THE PREVELENCE OF SEED DAMAGE BY THE INTRODUCED BRUCHID, *PENTHOBRUCHUS GERMAINI* (COLEOPTERA: BRUCHIDAE), A BIOLOGICAL CONTROL FOR PARKINSONIA, (*PARKINSONIA ACULEATA*), IN FAR NORTH AND CENTRAL QUEENSLAND

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Abstract *Parkinsonia aculeata* L is a spiny, leguminous tree, native to the Americas, that has become widely established as a weed in northern Australia. A biological control program was initiated in the 1980's and resulted in the introduction of three insect species. Of these insects, the seed bruchid, *Penthobruchus germaini* (Pic), has established most readily and reached high population densities at many sites. Field releases of *P. germaini* commenced in March 1995. In a monitoring program, that commenced in early 1997 and continued over the following two summer seasons, insect establishment was confirmed at all of the twenty three sites visited in two regional areas. The present study has revealed no evidence of field establishment of another seed bruchid, *Mimosestes ulkei*, released in the early 1990's.

INTRODUCTION

Parkinsonia aculeata (L) (Caesalpinaceae) was introduced into Australia as a shade and ornamental tree in the late 19th century and has become a major weed in Queensland, the Northern Territory and Western Australia (Parsons and Cuthbertson, 1992). It has spread along watercourses and over floodplains, forming dense, thorny thickets. It reduces pasture production, takes over native grasslands and restricts mustering and cattle access to water. In Queensland, parkinsonia was declared in river catchment systems, under the Rural Lands Protection Act 1995, after its potential to infest the major river floodplains was recognised (Anon. 1998).

Mature parkinsonia trees produce large numbers of pods containing small, hardcoated seeds. The pods, which float, are spread by floodwaters. Birds and animals that eat the seeds and void them in new areas also aid the spread (Parsons and Cuthbertson, 1992). In north Queensland, flowering has been observed at various times throughout the year although most seed is set following spring flowering in September.

Mature pods are available from late October/November onwards. In central Queensland flowering and seeding often occurs later in the year, with mature pods available from early January. Pods are retained on some trees in both regions into the following winter. Many graziers find the cost of control, including follow up treatments, greater than the value of the land.

Investigations into potential biological controls began in the 1980's with a project funded by Queensland, Western Australia and the Northern Territory. Work in the United States and Argentina resulted in the introduction of three insect species into Australia (Donnelly, 1995). The sucking bug, *Rhinacloa callicrates* Herring (Hemiptera: Miridae), and the seed beetle, *Mimosestes ulkei* (Horn) (Coleoptera: Bruchidae), have established at some sites, but are not expected to have an impact on parkinsonia (Donnelly and Lockett, 1998)

In contrast, the seed beetle, *Penthobruchus germaini* (Coleoptera: Bruchidae) has established well in the field and is expected to substantially reduce the amount of viable seed produced each season. Between March 1995 and December 1998 approximately 240,000 insects were released at over 125 sites in Queensland, covering many of the major known areas of parkinsonia infestation. The insect established at a number of sites within the first year of release and spread to new areas and to isolated trees within two years.

MATERIALS AND METHODS

Initial field sampling to confirm the establishment of *P. germaini* and to estimate the percentage seed attacked was conducted in early 1997. Five sites in northwest Queensland between Cloncurry and Burketown and six sites in central Queensland near Clermont and

Emerald were inspected and varying numbers of pods collected depending on their availability. Seed sample sizes ranged from 65 to 2478 and 208 to 267 in each area respectively.

In November 1997, six permanent field monitoring sites were established in north-west Queensland, between Cloncurry and Burketown while, in January 1998, five sites were established in central Queensland near Clermont and Emerald.

Site monitoring times were chosen to coincide with an availability of mature pods. Pod set typically occurred earlier in the season in the northwest than in central Queensland. It was also necessary to sample the northwestern areas at the beginning of the season before monsoonal rains made access to many areas impossible.

At all but one site, 20 podding trees were tagged and collections of >50 pods per tree were made. At a single site north of Cloncurry it was only possible to collect from 10 trees in November 1997. Twenty trees were sampled in the following year.

