Bugs offer sustainable control of *Mimosa invisa* and *Sida* spp. in the Markham Valley, Papua New Guinea

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Summary

A number of exotic weeds are a serious problem to the cattle industry in Papua New Guinea (PNG). They can displace pastures and native plants as new areas are colonized and can also become a nuisance to the local inhabitants. Both *Mimosa invisa* and *Sida* spp. are native to Mexico/Central America, but are now widespread in most areas of PNG, and have caused serious problems in the Markham Valley, especially following the 1997 drought. Control of such broadacre weeds with herbicides is difficult and environmentally risky. A psyllid, *Heteropsylla spinulosa*, was introduced in 1993 to control *M. invisa*, which has now become established and is exerting excellent control. Similarly, a chrysomelid beetle, *Calligrapha pantherina* was introduced in 2000 and again this agent had provided excellent control of *Sida* spp. infestations. Attempts have been made to distribute these agents widely in PNG, and in most cases have proved successful. The application of nitrogen to the plants before the release of biocontrol agents has had an indirect effect on insect numbers. Strategies for dealing with weed outbreaks following severe dry seasons are also discussed.

Keywords: *Calligrapha*, *Heteropsylla*, drought, *Mimosa*, nitrogen, psyllid, *Sida* spp.

Introduction

Exotic weeds cause much stress on agricultural systems as well as the wellbeing of rural people in Papua New Guinea (PNG). In agriculture, losses can be high due to direct crop losses and increased expenditure on control. For small farmers, this may cause complete farm failure. Certain aquatic weeds, such as salvinia and water hyacinth, have had serious impacts on local people along the Sepik River in the past (Room & Thomas 1985, Julien et al. 1999). The terrestrial weeds *Mimosa invisa*, giant sensitive plant (GSP) and *Sida* spp. have also had similar impacts on the livelihood of the rural people, but were most serious on the cattle industry in PNG (Kuniata 1994, 2001).

The control of such widespread weed species requires sustained efforts and a constant supply of limited resources. Biological control offers sustainable control and is also safe to people and the environment. However, as a prerequisite to a successful program, the biology and ecology of both the agent and target weed species need to be studied. In this paper we discuss the classical biological control cases achieved recently for GSP and *Sida* spp. in PNG. Strategies for dealing with weed explosions following droughts, especially in the Ramu–Markham valleys, are also discussed.

Giant sensitive plant, *Mimosa invisa*

Mart. ex Colla (Mimosaceae)

GSP, *M. invisa*, has become a serious weed in many parts of South-East Asia and the Pacific Islands, including PNG (Verdcourt 1979) and Australia (Holm et al. 1977). It is now widespread in coastal and island areas, is spreading into the Highlands of PNG, and has been a major weed of agriculture, pastures, wastelands and roadsides. In some places, the dense cover of GSP affected rural people too. In 1991, up to 40% of grazing land owned by Ramu Sugar Ltd in the Markham Valley was infested with GSP, with most of these areas useless for cattle grazing.

It is difficult to estimate economic losses and the cost of control of GSP for the whole of PNG. Kuniata

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(1994) reported from cattle properties owned by Ramu Sugar Ltd in the Ramu/Markham valleys in Madang/Morobe provinces that up to US$130,000 annually was spent on chemical control and slashing of this weed. On its sugarcane estate, up to three hours downtime per day/harvester was experienced as a result of GSP interference with normal sugarcane harvesting (green cane). Persistent herbicides such as 2,4-D used for GSP control are not only a hazard to people handling them, but also can contaminate the environment and cause pesticide residues in animal products.

The psyllid, Heteropsylla spinulosa Muddiman, Hodkinson and Hollis, is a native of Central America and is probably confined to M. invisa as a host plant (Muddiman et al. 1992). Of about 100 plant species tested by Wilson and Garcia (1992), H. spinulosa developed successfully only on M. invisa, indicating its high specificity to this host. Several attempts were made in 1992/93 to introduce this biocontrol agent from Charters Towers, Queensland. It was in 1993 that a colony was released from post-entry quarantine at Laloki Research Station, Port Moresby (Kuniata & Korowi 2001). Colonies were reared in cages at Ramu Sugar estate, some of which were treated with urea fertilizer. Large numbers of insects and severe damage was observed in fertilized cages compared with the unfertilized ones (Figure 1). These observations highlighted the need for nitrogen application in GSP to assist in the establishment of the psyllid and, therefore, this was recommended for all field releases.

