *Barklya syringifolia, Chamaecrista mimosoides* and *Pultenaea villosa* were the only pods to escape oviposition by *A. bottimeri* in these multiple-choice tests. In each of three replicates, 10 seeds of each of these three species were inserted into emptied endocarp capsules in excised sections of Mardie hybrid mesquite pods. For controls, 10 Mardie hybrid mesquite seeds were similarly inserted. First, a sufficient quantity of mesquite pods was exposed to oviposition by quarantine-reared *A.bottimeri* beetles for 1 week prior to the careful excision of the mesquite seeds. The seed substitutions were then made. Only pod sections on which clusters of eggs remained after seed excision were used for seed substitution. Care was taken not to damage the eggs. The sets of substituted seeds were stored in plastic food containers in a controlled-temperature cabinet with a daily temperature range of from 18°-32°. Beetle emergence was monitored and recorded. Seeds of test species were examined for larval entry holes after 7 weeks. Seeds with entry holes were kept a further 9 weeks before being dissected to determine the fate of the larvae. As all mesquite seeds produced beetles, no further examination of them was done.

Large Cage Tests

Test plant species on which either *A. bottimeri* or *A. prosopis* had successfully developed in the parallel multiple-choice tests, were used in large cage tests. These were conducted to determine if the beetles would oviposit on the test pods if not in close proximity to mesquite pods. In host specificity testing in South Africa (Peter and Zimmerman, 1987; Zimmermann, 1991), the researchers noted that oviposition by both *A. bottimeri* and *A. prosopis* occurred on *Cassia didymobotrya* pods in close proximity to mesquite pods but not on *C. didymobotrya pods* in the absence of mesquite pods, and they assumed that mesquite pods provided an olfactory stimulus for oviposition.

Five pods each of Mardie hybrid mesquite and the five species in which either *A. bottimeri* or *A. prosopis* beetles developed in the parallel multiple-choice tests were placed out in shallow plastic trays on low benches in a large sheer nylon cloth cage (2 m x 2 m x 1.5 m) in a quarantine glasshouse. The pods were of *Petalostylis labicheoides*, *Acacia aneura, Neptunia gracilis* and *Arachis hypogaea* in which both bruchids had developed and *Caesalpinia decapetala,* in which only *A. prosopis* had developed. The mesquite pods were placed on the opposite side of the cage, approximately 1.5 m away from the test pods. Fifty quarantine-reared beetles were placed in the cage. There were three replicates of this test. After 1 week the beetles were removed and the pods of each species were placed separately in sealed plastic food containers. These were kept in a controlled temperature cabinet with a daily temperature range of from 18°-32°C. After 2 to 4 weeks the pods were examined for eggs. When no eggs were found on any test pods, they were discarded. The beetle emergence from mesquite pods was monitored and recorded.

Results

Rearing

A. bottimeri has been reared successfully for 15 generations in quarantine on pods of *Prosopis* Mardie hybrid.

Mesquite Tests

Pods of all five mesquite taxa supported *A. bottimeri* development through to adult (Table 1) for three generations after which no viable seeds remained. Emergence of first generation beetles from pods of all mesquite taxa began 6 weeks after the tests were started.

Table 1. Mesquite Tests. *Algarobius bottimeri* emergence.

	P. hybrid		*P. pallida*		*P. velutina*		*P. glandulosa*		*P. juliflora*	
	R 1	R 2	R 1	R 2	R 1	R 2	R 1	R 2	R 1	R 2
Gen 1	35	31	51	23	15	23	13	12	40	34
Gen 2	26	20	42	49	36	18	37	36	22	19
Gen 3	2	1	0	5	6	2	7	1	0	4
Total	63	52	93	77	57	43	57	49	62	57

Abbreviations: *P.* hybrid = *Prosopis* Mardie hybrid, R = Replicate, Gen = Generation

Multiple-choice Tests

Oviposition by *A. bottimeri* occurred on pods of all test plant species except *Barklya syringifolia, Chamaecrista mimosoides* and *Pultenaea villosa.*

Beetles emerged from seeds of *Prosopis* Mardie hybrid, *Acacia aneura, Petalostylis labicheoides, Neptunia gracilis* and *Arachis hypogaea* (Table 2).

Dissected *A. aneura* seeds contained dead pupae and dead larvae of various sizes. Dissected *P. labicheoides* seeds and *A. hypogaea* seeds contained dead first instar larvae. Dissected *N. gracilis* seed contained dead beetles and dead larvae of various sizes. The causes of death of the various stages of *A. bottimeri* in these seeds were not apparent.

First instar larvae attempted to penetrate or penetrated seeds of most of the other test plant species, but only dead first instar larvae were found when these seeds were dissected. Many larval entry holes did not fully perforate the testa of some seeds. Larvae which had penetrated beyond the testa were found dead at distances of 1 mm-3 mm into the seeds. No larval entry holes were found in seeds of *Acacia monticola, Acacia glaucocarpa, Archidendropsis basaltica, Cassia brewsteri, Delonix regia* and *Hovea acutifolia.*

Table 2. *Algarobius bottimeri* emergence in multiple choice tests

Test plant species	Development time (Weeks)	Number of beetles emerged		
		Rep 1	Rep 2	Rep 3
Prosopis Mardie hybrid	5-10	70	61	73
Acacia aneura	20	1	0	0
Prosopis Mardie hybrid	6-10	71	58	60
Petalostylis labicheoides	15	3	1	1
Neptunia gracilis	15	2	0	1
Prosopis Mardie hybrid	5-9	53	52	73
Arachis hypogaea	31	1	0	0

No-choice Seed Substitution Tests

Each mesquite seed used in these tests produced a beetle. No development beyond first instar larvae occurred in any other seeds. No larval entry holes were found in *Pultenaea villosa* seeds.

Large Cage Tests

In the separate replicates, 296 eggs, 263 eggs and 217 eggs were laid on mesquite pods but none were laid on test plant pods.

Discussion

Since beetles of *A. bottimeri* developed readily in seeds of all of the *Prosopis* taxa screened in the mesquite tests (Table 1) and for many generations in Mardie hybrid mesquite seeds in rearing boxes, the failure of *A. bottimeri* to establish widely in South Africa (Hoffmann *et al*, 1993) should not be taken as an indicator of its possible performance in Australia. Some pest mesquites of Australia belong to different taxa to those of South Africa. In particular, most large Australian infestations are of *P. pallida* or *P. pallida* hybrid mesquite. As *P. pallida* has been a suitable host for *A. bottimeri* in Hawaii (Kingsolver *et al*, 1977; Kingsolver, 1986) and as *A. bottimeri* was successfully reared on Mardie hybrid mesquite pods, it should establish readily on these taxa in Australia.