Pod samples were returned to the Tropical Weeds Research Centre and kept for approximately four weeks to allow for the emergence and release of developing insects. Paper towels, sprayed with 1% kelthane to protect against pyemotid mites were placed, as required, in boxes (Johnson and Slobodchikoff, 1979). At the end of the four-week period all pods were frozen. Seeds were then examined for insect attack. If no emergence hole was present the seed was dissected. Records were kept of the number of seeds with bruchid emergence holes, the number of intact seeds and the number showing internal or other damage, typically caused by other insects or in some instances by unemerged *P. germaini.*

It was planned to revisit the permanent sites at the same times in the following season. Sampling in northwest Queensland was repeated in November 1998 but due to the early arrival of the summer rains, it was only possible to revisit four of the original six sites. One new site was added. In central Queensland it was not possible to revisit the sites until March 1999 due to wet weather. Four of the original five sites were revisited. The fifth had been poisoned. A new site, close to the original, was added.

Where it was not possible to find tagged trees, samples were collected from other podding trees within the same area to make a total of twenty samples per site. A summary of the number of sites, and the total number of seeds sampled in each regional area in each sampling season is given below (Table 1).

Table 1. The number of sites sampled, (month sampled) and the number of seeds collected in central Queensland (CQ) and in northwest Queensland (NWQ).

Region	96/97	97/98	98/99
CQ	6 sites 4900 seeds (March)	5 sites 12248 seeds (Jan)	5 sites 15653 seeds (March)
NWQ	5 sites 1255 seeds (April)	6 sites 12964 seeds (Nov)	5 sites 10213 seeds (Nov)

In order to examine the trend in each regional area the results for percentage seed attack at all sites were combined and the averages for each of the three sampling seasons compared using One Way ANOVA and Tukey Tests. Results from the four permanent monitoring sites in northwest Queensland and five permanent monitoring sites in central Queensland that were visited in two seasons, 1997/98 and 1998/99, were compared using a Three Way ANOVA.

RESULTS

A total of 23 separate sites were visited over the three summer seasons and establishment of *P. germaini* was confirmed at all of these sites. A total of 23146 pods containing 57233 seeds were collected and examined over the course of the study. Sampling for *P. germaini* has shown the insect to have established readily, spread well in the north west and to have increased in abundance since its first introduction into north west and central Queensland.

Initial field inspections north of Cloncurry in the 1996/97 season showed insect establishment in five areas, four of which were either not release sites or sites where the insect had been released within the previous eight months. The percentage seed attacked by *P. germaini* at these sites ranged from 2.7% to 34% in random seed samples (n=1255 seeds).

At all of the six sites where establishment was first seen in central Queensland, insects had been released within the previous nine months. Percentage seed attack ranged from 2.5% to 46% (n=4900 seeds).

At the monitoring sites in northwest Queensland, percentage seed attacked ranged from 69% to 89% in the 1997/98 season (n=12964 seeds, 6 sites) and from

11.5% to 58% in the 1998/99 summer season (n=10213 seeds, 5 sites).

At the monitoring sites in central Queensland, percentage seed attacked ranged from 9.5% to 77% in the 1997/98 summer season (n=12248 seeds, 5 sites) and from 68% to 85% (n= 15653 seeds, 5 sites) in the 1998/99 summer season.

The overall abundance of *P. germaini* in both regions increased significantly between the 1996/97 and 1998/99 seasons. The results for percentage seed attack at all sites were combined and the averages for three sampling seasons compared using One Way ANOVA and Tukey Tests (Figure 1).

A three way ANOVA of results obtained from sampling at the permanent monitoring sites that were visited over two seasons is given below (Tables 2 and 3). A comparison between plants, sites and years showed no interaction between plants at individual sites, but did show interactions between sites and years caused by natural variations in pod set on trees and time of insect attack.

Table 2. Three Way ANOVA of results of sampling in northwest Queensland in 1997/98 and 1998/99.