In long-term monitoring sites at Gusap-Ramu Sugar plantation, significant reductions in infestations of GSP have been observed since 1991 (Table 1, Figure 2). Ground cover infested with GSP declined from 100% in 1991 to less than 5% in two years following the release of the psyllid. Similarly, the prolific seed production observed in 1991 had been reduced to less than 20% in 2001. In 1998, the psyllid’s effect on GSP was delayed due to the severe drought of 1997, thus giving a slight increase in the infestations of the weed. However, the psyllids came back very strongly in 1999 and effectively controlled the GSP, reducing it to minor status in pastures in the Markham–Ramu valleys.

Releases of the psyllids have been made in New Ireland, New Britain, East Sepik, Central, Western Highlands and Sandaun provinces in PNG. The psyllids naturally spread into Morobe, Madang and the Eastern Highlands. In all these areas, good control of GSP has been observed. Land previously infested by GSP on properties owned by Ramu Sugar Ltd in the Markham Valley has been reclaimed for cattle production.

“Broom stick”, Sida spp. (Malvaceae)

Species of Sida are common weeds of disturbed areas, infesting crops, pastures and roadsides in many parts of the world, including PNG (Holm et al. 1977). In pastoral areas, they can become serious weeds, especially in areas frequented by cattle, particularly their feeding and drinking sites. Overgrazing of pastures can also result in Sida becoming a dominant weed species. Following the 1997 drought, up to 80,000 ha in the Markham–Ramu valleys in PNG were infested with Sida spp. Monospecific stands of plants up to 1.5 m high were observed. As a result of these infestations, culling of animals was carried out on a number of properties in the Markham Valley including up to 800 animals at Leron ranch owned by Ramu Sugar Ltd.

During a visit to Darwin in 1994, large tracts of Sida acuta Burman f. and S. rhombifolia Linnaeus were observed damaged by a chrysomelid beetle, Calligrapha pantherina Stål. Damage to juvenile and mature Sida was quite severe and provided excellent control of the weed. As a result of this excellent

![Figure 1](image-url). Effect of nitrogen on Heteropsylla spinulosa (a) adults, (b) eggs, (c) nymphs and (d) damage in GSP.
In general, females can lay up to 1800 eggs over a 6-month period, which is about 28–147 eggs/week (Forno et al. 1992). There are four larval stages with a total duration of 7–14 days. The mature larvae burrow into the topsoil to pupate, taking 7–10 days to do so. The adults can live for up to 6 months and for up to 15 days without food. This agent is reported to be highly specific on *Sida acuta* and *S. rhombifolia*.

The 1997 drought exacerbated the Sida problem in Papua New Guinea, especially in the Markham Valley and a program to obtain and release the beetle was funded by the Cattleman’s Association (Ramu Sugar Ltd, Zifasing cattle ranch and Sulikon Farming). A visit to Darwin to collect this biocontrol agent was made in early December 1999. A total of 740 adults were hand collected and brought back to Papua New Guinea, and these underwent post-entry quarantine at Laloki Research Station. The National Agricultural Research Institute provided facilities and personnel for the post-entry quarantine.

The initial releases were made in February 2000 under a 2 m × 2 m × 1.5 m screened cage at Gusap Ranch. The cage was surrounded by about 10 ha of dense *Sida* spp. cover. Within 7 days, the Sida inside the cage was exhausted and, therefore, the cage was lifted to allow the insects to disperse. Monitoring sites were established in sites where releases were made. The effect of the biocontrol agent was monitored by subjective assessment of ground cover where a score of 1 is no Sida and 10 is completely covered. Weed density was assessed using 50 cm × 50 cm quadrats. By April 2000, the agent was already inflicting severe damage on both young and mature Sida in the release areas, and by June 2000 these infestations of Sida were under control and remained very low up to end of 2001 (Figure 3). Young Sida plants were severely defoliated and stems heavily chewed. As a result, plant mortality was high in the release site, especially during the dry season (May to September). Mature Sida plants were completely stripped of their leaves and

Table 1. The effect of *Heteropsylla spinulosa* on *Mimosa invisa* seed production at Ramu, Papua New Guinea; field releases of the psyllid began in February 1993.