The failure of larvae to penetrate through the testa or to develop beyond first instar in the majority of test plant seeds in multiple choice and no-choice seed substitution tests, indicates that those species are unsuitable as hosts for *A. bottimeri*. Southgate (1979) suggested that legume seeds may contain, in the testa or cotyledons, toxins or other substances that inhibit bruchid larval feeding or development.

The development of beetles in seeds of the test plants *A. aneura, P. labicheoides, N. gracilis* and *A. hypogaea*, followed oviposition on their pods in the close presence of mesquite pods. The extended minimum development times in these species (Table 2) indicate that they are not ideal hosts.

In large cage tests, the rejection of all pods except mesquite for oviposition supports the view of Zimmermann (1991) that *A. bottimeri* females will oviposit on non-host pods if they are in close proximity to mesquite pods but not on non-host pods that are separated from mesquite pods. There may be some places in Australia where mesquite occurs in the presence of *A. aneura* (mulga), *N. gracilis* or *P. labicheoides*. However, the pods of these plants would not be close enough to mesquite pods for oviposition to be induced on them. There are no known mesquite infestations in peanut (*A. hypogaea*) producing areas. Peanut pods are subterranean until exposed to the air post-harvest. In the field, non-host pods in the same area as mesquite will be sufficiently separated from mesquite pods to avoid oviposition by *A. bottimeri* females. If *A. bottimeri* is released in Australia it will pose no threat to these plants.

Conclusion

I submit that *A. bottimeri* is specific to plants of the genus *Prosopis* and recommend that it be released against mesquite in Australia.

Acknowledgements

I thank Dr Jon Dodd, Dr Andrew Mitchell and Mick Minchin for pod collection in Western Australia and Peter Jeffery and Jim Wilmot for pod collection in Queensland. I thank Dr Dane Panetta, Dr Rachel Mcfadyen and Allan Tomley for reading and correcting the manuscript.

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APPENDIX A

Plants utilised in host specificity testing of *Algarobius bottimeri* and *Algarobius prosopis*

* Introduced species

PART 1 MESQUITES

Family Mimosaceae

Tribe Adenanthereae

* *Prosopis velutina*	Quilpie algarroba
* *Prosopis glandulosa*	honey mesquite
* *Prosopis juliflora*	mesquite
* *Prosopis pallida*	algarroba, mesquite
* *Prosopis pallida* x ? *P. laevigata*	mesquite, Mardie hybrid

PART 2 TEST PLANTS

Family Mimosaceae

Tribe Adenanthereae

Adenanthera pavonina	red beantree, red sandalwood
Neptunia gracilis	native sensitive plant
Dichrostachys spicata	Chinese lantern flower

Tribe Acacieae

Genus *Acacia*

Sub-genus *Acacia*

Acacia bidwillii	corkwood wattle

Sub-genus *Phyllodineae*

Section Botrycephalae

Acacia glaucocarpa	green wattle

Section Phyllodineae	
Acacia tetragonophylla	
Acacia victoriae	elegant wattle, gundabluie
Section Lycopodiifoliae	
Acacia galioides	
Section Pulchellae	
Acacia pulchella	prickly moses
Section Plurinerves	
Acacia coriacea	desert oak, dogwood, wirewood
Section Juliflorae	
Acacia aneura	mulga
Acacia monticola	
Tribe Euminoseae	
Mimosa pudica	common sensitive plant
Tribe Ingeae	
Archidendron lucyi	
Archidendropsis basaltica	dead finish
**Calliandra inaequilatera*	pom-pom tree
Paraserianthes lophantha	

Family Caesalpiniaceae	
Barklya syringifolia	
Caesalpinia decapetala	
Cassia brewsteri	Leichhardt bean
Chamaecrista mimosoides	five-leaved cassia
**Delonix regia*	poinciana
Lysiphyllum hookeri	white bauhinia, pegunny
Petalostylis labicheoides	butterfly bush
Senna artemisioides	
Family Fabaceae	
**Arachis hypogaea*	peanut
**Cajanus cajan*	pigeon pea
Clianthus formosus	Sturt's desert pea
Hardenbergia violacea	native sarsparilla
Hovea acutifolia	
**Macroptilium atropurpureum*	siratro
Pultenaea villosa	
**Vigna radiata*	mung bean

APPENDIX 3

HOST SPECIFICITY OF THE BRUCHID *ALGAROBIUS PROSOPIS* (LE CONTE) FOR THE BIOLOGICAL CONTROL OF MESQUITE, *PROSOPIS* SPP. IN AUSTRALIA

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January 1996

Introduction

Two bruchids, *Algarobius prosopis* and *Algarobius bottimeri* were imported into quarantine at the Alan Fletcher Research Station for host specificity testing as potential agents for the biocontrol of seeds of mesquites, *Prosopis* spp., in Australia. Host testing of these two insects was performed in parallel. This report covers the host specificity testing of *A. prosopis*.

The mesquites are prickly woody weeds of mainland Australia. The major infestations are of *Prosopis pallida* in Queensland and the Northern Territory, *P. velutina* (Quilpie algarroba) in Queensland, a hybrid (*P. pallida* x ?) in Queensland and the Mardie hybrid (*P. pallida* x *? P. laevigata*) at Mardie Station, Western Australia. While these major infestations and some minor infestations of various mesquite taxa occur in the northern half of the continent, there are also minor infestations of various mesquite taxa in the southern half. Quilpie algarroba has been referred to as *P. flexuosa* (Pedley, 1977). However Burkart (1976) and Panetta (pers. comm.) consider that it is *P. velutina*.

A. prosopis occurs naturally in the south-west USA and north-west Mexico. Johnson (1983) recorded its native hosts as *P. velutina, P. glandulosa* var. *torreyana, P. pubescens* and *P. articulata*. Kingsolver (1986) adds *P. palmeri* and *P. reptans* var. *cinerascens*, but does not include *P. articulata,* and notes that *A. prosopis* has been reared in Arizona from the introduced Argentinian species, *P. alba*.

Both *A. prosopis* and *A. bottimeri* were introduced into South Africa from the USA for the biocontrol of two mesquites, *P. velutina* and *P. glandulosa* var. *torreyana*, following host specificity testing in quarantine (Peter and Zimmermann, 1987; Zimmermann, 1991; Hoffman *et al*, 1993). *A. prosopis* is now widely established on *Prosopis* spp. in South Africa (Zimmermann, 1991: Hoffmann *et al*, 1993). Field and laboratory experience in South Africa suggests that *A. prosopis* out-competes *A. bottimeri* on the mesquite taxa in South Africa (Peter and Zimmermann, 1987; Zimmermann, 1991; Hoffmann *et al* 1993).

