A NEW INITIATIVE IN THE BIOLOGICAL CONTROL OF PARTHENIUM

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Summary Parthenium is an extremely prolific weed and causes severe economic loss, health problems and habitat destruction in Queensland. Biological control of the weed is the only cost-effective, environmentally safe and ecologically viable method available. Eight species of exotic insects have been introduced into Australia for the biological control of parthenium weed, of which at least six species are known to be established. The stem-galling moth *Epiblema strenuana*, the stem-boring weevil *Listronotus setosipennis*, and the leaf-mining moth *Bucculatrix parthenica* are the species that are successfully established in most of the parthenium infested areas in Queensland, while the leaf-feeding beetle *Zygogramma bicolorata* and the seed-feeding weevil, *Smicronyx lutulentus* appear to be established only in the central Queensland region.

The new initiative program on the biological control of parthenium is currently mapping the distribution of various biocontrol agents in Queensland, and assessing the role of already established biocontrol agents in controlling the weed populations. The stem-boring weevil *Conotrachelus* sp. and the stem-boring moth *Platphalonidia mystica* both from Argentina are being released in the central Queensland region. In addition, two new root-feeders, *Carmenta ithecae* and *Thecesternus hirsutus*, which are being imported from Mexico will be host-tested. The newly formed Parthenium Action Group is involved in the distribution and field evaluation of already established biocontrol agents in the central and northern Queensland regions.

INTRODUCTION

Parthenium (*Parthenium hysterophorus* L.) is an extremely prolific weed and is known to infest around 170 000 km^2 of Queensland prime grazing country (Chippendale and Panetta 1994). The economic loss to the pasture industry is estimated to be around $A16.5 million per year (Chippendale and Panetta 1994). Parthenium is also a serious health problem, causing hayfever, skin problems and asthma in at least 20% of the exposed population (McFadyen 1995). Other problems due to parthenium weed include contamination of grain, pasture and forage seed produce, resulting in the restriction on their sale and movement, along with total habitat change in native grasslands, open woodlands and along river and flood plains (Chippendale and Panetta 1994).

Biocontrol of the weed is the most cost-effective, environmentally safe and ecologically viable method. Among the eight species of exotic insects introduced as biocontrol agents into Australia, at least six species are known to be established. However, no quantitative information is available on the impact of these insects on parthenium populations. Hence a new Strategic Weed Eradication and Education Program (SWEEP) on parthenium was initiated by the Queensland government with the following objectives to:

1. evaluate the effectiveness of the already established biocontrol agents,
2. distribute the established biocontrol agents into new areas, and
3. introduce new biocontrol agents.

MATERIALS AND METHODS

A distribution map of parthenium and its biocontrol agents was made on the basis of regular field visits as well as from the feedback provided by the regional land officers and members of the Parthenium Action Group.

The impact of infestation by the stem-boring weevil *Listronotus setosipennis* (Hustache) on 4-week-old potted parthenium was evaluated in the glasshouse, with four treatments (T_1 = control, T_2 = 1 weevil per plant, T_3 = 4 weevils per plant and T_4 = 8 weevils per plant), each replicated twice with three plants per treatment. The impact of various levels of infestation by *L. setosipennis* on the dry stem weight and seed production was estimated at 12 weeks after the introduction of the weevils.

The impact of the leaf-feeding beetle *Zygogramma bicolorata* Pallister on parthenium was assessed by comparing the weed density, plant height and total flowers per plant between areas with and without *Z. bicolorata*, within the same property, in two properties in Rolleston region.

RESULTS

Distribution of biocontrol agents Among the six species of insects known to be established as biocontrol agents of parthenium in Australia, the stem-galling moth *Epiblema strenuana* Walk., introduced in 1982, is the most widespread and occurs in all the parthenium infested regions. The stem-boring weevil *L. setosipennis,* also introduced in 1982, has established well in the north and central Queensland regions but with low and sporadic incidence levels. In the Charters Towers region, incidence of *L. setosipennis* infestation (per cent of plants with larvae) during January–March 1996, was fairly low (7.69–13.4%, N=186), when compared with *E. strenuana* (73.7%, N=156) infestation. In central Queensland the incidence of *L. setosipennis* infestation during February 1996, ranged from 0.5 to 60.0% (N=133). The leaf-feeding beetle *Z. bicolorata*, introduced in 1980, reappeared only in 1990, with subsequent periodic outbreaks in the Rolleston–Springsure region of central Queensland (Figure 1). The distribution of *Z. bicolorata* is limited to an area of around 1000 km^2 in central Queensland, with black cracking soil and reliable winter rainfall. More recently, the seed-feeding weevil *Smicronyx lutulentus* Dietz, introduced in 1981, has been found to have established in central Queensland (Figure 1). The populations of widely distributed leaf-feeding *Buccalatrix parthenica* Bradley and localized sap-feeding delphacid *Stobaera concinna* (Stal) are very low with no obvious impact on parthenium.