<table>
<thead>
<tr>
<th>Season</th>
<th>No. of sites</th>
<th>Ground cover score</th>
<th>No. of clusters/m²</th>
<th>No. of seeds/cluster</th>
<th>Est. no. of seeds/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>40</td>
<td>5.9</td>
<td>300</td>
<td>55</td>
<td>16,630</td>
</tr>
<tr>
<td>1992</td>
<td>40</td>
<td>5.8</td>
<td>242</td>
<td>61</td>
<td>14,860</td>
</tr>
<tr>
<td>1993</td>
<td>75</td>
<td>5.2</td>
<td>126</td>
<td>36</td>
<td>4,580</td>
</tr>
<tr>
<td>1994</td>
<td>44</td>
<td>3.4</td>
<td>57</td>
<td>9</td>
<td>530</td>
</tr>
<tr>
<td>1995</td>
<td>51</td>
<td>1.8</td>
<td>50</td>
<td>8</td>
<td>415</td>
</tr>
<tr>
<td>1996</td>
<td>36</td>
<td>1.6</td>
<td>106</td>
<td>7</td>
<td>439</td>
</tr>
<tr>
<td>1997</td>
<td>43</td>
<td>1.8</td>
<td>31</td>
<td>10</td>
<td>326</td>
</tr>
<tr>
<td>1998</td>
<td>43</td>
<td>3.8</td>
<td>128</td>
<td>26</td>
<td>3,546</td>
</tr>
<tr>
<td>1999</td>
<td>16</td>
<td>1.0</td>
<td>21</td>
<td>6</td>
<td>125</td>
</tr>
<tr>
<td>2000</td>
<td>16</td>
<td>1.0</td>
<td>4</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>2001</td>
<td>12</td>
<td>1.0</td>
<td>6</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>2002</td>
<td>12</td>
<td>1.0</td>
<td>&lt;1</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

* Score: 1 = 0–1%, 2 = 1–5%, 3 = 5–25%, 4 = 25–50%, 5 = 50–75%, 6 = 75–100% ground cover.

Figure 2. Summary of *Mimosa invisa* cover at a long-term monitoring site at Ramu Sugar plantation and Gusap ranch.
of other green tissue from stems. This allowed pasture and other weeds to invade and overtake Sida.

In April 2001, an exclusion trial was established at Gusap ranch to study the effect of *C. pantherina* on semi-mature Sida (up to 50 cm high, but not flowering) and other weed species. Permethrin was applied at 250 g active ingredient/ha at 2-week intervals to control the insects in the sprayed plots while the unsprayed plots were not sprayed. In the sprayed plots, Sida ground cover increased and was 100% for the rest of the trial period, while other weed species cover declined and remained low (Figure 4). There was severe defoliation in the unsprayed plots and cover was less than 1% from December 2001. Ground cover for other weeds and pasture species then increased, reaching 100% by January 2002. Sida densities remained higher and continued to increase in the sprayed compared to unsprayed plots (Figure 5). By the end of December 2001, much of the mature Sida had died following the dry season. Plant densities observed in early 2002 were lower than those seen in 2001, but the trends were similar, with the sprayed having more plants than in the unsprayed plots. These results strongly indicate the potential of *C. pantherina* for controlling Sida infestations in PNG. Severe infestations can be brought under effective control within 12 months.

A field trial was established in 2002 to study the effect of nitrogen application on populations of *C. pantherina*. It was clear from the results that application of nitrogen had an indirect effect on the biocontrol agent, with significantly higher numbers of egg masses, larvae and adults found in the fertilized plots than in the unfertilized treat-
ments (Table 2). Adult numbers increased rapidly in a week after fertilizer application, followed by oviposition and appearance of larvae. The insect numbers in the unfertilized plots declined over the duration of the trial. These results further highlighted the need for fertilized plants to provide the high-quality plants required by the insects. Therefore, fertilizer application has been recommended for all new releases of *C. pantherina*.