Biology

A. prosopis and *A. bottimeri* are almost identical mottled brown beetles from 2.2 to 5.0 mm long (Peter and Zimmerman, 1987). The only easily detected external difference between the two species is in the positions and shape of the pygidial sulci in the females, while the males can only be separated by studying the genitalia (Kingsolver,1986; Peter and Zimmermann, 1987).

According to Peter and Zimmermann (1987), *A. prosopis* adults mate within 24 hours of emergence and after a short pre-oviposition period females commence oviposition into surface cracks and crevices of mesquite pods. If there are no suitable protected sites, the female may oviposit clumps of 10-15 eggs on pod surfaces. Hoffman *et al* (1993) found that females (n=35) could oviposit for 45 days with a cumulative mean oviposition of 225 eggs.

In nature, adults feed on pollen from any plants that are flowering (Kingsolver, 1986) and probably drink nectar. They are sustained successfully in the insectary on a paste made of honey and pollen. They are also sustained using a dilute sugar solution (Hoffmann *et al,* 1993).

Eggs hatch in 8-9 days at 34°C and larvae pass through four instars before pupation (Zimmermann, 1991). The first instar larvae have legs, are highly mobile (Peter and Zimmermann, 1987) and are able to tunnel through the sticky mesocarp, fibrous endocarp and hard seed coat to enter seeds. Only one larva develops through to the adult stage in each seed. Hoffman *et al* (1993) found that full *A. prosopis* development took from 24 to 175 days (median 34 days) in an insectary with a temperature regime of 27±2°C for 12 hour "days" and 23±2°C for "nights". They found the male/female sex ratio of emerged beetles to be 1:1 and that newly emerged males consistently weighed significantly more than females.

Materials and Methods.

A shipment of *A. prosopis* beetles was obtained from the University of Capetown, South Africa in February, 1994. In quarantine, the beetles were reared on Mardie hybrid mesquite pods in plastic food storage containers or in styrofoam boxes in an airconditioned room with a daily temperature range of from 18° C to 26°C. The ovipositing beetles in rearing boxes were fed on a mixture of commercially available honey and pollen. Mardie hybrid mesquite pods were used because a good supply of them was readily available from the field.

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tissue paper. Three replicates were set up for each pod combination. Fifty quarantine-reared beetles were added to each test container before the containers were sealed and placed in a controlled-temperature cabinet with a daily temperature range of from 18°-32°C. The beetles were removed after 14 days. Pods of each taxon tested were placed in appropriately sized and labelled sealed containers to await possible development and emergence of beetles. The containers were stored in an airconditioned quarantine room with a daily temperature range of from 18°-26°C. Pods were examined for eggs after sufficient time had elapsed for them to have hatched. This timing was necessary as examination of some pods was possibly damaging to eggs. Egg numbers were recorded. Beetle emergence was monitored and recorded. At least 14 weeks after the pods were removed from the oviposition containers, the seeds were removed from the pods and examined for larval entry holes. Non-mesquite seeds with entry holes were dissected to determine the fate of the larvae. Details of this examination were recorded.

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or *A. bottimeri* beetles developed in the parallel multiple-choice tests were placed out in shallow plastic trays on low benches in a large sheer nylon cloth cage (2 m x 2 m x 1.5 m) in a quarantine glasshouse. The pods were of *Petalostylis labicheoides*, *Acacia aneura, Neptunia gracilis* and *Arachis hypogaea* in which both bruchids had developed and *Caesalpinia decapetala,* in which only *A. prosopis* had developed. The mesquite pods were placed on the opposite side of the cage, approximately 1.5 m away from the test pods. Fifty quarantine-reared beetles were placed in the cage. There were three replicates of this test. After 1 week the beetles were removed and the pods of each species were placed separately in sealed plastic food containers. These were kept in a controlled temperature cabinet with a daily temperature range of from 18°-32°C. After 2 to 4 weeks the pods were examined for eggs. When no eggs were found on any test pods, they were discarded. The beetle emergence from mesquite pods was monitored and recorded.

Results

Rearing

A. prosopis has been reared successfully for 15 generations in quarantine on pods of *Prosopis* Mardie hybrid.

Mesquite Tests

Pods of all five mesquite taxa supported the development of *A. prosopis* through to adult (Table 1) for three generations after which no viable seeds remained. Emergence of first generation beetles from pods of all mesquite taxa began 6 weeks after the tests were started.

Table 1. Mesquite tests. *Algarobius prosopis* emergence.

	P. hybrid		*P. pallida*		*P. velutina*		*P. glandulosa*		*P. juliflora*	
	R 1	R 2	R 1	R 2	R 1	R 2	R 1	R 2	R 1	R 2
Gen 1	28	28	*	56	*	27	*	24	55	55
Gen 2	33	23	*	19	*	25	*	19	25	40
Gen 3	1	0	*	1	*	5	*	1	5	5
Total	62	51	*	76	*	57	*	44	85	100

P. hybrid = *Prosopis* Mardie hybrid, R = Replicate, Gen = Generation

* - Pods became wet and mouldy when condensate water leaked into their containers in the CT cabinet . They were autoclaved.

Multiple-choice Tests

Oviposition by *A. prosopis* occurred on pods of all test plant species except *Barklya syringifolia, Chamaecrista mimosoides* and *Pultenaea villosa.*

Beetles emerged from seeds of *Prosopis* Mardie hybrid, *Acacia aneura, Caesalpinia decapetala, Petalostylis labicheoides, Neptunia gracilis,* and *Arachis hypogaea* (Table 2).

Dissected *A. aneura* seeds contained a dead beetle and dead large larvae. Dissected *P. labicheoides* seeds and *A. hypogaea* seeds contained dead beetles, dead pupae and dead larvae of various sizes. Dissected *N. gracilis* seed contained dead beetles and dead larvae of various sizes. Dissected *C. decapetala* seeds contained dead first instar larvae. The causes of death of the various stages of *A. prosopis* in these seeds were not apparent.

First instar larvae attempted to penetrate or penetrated seeds of most of the other test plant species, but no development beyond first instar larvae was found when these seeds were dissected. Many larval entry holes did not fully perforate the testa of some seeds. Larvae which had penetrated beyond the testa were found dead at distances of 1-3 mm into the seeds. No larval entry holes were found in seeds of *Acacia galioides, Delonix regia,* and *Hovea acutifolia.*

Table 2. *Algarobius prosopis* emergence in multiple-choice tests

Test plant species	Development time	Number of beetles emerged		
	(Weeks)	Rep 1	Rep 2	Rep 3
Prosopis Mardie hybrid	6-11	67	69	69
Acacia aneura	20-34	9	9	7
Prosopis Mardie hybrid	6-11	73	80	83
Petalostylis labicheoides	15-31	12	14	11
Neptunia gracilis	15-19	10	2	3
Prosopis Mardie hybrid	8-35	78	73	58
Arachis hypogaea	9-23	6	6	5
Prosopis Mardie hybrid	4-26	86	86	94
Caesalpinia decapetala	13	0	1	1

No-choice Seed Substitution Tests

Each mesquite seed used in these tests produced a beetle. No development beyond first instar larvae occurred in any other seeds. No larval entry holes were found in *Pultenea villosa* seeds.

