Parkinsonia aculeata: surveys for natural enemies, native range ecological studies, and prospects for biological control

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Summary Parkinsonia (*Parkinsonia aculeata* L., Caesalpiniaceae) is a Weed of National Significance. Sustainable management of this weed will largely depend on effective biological control. A biocontrol project was reactivated in 2002 and has focused on natural enemy surveys and native range ecology, with links to a project on ecology of the weed in Australia. Natural enemy surveys are being conducted on what is now considered the native range focusing on the evolutionary centre of origin of the plant where the greatest diversity of natural enemies is likely to be found. Several species of potentially important biocontrol agents have been found. A modernisation of the test plant list is proposed. Native range plant ecological studies, in particular on phenology, demography and seed production, are being conducted opportunistically in conjunction with the natural enemy surveys. These studies provide information useful for biological control and other forms of weed management.

Keywords Biocontrol, bioprospecting.

INTRODUCTION

Parkinsonia aculeata, a pastoral and environmental weed across northern Australia, is rated one of Australia's 20 Weeds of National Significance (Thorp and Lynch 2000). Plants form dense thorny thickets, which cause problems for stock management, feral animal control and displace beneficial pasture species and natural vegetation.

Sustainable management of *P. aculeata* will largely depend on effective biocontrol. It was the target of a biocontrol program in the 1980s (Woods 1992), with extensive native-range surveys conducted in the United States and Mexico with a short trip to Costa Rica. As a result, two agents were released (*Rhinocloa callicrates* Herring in 1989 and *Mimosestes ulkei* Horn in 1993), but neither became widely established or abundant. Several other potential agents were identified, but were either difficult to rear and test, or were rare (Woods 1992). In addition, surveys in Argentina and Paraguay were conducted by the USDA South American Biological Control laboratory from 1976 (Cordo and Briano, unpublished data). This resulted in a third insect, the seed-feeding bruchid *Penthobruchus germaini* (Pic.) being introduced from Argentina in 1995 (Briano *et al.* 2002). This agent has become widespread and damaging. However, seed predation rates, and therefore impacts, are limited (van Klinken 2005).

Surveys for natural enemies should focus on the evolutionary centre of origin as this is where the greatest diversity of natural enemies is likely to be found. It is also expected that a greater proportion of the fauna from the new collections in the putative centre of origin will be more host-specific. New information on this centre of origin and native range of this plant raised the need for new surveys. In this paper, I describe these surveys and the preliminary results. In addition, I describe the ecological work that is being undertaken in conjunction with the surveys. I also discuss the need for a modernisation of the test plant list.

NATIVE RANGE AND CENTRE OF ORIGIN

The genus *Parkinsonia* (including *Cercidium*) consists of a strongly supported monophyletic group of about 11 species, four from Africa and seven from the Americas (Haston *et al*. 2005). The African species form a distinct clade. The American species form three clades with five, one and one species: *P. aculeata* forms a close relationship with *Parkinsonia peruviana* C.E.Hughes, Daza & J.Hawkins (from Peru), *Parkinsonia florida* (Benth. ex A.Gray) S.Watson (Sonora desert of southern Mexico and southern USA), *Parkinsonia andicola* Griseb. (limited distribution in Argentina and Bolivia) and *Parkinsonia praecox* (Ruiz & Pav.) J.Hawkins (disjunct distribution in the arid regions of tropical and subtropical North and South America) (Hawkins *et al.* 1999). *Parkinsonia microphylla* Torr. also occupies the Sonora desert of southern Mexico and southern USA and *Parkinsonia texana* (A.Gray) S.Watson occurs in Texas, and northern Mexico. *P. aculeata* readily forms hybrids with *P. praecox* in areas where their distributions overlap, this hybrid has been named *Parkinsonia* × *carterae* Hawkins (Hawkins *et al*. 1999).

The current distribution of *P. aculeata* (Figure 1) overlaps broadly with all of the other species of American *Parkinsonia* so there are no obvious opportunities for searches on these other species in the hope of finding new associations; that is, organisms from other species of *Parkinsonia* that are pre-adapted to use *P. aculeata* if united with it. If this were to be the case, I would expect that these organisms would already have colonised of their own accord and they would be found on searches on *P. aculeata*.

Although *P. aculeata* now occupies a wide range from USA to Argentina, Hughes (1989) opined that the only known native populations occur in Central America (and perhaps Venezuela, Julie Hawkins, pers. comm.). The timing of the spread to its current range is unknown (Hughes *et al*. 2003); it may have occurred millions of years ago or may be associated with post-Columbian human cultivation and disturbance. As the previous surveys focused on apparently weedy populations in North America, a need exists to search for agents in areas not previously surveyed but likely to form part of the native range.

SURVEYS OF NATURAL ENEMIES

Surveys consisted of collecting insects on the plant, rearing those insects to adult stages if necessary, and preserving and sending them to expert taxonomists for identification. The large volume of data on collection site, plant condition, climatic conditions, insect species, etc., was entered into a survey sheet in the field and then into a database for storage and analysis.

Figure 1. Current geographic range of *P. aculeata* in the Americas. The extent to which this is the native range versus an expanded range due to post-Columbian human activities is uncertain.

Insects were collected in several ways to ensure that all 'guilds' were sampled. First the plant is visually inspected (for signs of gall-formers, stemborers, pathogens etc.), then it was beaten with a stick with a drop sheet placed below (perhaps after cutting the branch off the plant) and finally another visual inspection was done and any insects remaining on the plant were removed by hand. A sample of seeds and stems were collected for rearing of insects.