**Strategies for dealing with weed explosions**

There is a pronounced dry season from May to September in the Ramu–Leron areas of the Markham Valley. Sometimes the dry period can extend to the end of November, as was the case in the 1987, 1993, and 1997 droughts. Coupled with these dry periods, frequent burning of the grasslands can also affect the establishment of the biocontrol agents. Weed explosions occur following the first rains in September and large areas can be affected. Often the biocontrol populations are too low at this time to provide adequate control of the weeds.

Kuniata (1994) observed that application of nitrogen to GSP indirectly increased the psyllid populations and severe damage was inflicted in the plants sooner than in unfertilized plots (Figure 1). Similar studies done with *Sida* spp. showed a high number of *C. pantherina* insects were found in fertilized plots than in unfertilized plots. Therefore, it is standard practice that some nitrogenous fertilizer is applied to GSP and *Sida* spp. before the inoculation of the biocontrol agents.

The gradual invasion of weeds such as *Sida* spp. in pastures may not pose any problems for the ability of the biocontrol agents to colonize and maintain an equilibrium situation. However, in the Markham Valley, “recreational” burning of large areas of grassland is often done and severe droughts such as the one experienced in 1997 can cause severe weed explosions, especially after the first rains. Large areas can be infested at once, while the biocontrol agents may be slow to provide adequate control of the weeds. This has been observed for *H. spinulosa* in 1997/98, with poor control achieved on GSP (Table 1, Figure 2).

![Figure 5](image)

**Table 2.** Summary of *Calligrapha pantherina* numbers in nitrogen fertilized and unfertilized plots (no./m²).

<table>
<thead>
<tr>
<th>Date (2002)</th>
<th>Nitrogen applied (40 kg/ha)</th>
<th>Unfertilized</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Egg masses</td>
<td>Larvae</td>
</tr>
<tr>
<td>12 Apr&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2</td>
<td>36</td>
</tr>
<tr>
<td>19 Apr</td>
<td>24</td>
<td>59</td>
</tr>
<tr>
<td>2 May</td>
<td>2</td>
<td>151</td>
</tr>
<tr>
<td>17 May</td>
<td>1</td>
<td>33</td>
</tr>
<tr>
<td>23 May</td>
<td>1</td>
<td>40</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>320</td>
</tr>
</tbody>
</table>

<sup>a</sup> Pre-treatment counts.
Plots of *M. invisa* and *Sida* spp. were established on Ramu Sugar plantation to maintain sufficient numbers of the biocontrol agents during the dry season (July to September). Insects from these plots were used to make inoculation releases once the rains returned in September/October. We used a 12-monthly rolling total rainfall as a guide to determine whether the dry season would be severe, so that plots of *Sida* and GSP could be established (Figure 6). If the 12-month rolling total rainfall continues to decline from June, this prompts the establishment of these plots.

Following the successful use of nitrogen fertilizer, it has also been recommended that plots of *Sida* spp. or *M. invisa* are fertilized at 40 kg N/ha before the agents are released in the field, to increase the insect numbers so as to be able to cope with weed explosions.

Large numbers of *C. pantherina* can be obtained by breeding in the laboratory. Adult beetles are confined in cages with fresh leafy shoots of *Sida*. Eggs are removed and fresh plant material is replenished daily. These eggs are allowed to hatch in the laboratory and then released in the field as stage 3–4 larvae. Up to 20,000 eggs per week can be obtained if 800–1000 adults are used. Release of larval stages rather than the adults may assist the insects to keep together, enabling them to more easily find their “mates”. The adults are replaced every month with field-collected insects to maintain a continuous supply of eggs.

**Conclusion**

Exotic weeds have become important constraints in agricultural production in PNG and new species are continuing to appear. The most recent arrivals are Noogoora burr (*Xanthium strumarium* L.) and Siam weed (*Chromoleana odorata*). These are now present in the Markham Valley and will become very important in the near future as infestations spread, especially for siam weed. Although herbicides can be used against these weeds, they are often expensive, pose health risks to people, and could contaminate the environment. The recent successes achieved in the biocontrol of GSP and *Sida* spp. in PNG are further cases of classical biological control. Such successes can be achieved at relatively low costs.

**Acknowledgements**

We thank Ramu Sugar Ltd for financial support. Queensland Department of Primary Industries supplied the psyllids, while the *C. pantherina* was provided by Northern Territory Department of Primary Industries and Fisheries.

**References**