Large Cage Tests

In the separate replicates, 471 eggs, 370 eggs and 205 eggs were laid on mesquite pods but none were laid on test plant pods.

Discussion

Beetles of *A. prosopis* developed readily in seeds of all of the *Prosopis* taxa screened in the mesquite tests (Table 1) and for many generations in Mardie hybrid mesquite seeds in rearing boxes. *A. prosopis* should be able to develop in seeds of these taxa in the field. *A. prosopis* established readily on *P. velutina* in South Africa (Zimmermann, 1991).

The failure of larvae to penetrate through the testa or to develop beyond first instar in the majority of test plant seeds in multiple choice and no-choice seed substitution tests, indicates that those species are unsuitable as hosts for *A. prosopis*. Southgate (1979) suggested that legume seeds may contain, in the testa or cotyledons, toxins or other substances that inhibit bruchid larval feeding or development.

The development of beetles in seeds of the test plants *A. aneura, C. decapetala, P. labicheoides, N. gracilis* and *A. hypogaea,* followed oviposition on their pods in the close presence of mesquite pods. The extended minimum development times in these species (Table 2) indicate that they are not ideal hosts.

In large cage tests, the rejection of all pods except mesquite for oviposition supports the view of Zimmermann (1991) that *A. prosopis* females will oviposit on non-host pods if they are in close proximity to mesquite pods but not on non-host pods that are separated from mesquite pods. There may be some places in Australia where mesquite occurs in the presence of *A. aneura* (mulga), *N. gracilis* or *P. labicheoides*. However, the pods of these plants would not be close enough to mesquite pods for oviposition to be induced on them. *C. decapetala* does not grow near mesquite in Australia. There are no known mesquite infestations in peanut (*A. hypogaea*) producing areas. Peanut pods are subterranean until exposed to the air post-harvest. In the field, non-host pods in the same area as mesquite will be sufficiently separated from mesquite pods to avoid oviposition by *A. prosopis* females. If *A. prosopis* is released in Australia it will pose no threat to these plants.

Conclusion

I conclude that *A. prosopis* is specific to plants of the genus *Prosopis* and recommend that it be released against mesquite in Australia.

Acknowledgements

I thank Dr Jon Dodd, Dr Andrew Mitchell and Mick Minchin for pod collection in Western Australia and Peter Jeffery and Jim Wilmot for pod collection in Queensland. I thank Dr Dane Panetta, Dr Rachel Mcfadyen and Allan Tomley for reading and correcting the manuscript.

This research was supported by the Meat Research Corporation, the Queensland Department of Lands and the Western Australia Department of Agriculture.

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Acknowledgements

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This research was supported by the Meat Research Corporation, the Queensland Department of Lands and the Western Australia Department of Agriculture.

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Johnson, C.D. 1983. Handbook on seed insects of *Prosopis* species: Ecology, control, and identification of seed-infesting insects of New World *Prosopis* (Leguminosae). Food and Agric. Organiz. of the United Nations, Rome, 55pp.

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APPENDIX A

Plants utilised in host specificity testing of *Algarobius bottimeri* and *Algarobius prosopis*

* Introduced species

PART 1 MESQUITES

Family Mimosaceae

Tribe Adenanthereae

* *Prosopis velutina*	Quilpie algarroba
* *Prosopis glandulosa*	honey mesquite
* *Prosopis juliflora*	mesquite
* *Prosopis pallida*	algarroba, mesquite
* *Prosopis pallida* x ? *P. laevigata*	mesquite, Mardie hybrid

PART 2 TEST PLANTS

Family Mimosaceae

Tribe Adenanthereae

Adenanthera pavonina	red beantree, red sandalwood
Neptunia gracilis	native sensitive plant
Dichrostachys spicata	Chinese lantern flower

Tribe Acacieae

Genus *Acacia*

Sub-genus *Acacia*

Acacia bidwillii	corkwood wattle

Sub-genus *Phyllodineae*

Section Botrycephalae

Acacia glaucocarpa	green wattle

Section Phyllodineae	
Acacia tetragonophylla	
Acacia victoriae	elegant wattle, gundabluie
Section Lycopodiifoliae	
Acacia galioides	
Section Pulchellae	
Acacia pulchella	prickly moses
Section Plurinerves	
Acacia coriacea	desert oak, dogwood, wirewood
Section Juliflorae	
Acacia aneura	mulga
Acacia monticola	
Tribe Euminoseae	
Mimosa pudica	common sensitive plant
Tribe Ingeae	
Archidendron lucyi	
Archidendropsis basaltica	dead finish
**Calliandra inaequilatera*	pom-pom tree
Paraserianthes lophantha	

Family Caesalpiniaceae	
Barklya syringifolia	
Caesalpinia decapetala	
Cassia brewsteri	Leichhardt bean
Chamaecrista mimosoides	five-leaved cassia
**Delonix regia*	poinciana
Lysiphyllum hookeri	white bauhinia, pegunny
Petalostylis labicheoides	butterfly bush
Senna artemisioides	
Family Fabaceae	
**Arachis hypogaea*	peanut
**Cajanus cajan*	pigeon pea
Clianthus formosus	Sturt's desert pea
Hardenbergia violacea	native sarsparilla
Hovea acutifolia	
**Macroptilium atropurpureum*	siratro
Pultenaea villosa	
**Vigna radiata*	mung bean

AQIS

AUSTRALIAN QUARANTINE AND INSPECTION SERVICE
DEPARTMENT OF PRIMARY INDUSTRY AND ENERGY
Quarantine Act 1908

Tel:(06) 272 5385
Fax:(06) 273 2097

Permit to Import Quarantine Material

A Quarantine Entry must be completed in respect of goods subject to Quarantine

Page: 1 of: 1

Permit: 99608302 **Valid From:** 20-Sep-1996 **To:** 20-Sep-1998

Importer 99602512	**Supplier** 99222318
Alan Fletcher Research Station PO Box 36 Sherwood QLD 4075 ATTN: Mr Graham Donnelly	South Africa SOUTH AFRICA

You are authorised to import the following material under the listed conditions.
Note: *Quarantine permission does not absolve the importer from obtaining any necessary clearance from customs or other relevant authorities. All imports are subject to quarantine inspection on arrival to ensure compliance with the listed permit conditions and freedom from contamination. Imports not in compliance or not appropriately identified or packaged and labelled in accordance with the quarantine risk they represent may be subject to seizure, re-export or destruction at the importer's expense.*

AQIS Product Id	Product Name Conditions	Quantity
99400474	ALGAROBIUS BOTTIMERI 90002 and 90003 and 90019 and 90021	

Condition	Condition Text
0002	Safety precautions shall be maintained during shipment and handling to prevent dissemination of pathogens.
0003	Packaging materials and containers must be disposed of by incineration, autoclaving or other method approved by the Director of Animal/Plant Quarantine.
0019	To be bred through one generation in quarantine before release and to be tested free of hyperparasites and disease.
0021	This permit is not valid unless accompanied by an import permit from the Australian Nature Conservation Agency.