Impact of biocontrol agents Infestation by *E. strenuana*, especially in the rosette stage of parthenium is believed to reduce plant vigour and seed production. However, in the field, mature parthenium plants with severe *E. strenuana* infestation (up to 20–30 larvae per plant) appear lush and produce flowers. The actual impact of *E. strenuana* on parthenium weed population under field conditions is yet to be assessed.

Infestation by the stem-boring weevil *L. setosipennis* significantly reduced dry stem weight by 21.9% (F=571.1, P=<0.001) and total seed production by 75.1% (F=61.7, P=<0.001) under glasshouse conditions. The impact was significant in plants exposed to higher numbers of weevils (4 and 8 weevils per plant), while there was no significant difference between the control plants (no weevils) and plants exposed to one weevil per plant (Figure 2). However, no information is available on the impact of *L. setosipennis* weevil on parthenium under field conditions.

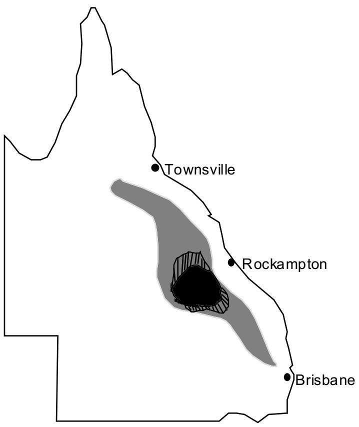

Figure 1. Distribution of parthenium and two of its biocontrol agents in Queensland. ▢ Parthenium, ■ *Zygogramma bicolorata*, ▨ *Smicronyx lutulentus*.

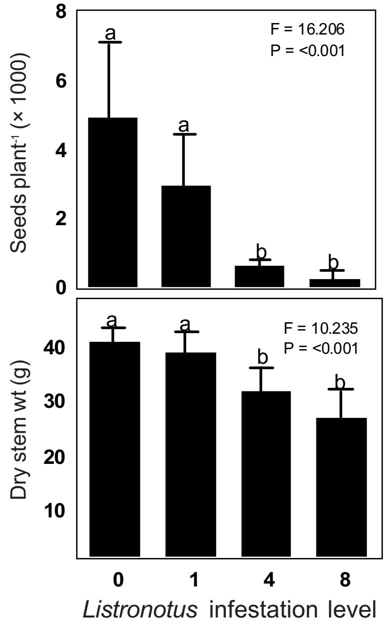

Figure 2. Impact of various levels of infestation (0, 1, 4 and 8 weevils per plant) by *Listronotus setosipennis* on the dry stem weight and seed production of parthenium. One-way ANOVA, Bonferroni's method: means followed by the same letter are not significantly different (P>0.05, df = 20). Vertical lines = SD.

Periodic outbreaks of the leaf-feeding *Z. bicolorata* in parts of central Queensland from January 1993 onwards, significantly reduced the parthenium weed populations, resulting in the re-establishment of buffel grass. In the Rolleston region, within the same property, the average number of parthenium plants per unit area (t=4.186, P=0.001), average plant height (t=2.309, P=0.04) and the average number of flowers per plant (t=3.254, P=0.007) were significantly lower in areas with *Z. bicolorata* outbreaks than in areas without *Z. bicolorata* (Table 1). The impact of the seed-feeding weevil *S. lutulentus,* established in localized areas in central Queensland is yet to be studied.

Simulated cage and open field trials to quantify the impact of the established biocontrol agents *Z. bicolorata, E. strenuana* and *L. setosipennis* at Charters Towers and Rolleston have been initiated. The impact of simulated

Table 1. Impact of defoliation by *Z. bicolorata* on the height, density and seed production potential of parthenium in central Queensland.

Parthenium attribute	*Zygogramma*		t[C]	P
	Present	Absent		
Height[A] (m)	0.692	1.001	22.309	0.040
Density[B] (0.25 m^2)	0.850	4.650	4.186	0.001
Flowers per plant[A]	278.38	4614.0	3.254	0.007

[A] Mean of 20 plants.
[B] Mean of 20 plots of 0.25 m^2 each.
[C] Paired t-test.

and natural herbivory by *Z. bicolorata* on the survival and reproduction of parthenium weed is also being conducted under glasshouse conditions.