The first trips were made opportunistically from 1999, with systematic surveying starting in 2002 and continued until the present. A total of 101 sites in five countries have been visited in this period. Some of these sites have been visited more than once so a total of 144 collections have been made. The sites are distributed over five countries (Table 1). I used a strategy of intensive regular sampling that covers all seasons and several years at several sites along with occasional or even single visits to other sites. Effort was made to identify different habitats in which *P. aculeata* might occur, and sample each. Future surveys may include new sites in Peru, Ecuador and Brazil.

Over 4000 individual insects have been collected and over 1200 individuals sent for identification. These have been sorted into over 100 morphotypes. This number is only a preliminary estimate of the natural enemy fauna as identifications are far from complete (only about 10% of specimens have been identified) and some will not be herbivores.

The number of natural enemies collected so far in this project in Tropical America is fewer than the 142 phytophagous species collected on this same plant by Woods (1988). However, most insects in Woods' study were polyphagous, particularly wood-boring beetles and seed-feeders, a common pattern being the utilisation of the genera *Prosopis*, *Acacia*, and *Parkinsonia*, all common desert leguminous shrubs. It will be interesting to analyse whether a greater proportion of the fauna from the new collections in the putative centre of origin will be more host specific.

Table 1. The number of sites visited and collections made of natural enemies of *P. aculeata*.

Country	Sites	Collections
Mexico	52	76
Nicaragua	10	22
Costa Rica	4	4
Guatemala	2	3
Venezuela	33	39
Total	101	144

STUDIES OF POTENTIAL AGENTS

Although a large number of species have been collected in our survey, few appear to be common and damaging. However, herbivorous insects in the native range are often uncommon because of poor quality resources or suppression by their own natural enemies. For example *Neurostrota gunniella* Busck, a herbivore of *Mimosa pigra*, is approximately 50 times more common in Australia than in its native Mexico (Heard and Edwards unpublished data).

The tortricid (Cochylinae) moth, *Rudenia leguminana* Busck or near, is one of the most common and damaging herbivores that has been found. Each larva harbours in a hole that it bores in the tip, thereby killing the tip. This species appears to be wide-ranging geographically and with a wide host range that includes *Acacia* species. However, molecular sequencing of the *MTCO2* gene indicates strong genetic differentiation of the populations from different provenances. Furthermore preliminary host testing of a provenance from Mexico indicates specificity to *P. aculeata*. Hence there is a possibility of the existence of races or cryptic species with limited host ranges. Rearing is not difficult and the feeding damage to leaves and tip death due to boring are impressive.

The majority of the most impressive biocontrol agents are leaf-feeders, including a geometrid moth and a fungus. An unidentified leaf-feeding geometrid species from Guatemala has been reared at the Mexican Field Station and preliminary observations suggest that it may be specific. A *Septoria* sp., believed to be a new species, has great potential as a biocontrol agent. In addition to leaf lesions, this fungus can also cause cankering on the rachides and branches leading to significant damage and die-back (H. Evans pers. comm.).

Other agents recognised as having potential in earlier surveys deserve re-assessment. In particular, the Tortricidae (Tortricinae) *Ofatulena luminosa* Heinrich that attacks tips and green seeds was discounted as it is difficult to rear and test for host specificity (Woods 1988) but new techniques may be applied to assess this insect. Similarly the bruchid *Mimosestes amicus* Horn deserves a reappraisal. The host range of this species appears to be too wide, but research on the occurrence of races or cryptic species with limited host ranges may be useful.

Other possible agents from Argentina and Paraguay were identified during the early surveys, among them a geometidae moth (Briano *et al*. 2002) which may be *Eureupithecia cisplatensis* Prout, or *Euacidalia* sp. (J. Briano pers. comm.). These surveys were not published so a review of the collection still held at the USDA South American Biological Control laboratory may prove fruitful.

The list of potential agents is likely to be short; hence it is crucial that no agents are missed. To ensure this, surveys will be continued at as many sites as possible and effort in the area of taxonomic identification of collected species will be expended. Potential agents may be imported into Australian quarantine for evaluation as early as 2007.

TEST PLANT LIST

Parkinsonia aculeata is the only species of Caesalpiniaceae targeted for biocontrol worldwide (Julien and Griffith 1998). The test plant list used for previous agents (Donnelly 2000) is now outdated for two reasons, first, it includes large numbers of species that are not phylogenetically related; and second, recent systematic revisions of the Caesalpiniaceae reveal new relationships. The list used for the first agent, *Rhinocloa callicatres* Herring, contained 31 species of distantly related crop species. Modern test lists are based on phylogenetically related species which are more useful in determining the host range of a phytophagous organism than distantly related crop species (Briese 2005). Recent systematic revisions of the legumes show that the Caesalpiniaceae is paraphyletic with respect to the other legume families (Bruneau *et al.* 2001). A new test list is being compiled to account for these recent changes.

ECOLOGICAL STUDIES ON THE PLANT

Studies on the phenology, demography and seed production are being conducted opportunistically in conjunction with the natural enemy surveys. These studies provide information useful for biocontrol and other forms of weed management. For example, a comparison of seed production in native and introduced ranges allows prediction of the probability that biocontrol will be effective. Measurements of phenology, seed production and tree growth rates are currently being conducted in Australia and equivalent studies in the native range will assist in evaluation of the impact of future biocontrol agents and will provide information to assist agent selection.

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