End of Condition Text

This permit is granted subject to the condition that fees determined under Section 86E are paid

Authorising Officer (for Director Animal and Plant Quarantine)

Signature	Printed Name	Date
	R SCHWARTZ	20-Sep-1996

This receipt must bear a cash register imprint, an official stamp and the signature of a quarantine officer

Signature	Printed Name	Date
	R SCHWARTZ	20-Sep-1996

Stamp: DEPARTMENT OF PRIMARY INDUSTRIES & ENERGY OF QUARANTINE AUSTRALIA Q738

P1985 - 2/94

AQIS
AUSTRALIAN QUARANTINE AND INSPECTION SERVICE
DEPARTMENT OF PRIMARY INDUSTRY AND ENERGY
Quarantine Act 1908
Tel:(06) 272 5385
Fax:(06) 273 2097

Permit to Import Quarantine Material

A Quarantine Entry must be completed in respect of goods subject to Quarantine

Page: 1 of: 1

Permit: 99608301 **Valid From:** 20-Sep-1996 **To:** 20-Sep-1998

Importer 99602512

Alan Fletcher Research Station
PO Box 36
Sherwood
QLD 4075

ATTN: Mr Graham Donnelly

Supplier 99222318

South Africa
SOUTH AFRICA

DEPARTMENT OF LANDS
ALAN FLETCHER RESEARCH STATION, SHERWOOD
2 6 SEP 1996
RECEIVED

You are authorised to import the following material under the listed conditions.
Note: *Quarantine permission does not absolve the importer from obtaining any necessary clearance from customs or other relevant authorities. All imports are subject to quarantine inspection on arrival to ensure compliance with the listed permit conditions and freedom from contamination. Imports not in compliance or not appropriately identified or packaged and labelled in accordance with the quarantine risk they represent may be subject to seizure, re-export or destruction at the importer's expense.*

AQIS Product Id	Product Name Conditions	Quantity
99400473	ALGAROBIUS PROSOPIS 90002 and 90003 and 90019 and 90021	

Condition	Condition Text
90002	Safety precautions shall be maintained during shipment and handling to prevent dissemination of pathogens.
90003	Packaging materials and containers must be disposed of by incineration, autoclaving or other method approved by the Director of Animal/Plant Quarantine.
90019	To be bred through one generation in quarantine before release and to be tested free of hyperparasites and disease.
90021	This permit is not valid unless accompanied by an import permit from the Australian Nature Conservation Agency.

End of Condition Text

This permit is granted subject to the condition that fees determined under Section 86E are paid.

Authorising Officer (for Director Animal and Plant Quarantine)

Signature	Printed Name	Date
	R SCHWARTZ	20-Sep-1996

This receipt must bear a cash register imprint, an official stamp and the signature of a quarantine officer

Signature	Printed Name	Date
	R SCHWARTZ	20-Sep-1996

Stamp: DEPARTMENT OF PRIMARY INDUSTRIES & ENERGY OF QUARANTINE Q738

P1985 - 2/94

APPENDIX 8

Australian Nature Conservation Agency

Canberra Office
GPO Box 636
Canberra ACT 2601
Ph (06) 250 0200
Fax (06) 250 0399

21 October 1996

Mr G Donnelly
Entomologist
Alan Fletcher Research Station
PO Box 36
SHERWOOD QLD 4075

Fax: 07 33796815

Dear Mr Donnelly

Release of *Algarobius prosopis* and *Algarobius bottimeri*

I refer to your application and attached information concerning the proposal by the Alan Fletcher Research Station to release the biological control agent *Algarobius prosopis* and *Algarobius bottimeri* in Australia to control Mesquite.

The Australian Nature Conservation Agency (ANCA) has received supportive comment from the State and Territory conservation and agricultural authorities on the preceding proposal, and a copy of a letter from the Australian Quarantine and Inspection Service agreeing to the release of *Algarobius prosopis* and *Algarobius bottimeri*.

As the Designated Authority under Section 20(1) of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982* and with respect to sub-section 50(1)(b) of the Act, I hereby approve of *Algarobius prosopis* and *Algarobius bottimeri* being removed from the approved facility at the Alan Fletcher Research Station for release into the Australian environment for control of Mesquite.

This approval, as per all other similar releases, is conditional on the Alan Fletcher Research Station:

- monitoring the effect of *Algarobius prosopis* and *Algarobius bottimeri* on species of native flora that are growing in the vicinity of (randomly selected) release sites; and
- providing the ANCA with a periodic report on the effectiveness of *Algarobius prosopis* and *Algarobius bottimeri* as a biological control agent in controlling Mesquite in the Australian environment.

Yours sincerely

Chris Mobbs
Deputy Director
Environmental Assessment and Trade
Wildlife Protection Authority

An agency of the Federal Environment Portfolio

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APPENDIX 9

DEPARTMENT OF NATURAL RESOURCES
OFFICE MEMO

Your Ref.: **Our Ref.:**
Author: GPD **Telephone:** (07) 33750743 **Facsimile:** (07) 33796815

DATE: April 21, 1997

FROM: Graham Donnelly
Entomologist

TO: Dr Dane Panetta, Professional Leader

SUBJECT: **FIELD TRIP TO MARDIE STATION, KARRATHA, WA.**

REPORT ON INTERSTATE FIELD TRIP TO RELEASE MESQUITE BIOLOGICAL CONTROL AGENTS AT MARDIE STATION, KARRATHA, WESTERN AUSTRALIA 8 APRIL 1997 TO 12 APRIL 1997

GRAHAM DONNELLY

SUMMARY

From 8 to 12 April, I visited WA to assist officers of Agriculture WA to release mesquite biological control agents and discuss further releases and future monitoring of release sites. Algarobius bottimeri *beetles were released at two sites and* Algarobius prosopis *were released at one site on Mardie Station, Karratha. I advised Dr Jon Dodd and Agriculture WA, Karratha staff on further releases and future monitoring of sites.*

In preparation for field releases on my trip to Western Australia, I collected and despatched to Dr Jon Dodd, Agriculture WA, South Perth, approximately 1,260 *Algarobius prosopis* beetles and approximately 3660 *Algarobius bottimeri* beetles on 27 March 1997. These beetles were packed in with pods previously collected at Mardie Station, Karratha. On 7 April 1997, I collected approximately 617 *Algarobius prosopis* beetles and approximately 3000 *Algarobius bottimeri* beetles which I subsequently took to WA. The beetles were packed in plastic jars and were provided with a substrate of paper towel.