Introduction of new biocontrol agents A stem-boring moth *Platphalonidia mystica* Rakowski and Becker, and a stem-galling weevil *Conotrachelus* sp., both from Argentina, have been released since 1992 and 1995 respectively from the Alan Fletcher Research Station. By May 1996, a total of 2370 *Conotrachelus* adult weevils and >12 000 *P. mystica* moths have been released in many sites in the central Queensland region. Attempts are being made to mass-rear *Conotrachelus* sp. at the Tropical Weeds Research Centre for field-release in northern Queensland. Efforts are underway to import a root-boring moth C*armenta ithecae* (Beutenmuller) and a root-feeding weevil *Thecesternus hirsutus* Pierce, both from Mexico, for host-specificity trials under quarantine conditions. If approved, these two new agents would be field released, to complement the existing biocontrol agents.

Due to localized distribution of *Z. bicolorata* in some parts of central Queensland, the Parthenium Action Group, in collaboration with local landcare groups, is coordinating the collection and distribution of *Z. bicolorata* from properties with beetle infestation in the Rolleston region to other properties in Queensland. A total of 400 000 adult beetles have been distributed so far, to over 100 properties in the southern, central highland, northern and western regions of Queensland. Among these, in at least two properties in the central Queensland region the beetle has been found to be established. Similar efforts are being made to distribute parthenium stem-cuttings from *L. setosipennis* infested areas to other areas.

DISCUSSION

Among the six species of biocontrol agents known to be established in Australia, the stem-galling moth *E. strenuana* is the most widespread and has been considered to be the only insect to have any impact on parthenium (McClay 1987, McFadyen 1992). Heavy infestations by *E. strenuana,* especially in the rosette stage, reduce plant height and seed production (McFadyen 1992). However, parthenium continues to remain a major weed and is spreading into other areas. This is partly due to seasonal non-synchronization between parthenium establishment and *E. strenuana* activity. McFadyen (1992) reported that prolonged dry periods in spring and early summer reduce the *E. strenuana* population, while subsequent widespread rain favours the establishment of parthenium without *E. strenuana* infestation.

Since 1990, the leaf-feeding beetle *Z. bicolorata* has emerged as the most promising agent, after *E. strenuana*. Defoliation by *Z. bicolorata* has a visible effect on the parthenium weed population. This is further evident from the limited field collected data on the reduction in plant vigour and seed production in parthenium due to defoliation by *Z. bicolorata*. Jayanth and Visalakshy (1994) also reported up to 98% reduction in seed production due to *Z. bicolorata* infestation in India. However, owing to its localized distribution in the central Queensland region, the biocontrol potential of *Z. bicolorata* is yet to be realised in a wide area. In Australia, since *Z. bicolorata* took more than 10 years to become abundant in parthenium, the current attempts to distribute *Z. bicolorata* into new areas may take several years before its impact could be assessed. Again, the establishment of *Z. bicolorata* depends on factors like soil type, rainfall pattern, and temperature.

Infestation by *L. setosipennis* is known to kill or prevent the further development of parthenium seedlings (Wild *et al*. 1992). However, although widely distributed the stem-boring weevil appears not to have a major impact on parthenium under field conditions, possibly due to low infestation levels. This is further supported by the fact that low levels of infestation by *L. setosipennis* under glasshouse conditions did not have any significant impact on parthenium. However the results from the glasshouse studies have to be considered with caution, as the study was based on the adult weevil population per plant, rather than on larval infestation per plant, which is the most important factor in the impact assessment studies. However, that study did suggest that the impact was significant at high infestation levels (>4 weevils per plant).

Establishment by the seed-feeding weevil *S. lutulentus* in central Queensland was observed only after 14–15 years. Each female S. *lutulentus* oviposit an average of 237 eggs in its life time, with each emerging larva having the potential to destroy one seed (McFadyen and McClay 1981). In view of the enormous number of inflorescences produced per plant (4963 ± 2192), a very high S. *lutulentus* (³19.5 weevils per plant) population is required even to achieve 50% reduction in seed production. With the current apparently low infestation levels of S. *lutulentus* it will be difficult to estimate its impact on parthenium under field conditions.

It may take several years before we know whether the recently introduced agents *P. mystica* and *Conotrachelus* sp. have established in the field. The variations in the time taken for biocontrol agents to become abundant in places where introduced, appear to depend upon the climatic differences between the countries of origin and introduction. For example *Z. bicolorata* took three years in India (Jayanth and Geetha Bali 1994) and 12 years in Australia, to have any significant impact on parthenium. This is possibly due to the prolonged process of selection for adaptation to extreme local climatic conditions. This could have been the reason for the prolonged period required for *S. lutulentus* also to become abundant in Australia. Hence, climate matching between the countries of origin and introduction of biocontrol agents, using CLIMEX appear important for any future biocontrol agent introduction. Other factors like soil type at release site, time of year of release and the incidence of natural enemies at release site may also affect the establishment success of introduced biocontrol agents.

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