Source of Variation	DF	F	P
Site (s)	3	18.606	<0.001
Year (y)	1	405.509	<0.001
Plant (p)	19	0.631	0.863
s × y	3	14.329	<0.001
s × p	57	1.054	.430
y × p	19	0.749	0.75

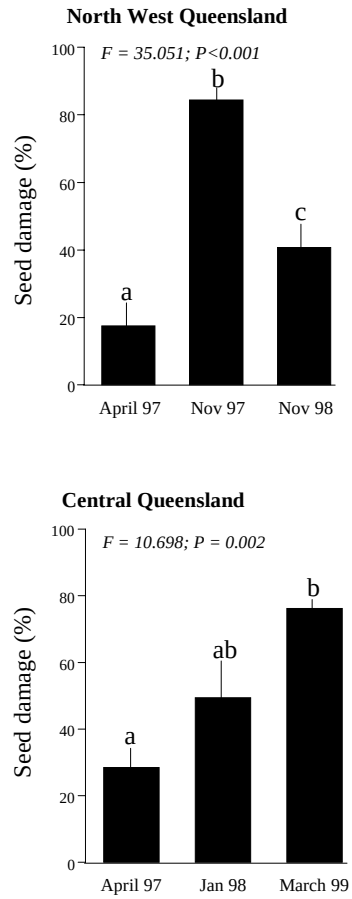

Figure 1. Prevalence of seed damage (Mean ± SEM) by *P. germaini* in northwest Queensland and central Queensland. Bars with the same letter are not significantly different

Table 3. Three Way ANOVA of results of sampling in central Queensland in1997/98 and 1998/99.

Source of Variation	DF	F	P
Site (s)	4	72.796	<0.001
Year (y)	1	248.105	<0.001
Plant (p)	19	1.009	0.462
s × y	4	29.465	<0.001
s × p	76	0.830	0.789
y × p	19	1.050	0.419

Between 0.5% and 18% of seeds were destroyed by a native moth. The November 1997 collections from r northwest Queensland showed the highest overall attack and when combined with attack by *P. germaini*, 87-99.8% of seed was affected.

DISCUSSION

The establishment of *P. germaini* has been confirmed over three summer seasons in northwest and central Queensland. The overall incidence of *P. germaini* in both regions increased significantly between 1996/97 and 1998/99.

The first site inspections were made within nine months of insect release and showed the insect capable of establishing readily. At some sites 80-90% of seed was attacked within 2 years of insect release. Donnelly (1998) found similar rapid establishment and reported up to 99.68% of available seed i.e. not attacked by the native gelechiid, *Mesophleps palpigera*, to be attacked by *P. germaini*.

The speed with which establishment occurred may be due to the fact that parkinsonia can flower and seed opportunistically if conditions are suitable or that pods from summer may be retained on the tree into the following winter thus providing either overwintering or oviposition sites for insects. In the northwest, if pods were available, insects may have continued breeding throughout the winter months to reach the high infestation levels of November 1997. The drop in percentage seed attacked in November 1998 may have been due to natural seasonal variations relating to flowering and pod maturation time. The cycle may not have continued through winter of that year. Sampling was conducted relatively early in the season in order to avoid the monsoon and there was still time for the infestation levels to increase within the next few months. At present we have no knowledge of what effect a major wet season will have on the populations of the insect.

In central Queensland insect establishment also occurred rapidly but no significant increase was seen in the percentage seed attacked until the third year of sampling. This may reflect the lower winter temperatures and the longer time taken for the insect populations to build up if overwintering occurred in old pods on or beneath trees. The difference in the sampling months in 1998 and 1999 may also have lead to the higher percentages being found in March 1999 as the populations could have gone through another generation before collections were made. No definite conclusions can be drawn without further sampling throughout the podding season.

It is hoped that in follow up work it will be possible to sample pods at least twice a year, once at the beginning of the podding season and once near the end, to confirm the trends observed to date.

P. germaini has shown itself capable of establishing readily and destroying a large percentage of seed produced each season. This should lead to a substantial reduction in the amount of viable seed falling each year and in turn slow the rate of spread of Parkinsonia. There is very little published information on the seed dynamics of Parkinsonia including the fate of fallen seed, its survival on and in the soil, its germination rate and the survival of seedlings. Without further ecological data it is impossible to predict what percentage seed attack is needed to reduce seedling establishment.

Three hymenopteran parasites have been recoverd from samples collected in 1997/98 and 1998/99. Their incidence has been very low but it is difficult to determine if they will impact on the populations of *P. germaini* in the future.

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