8 April
I travelled to Perth.

9 April
I met with Dr Dodd and we travelled together to Karratha. Dr Dodd brought along the beetles that I collected on 27 March. At Karratha, we were met by Agriculture WA Regional Officer Dennis Rafferty with whom we discussed aspects of the biocontrol project and our plans for the next day. We also discussed ideas for sampling pods near release site to determine the effects of the seed beetles.

10 April

Dr Dodd and I travelled to Mardie Station with Agriculture WA Operators Rob Parr and Dave Landless and Murdoch University Environmental Science student Rick Glaedell. At Mardie we visited four sites chosen on our previous visit (December 1995) as release sites. Following that visit, Dave Landless and Rob Parr had put up sheep fencing around selected clumps of mesquite at these site to protect pods from livestock. During this current visit, we determined the latitude and longitude of each site by GPS.

In describing the sites below in the order in which we visited them, I use property location names as used on Mardie Station. The numbers were given to the sites by Dr Jon Dodd on our previous visit. The release sites are marked on a map of part of Mardie Station (Fig. 1).

#4. Du Bourlay. This site is located at S 21° 03' 54.2", E 116° 06'12.3" between Du Bourlay Creek and the Fortescue River about 2 km south-west of where the Fortescue River Mouth Road crosses Du Bourlay Creek.

On 12 March, Rob Parr released approximately 3,000 *Algarobius bottimeri* beetles sent by Ian Lacey, Agriculture WA, Kununurra. As their release had been delayed by bad weather and flooding, many of the beetles were dead.

On 10 April, we released approximately 1500 *A. bottimeri* beetles from AFRS. Pods were plentiful under some of the mesquite trees both within and without the fenced exclosure but most had only a few pods under them. No trees carried pods. A few trees had some flowers. There were eggs of a bruchid (possibly *Caryedon serratus*) on some pods. There were emergence holes in some pods. When I examined these and the holes in the seeds they appeared to be bruchid emergence holes. It is too soon since the March release for them to be caused by *A. bottimeri*. Samples of pods with eggs and holes were collected for laboratory examination.

#1. Cow Paddock. This site is located at S 21°11' 21.4", E 115° 57' 45.2" adjacent to Cowpaddock Well. It is about 1 km west of Mardie homestead. Part of an existing paddock fence was upgraded and used in the exclosure.

On 12 March, Rob Parr released approximately 6,000 *Algarobius prosopis* beetles sent by Ian Lacey, Agriculture WA, Kununurra. As their release had been delayed by bad weather and flooding, many of the beetles were dead.

We made no further releases on 10 April. Pods were plentiful in litter on the ground especially under mesquite thickets. Eggs and holes as described from the Du Bourlay site were found. It is too soon since the March release for them to be caused by *A. prosopis*. Samples of pods with eggs and holes were collected for laboratory examination.

#3. Woolawandawoolana. This site is located at S 21° 08' 01.5", E 116° 02' 03.3" about 100m west of a north-south fence with a gate that leads to Woolawandawoolana Well on the track to Pilling Well.

On 10 April, we released approximately 1877 *A. prosopis* beetles from AFRS (1260 beetles collected on 27 March and 617 on 7 April). There were few dead beetles in the containers. The box containing "Mardie" pods was wedged in the fork of a tree. These pods will have had eggs laid during transit. Beetles should emerge from these pods in 4 to 6 weeks. There were plentiful pods in litter under the trees at the site. Some of these pods had bruchid eggs and emergence holes as observes at other sites. No pod samples were collected.

#2. Jilan Jilan. This site is located at S 21° 09' 42.7", E 116° 04' 28.2" near Jilan Jilan Well. Two adjacent fenced exclosures remain here from a goat grazing trial conducted 10 years ago. The fences were repaired for the release site exclosure.

On 10 April, approximately 5,160 *A. bottimeri* beetles from AFRS (3,660 beetles collected on 27 March and 1500 beetles collected on 7 April) were released inside the westernmost of the two exclosures. There were few dead beetles in the containers. The box containing "Mardie" pods was wedged in the fork of a tree. These pods will have had eggs laid during transit. Beetles should emerge from these pods in 4 to 6 weeks. There were plentiful pods in litter under the trees at the site. Some of these pods had bruchid eggs and emergence holes as observed at other sites. No pod samples were collected.

On Mardie Station there has been a considerable increase in the extent and density of mesquite since my last visit in December 1995. Property tracks have become overgrown in places and detours had to be made to gain access to some sites.

11 April
Dr Dodd and I had further discussions with Dennis Rafferty before going to the airport. Our aircraft was grounded because of a fuel leak. We waited over four hours before we left for Perth on the next flight.

12 April
I returned to Brisbane.

Graham Donnelly
ENTOMOLOGIST

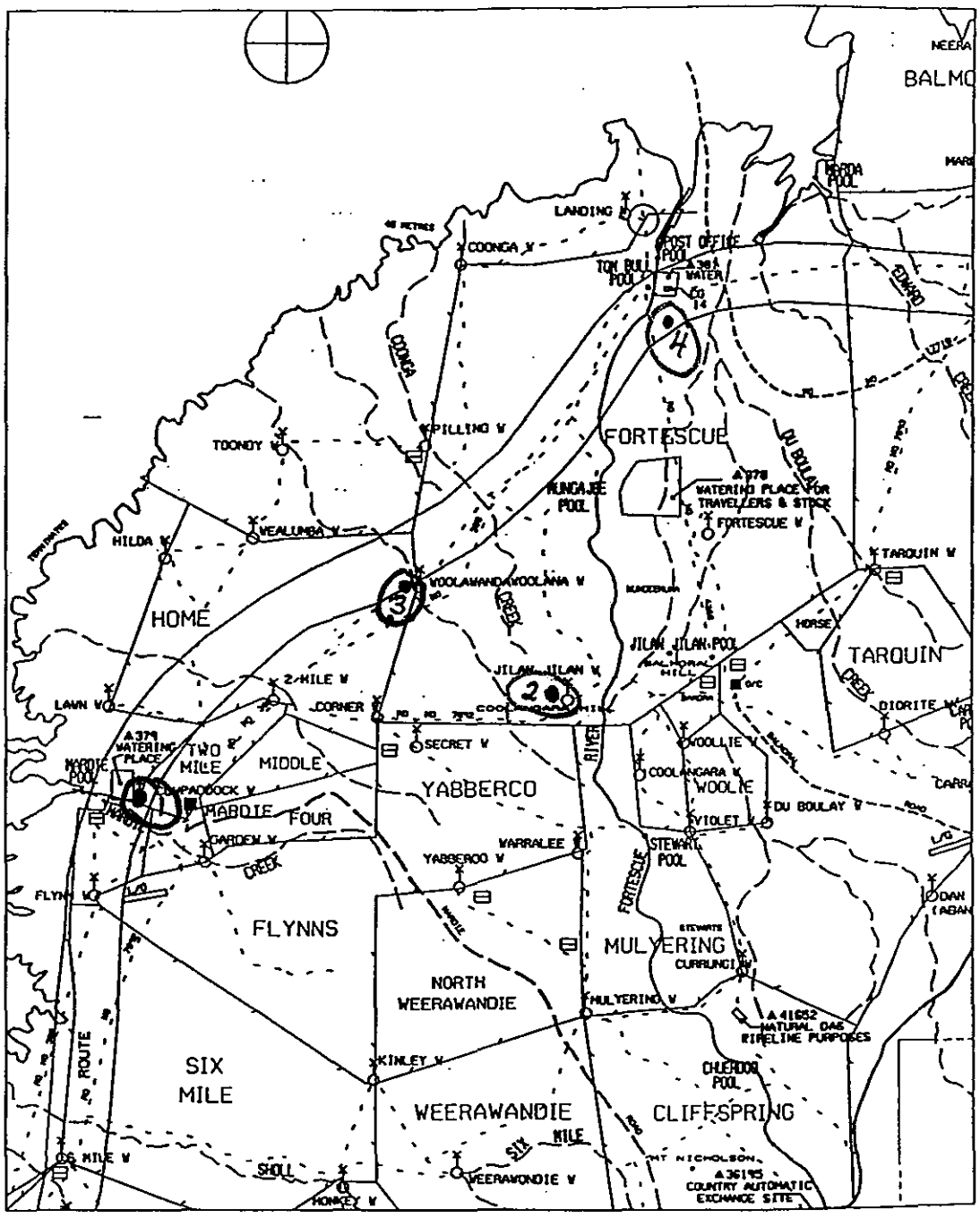

FIG 1. MARDIE STATION VIA KARRATHA WA
MESQUITE SEED BEETLE RELEASE SITES

Algarobius bottimeri

Algarobius prosopis

DAW. C 93

COST/BENEFIT OF PROJECT PROPOSALS

APPENDIX 10

Provide the following information to enable a cost/benefit analysis to be undertaken. Refer to "INFORMATION REQUIRED FOR COST/BENEFIT ASSESSMENT OF PROJECT PROPOSALS". Estimates of costs and benefits should be in 1993/94 dollars (in units of $1,000).

YEAR	RESEARCH COSTS	DEVELOPMENT COSTS	COMMERCIALISATION COSTS	MAXIMUM BENEFITS	ADOPTION LEVEL %	NET REALISED BENEFITS	SUCCESS (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1993/1994	71	0					
1994/1995	61	0					
1995/1996	86	15	0	10	5	0.5	90
1996/1997				100	10	10	↓
1997/1998				200	15	30	
1998/1999				300	20	60	
1999/2000				400	30	120	
2000/2001				500	40	200	
2001/2002				600	50	300	
2002/2003				700	75	525	
2003/2004				800	100	800	
2004/2005				900	↓	900	
2005/2006				1000		1000	
2006/2007				↓		↓	
2007/2008							
2008/2009							
2009/2010							
2010/2011							
2011/2012							
2012/2013							
2013/2014				↓	↓	↓	↓

* A separate sheet should be provided if more rows are required.

PQDL. A26

COST/BENEFIT OF RESEARCH PROPOSALS

Provide the following information to enable a cost/benefit analysis to be undertaken. Refer to "INFORMATION REQUIRED FOR COST/BENEFIT ASSESSMENT OF PROJECT PROPOSALS". Estimates of costs and benefits should be in 1996/97 dollars (in units of $1,000).

YEAR	RESEARCH COSTS	DEVELOPMENT COSTS	COMMERCIALISA-TION COSTS	MAXIMUM BENEFITS	ADOPTION LEVEL %	NET REALISED BENEFITS	SUCCESS (%)
	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1996/1997	164	0	0	150	9.5	14.3	50
1997/1998	147	0	0	300	19.0	57.0	
1998/1999	162	0	0	450	28.5	128.3	
1999/2000		0		600	38.0	228.0	
2000/2001				750	47.5	356.3	
2001/2002				900	57.0	513.0	
2002/2003				1050	66.5	698.3	
2003/2004				1200	76.0	912.0	
2004/2005				1350	85.5	1154.3	
2005/2006				1500	95.0	1425.0	
2006/2007							
2007/2008							
2008/2009							
2009/2010							
2010/2011							
2011/2012							
2012/2013							
2013/2014							
2014/2015							
2015/2016							
2016/2017							

* A separate sheet should be provided if more rows are required.

APPENDIX 11

Radio Interview
@ Radio NW.
(Tim ---) 10/4/94

NEWSFAX

AGRICULTURE PROTECTION BOARD OF WA
Baron-Hay Court, South Perth WA 6151

From: Frank Smith, Agriculture Protection Adviser
Tel: (09) 368 3730 Fax 368 2958 a/h 364 2072
Date: May 6, 1994

Pilbara Mesquite to Feed American Beetles

KARRATHA :– Biological control agents for mesquite, a spiny invasive shrub from North America, may soon be released on Mardie station, near Karratha. This is the result of a research project run jointly by the Agriculture Protection Board and the Queensland Department of Lands.

Entomologist, Graham Donnelly has two species of recently-arrived seed-eating insects in his laboratory at the Alan Fletcher Research Station near Brisbane.

He has begun to test the imported insects in quarantine to make quite sure they don't attack native Australian plants. Previous testing in South Africa showed they did not attack cultivated and South African native plants.

Mr Donnelly is working on a Meat Research Council-funded biological control project with Agriculture Protection Board weed scientist Jonathan Dodd

The insects, which originated in Texas and New Mexico are seed-eating beetles called *Algarobius bottimeri* and *Algarobius prosopis*.

"We imported the insects from South Africa," he said. "They are being used on mesquite infestations there, one of them with considerable success.

"But both insects could become established and effective in Australia.

"They destroy the seeds in the pod, effectively preventing the spread of mesquite."

Mr Donnelly and Dr Dodd recently inspected the mesquite infestation on Mardie station to find the fate of mesquite pods and to collect the pods needed for testing the captive insect colony in Brisbane.

"Mesquite pods don't last long after they fall from the tree. They are full of sugar and highly nutritious. Native animals and livestock eat them very quickly.

"As a result we may have to exclude stock from a patch of mesquite while the insects get themselves established."

Once a nucleus of insects is established in WA, APB staff will spread the insects to other infestations.

"Other stations with mesquite may have different species of mesquite or hybrids between different forms. We shall need to check if the same biological control agents attack all the pest species," Mr Donnelly said.

All members of the genus *Prosopis* are declared plants in WA, but not all of them are true mesquite.

Spineless varieties of mesquite were planted around homesteads during the 1920s as shade and fodder trees. However, seeds from these plantings produced trees with long, sharp thorns.

Mesquite forms dense thickets around watering points and along water courses, competes with native rangeland plants and prevents stock from grazing or getting to water.

Dense stands of mesquite make mustering nearly impossible.

Large areas of some coastal stations near Karratha have become unusable because of mesquite invasions. Smaller infestation have spread to a large number of other stations between Carnarvon and Broome.

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Graham Donnelly (07) 379 6815 (fax)
Photographs: Robyn Knox (09) 359 9343

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Entomologist Graham Donnelly inspects a mesquite plant similar to the ones which beetles imported from South Africa will soon be attacking.

Beetles set to tackle mesquite

TWO species of beetles imported from South Africa look set to eat their way through infestations of a spiny shrub which has invaded big areas of land near the coast in the Pilbara and Gascoyne.

The battle-lines between seed-eating beetles, Algarobius bottimeri and Algarobius prosopis, and the North American mesquite plant are being drawn by WA's Agriculture Protection Board and Queensland's Department of Lands.

The QDOL has been testing the insects at a research laboratory near Brisbane to make sure they do not attack native plants.

Entomologist Graham Donnelly, who is working on the Meat Research Council-funded biological project with APB weed scientist Jonathan Dodd, believes they will beat the mesquite problem.

"We imported the insects from South Africa. They are being used on mesquite infestations there, one of them with considerable success," Mr Donnelly said.

"But both insects could become established and effective in Australia.

"They destroy the seeds in the pod, effectively preventing the spread of mesquite."

The APB will let the first lot of beetles loose on Mardie station near Karratha before moving them into other areas affected by the plant.

Dr Dodd recently inspected the infestation on the station and collected pods needed for beetle tests in Queensland.

"Pods don't last long after they fall from the tree. They are full of sugar and highly nutritious. Native animals and livestock eat them very quickly," he said.

"As a result we may have to exclude stock from a patch of mesquite while the insects get themselves established."

He said other stations may have different species of mesquite or hybrids between different forms.

"We shall need to check if the same biological control agents attack all the pest species," Dr Dodd said.

All members of the genus Prosopis were declared plants in WA but not all of them were true mesquite.

Spineless varieties of mesquite were planted near homesteads during the 1920s as shade and fodder trees but seeds from these produced trees with long, sharp thorns.

Mesquite formed dense thickets around watering points and water courses, competing with native rangeland plants and preventing stock from getting to water and grazing.

In some places, outbreaks had also made mustering very difficult.

APPENDIX 14

Beetles set to give mesquite a beating

The Minister for Natural Resources, Mr Howard Hobbs today announced the impending release of two beetles which will help stop the spread of mesquite in Australia.

"This release is of great significance to Australia as it is the first release of a biocontrol agent on to mesquite, the declared woody weed which has the potential to spread across much of northern Australia.

"Mesquite is already a major problem in parts of western, central and north-western Queensland and in the Pilbara of Western Australia. Small infestations also occur in the Northern Territory, western New South Wales and northern South Australia.

"However, the area currently infested is relatively small when compared with its potential distribution".

Introduced to Queensland in the early 1900's from South America to be used as ornamental and shade trees and to colonise unstable arid soils, mesquite is a thorny tree with a tendency to form dense thickets.

"Over the last 120 -150 years mesquite has spread to cover 28 million hectares in the United States and direct losses to graziers attributable to mesquite are between $200 - $500 million annually, a situation we wish to avoid here in Australia.

"The weed out-competes natural vegetation, interferes with mustering, injures stock and causes damage to property vehicles.

"Its massive production of long lived seeds packaged in palatable pods attractive to stock, feral animals and wildlife means that it is easily spread.

This is where the beetles come into their own

The grubs of the two beetles, *Algarobius bottimeri* and *Algarobius prosopis*, live inside mesquite seeds and kill them.

"When released the beetles are expected to contribute to mesquite control by greatly reducing mesquite seed production thus reducing the potential for spread of the weed.

In South Africa, where these beetles have been introduced for mesquite biocontrol, the beetles have destroyed up to 90% of mesquite seed crops.

"The release of the biocontrol agents will complement the DNR Strategic Weed Eradication and Education (SWEEP) program which is currently undertaking major control work on this weed, aiming at the eventual eradication of mesquite from Queensland.

"The multi-pronged attack on mesquite here in Queensland will have a significant impact on the declared woody weed, helping to control this long term problem.

The research leading to the introduction of these beetles is a joint project of the Queensland Department of Natural Resources and Agriculture Western Australia, supported by the Meat Research Corporation.

The beetles will be released in Queensland by the Department of Natural Resources and in Western Australia by Agriculture WA. Mass rearing in Queensland will occur at the Alan Fletcher Research Station.

Ends....

For further information contact: Mr Ian Dick, Media adviser on 38963694 or Ms Joanne Rayner, Project Officer on 07 3406 2864 or 014 986 170.

(Photos of beetle, mesquite, and SWEEP team controlling mesquite are available by leaving a message at 07 34062864)

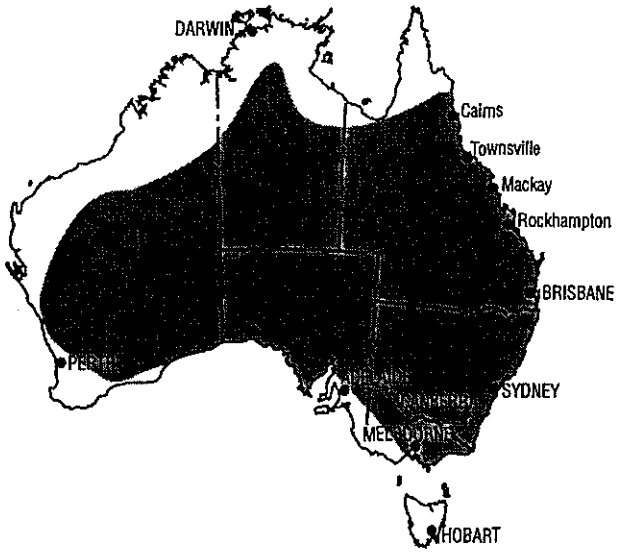

Fig 1. Potential distribution of Mesquite extrapolated from current known distribution and climatic data.