
The Successful Biological Control of Spinyhead Sida, *Sida Acuta* [Malvaceae], by *Calligrapha pantherina* (Col: Chrysomelidae) in Australia's Northern Territory

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Abstract

Calligrapha pantherina Stål was introduced into Australia from Mexico as a biological control agent for the important pasture weed *Sida acuta* Burman f. (spinyhead sida). *C. pantherina* was released at 80 locations in Australia's Northern Territory between September 1989 and March 1992. It established readily at most sites near the coast, but did not establish further inland until the mid to late 1990's. Herbivory by *C. pantherina* provides complete or substantial control in most situations near the coast. It is still too early to determine its impact further inland.

Introduction

The malvaceous weed *Sida acuta* (sida) Burman f. (Kleinschmidt and Johnson, 1977; Mott, 1980) frequently dominates improved pastures, disturbed areas and roadsides in northern Australia. This small, erect shrub is native to Mexico and Central America but has spread throughout the tropics and subtropics (Holm *et al.*, 1977). Chinese prospectors, who used the tough, fibrous stems to make brooms (Waterhouse and Norris, 1987), may have introduced it into northern Australia last century. Today it is widespread in higher rainfall areas from Brisbane in Queensland to the Ord River region of Western Australia.

A biological control program aimed at weedy *Sida* spp. in northern Australia, involving both the CSIRO Division of Entomology and the Northern Territory Department of Primary Industry and Fisheries, began in 1984 (Wilson and Flanagan, 1990). Preliminary investigations in Mexico suggested that a beetle, *Calligrapha pantherina* (Calligrapha) Stål (Chrysomelidae), had potential as a biological control agent, and its restricted host range was verified by Forno *et al.* (1992). They found that *S. acuta* was the preferred host of *C. pantherina*, although *S. spinosa* L. (spiny sida) and *S. rhombifolia* L. (Paddy's lucerne), both considered as introduced weeds in northern Australia, could also support beetles through successive generations.

C. pantherina was subsequently approved for release in Australia, and liberated on the Finnis River floodplain in the Northern Territory on 29 September 1989 (Forno *et al.*, 1992). This paper reports on the establishment of *C. pantherina* in Australia's Northern Territory and its impact on populations of *S. acuta* over the 10 years since its release.

Materials and Methods

Life cycle of *C. pantherina*

The life cycle of *C. pantherina* is described by Forno *et al.* (1992) and summarized here. Each female lays a batch of about 50 eggs on a mature leaf of the host plant every few days. The incubation period is 5 days. Early instar larvae feed gregariously on leaves, while later instars feed singly and may also eat flowers and fruits. The larval and pupal periods each last about 12 days and there follows a pre-oviposition period of a further 16-24 days. Pupation takes place in soil. Females lay a total of about 1,800 eggs, and adults can survive without feeding for up to 12 weeks. Larval feeding sometimes completely defoliates the host plant.

Laboratory Rearing

C. pantherina were reared in gauze-covered cages measuring 40 x 40 x 90 cm. Each cage contained four potted *S. acuta* plants. Ten pairs of mature *C. pantherina* adults were placed in each cage for 5 days, during which time 5-10 egg batches were laid. When larvae completely defoliated all plants in a cage, new potted plants were added. Pupation occurred in the plant pots and emerging adults were allowed to mature on potted plants in cages for 1-2 weeks and then released into the field.

Release and Establishment

When *C. pantherina* adults were approaching sexual maturity, signaled by a change in colour from dull brown to bright green (Forno *et al.*, 1992), they were released in unsexed batches of at least 100. Each batch was free-released at one point in a dense infestation of *S. acuta*. No attempt was made to cage the beetles to delay dispersal, as observation revealed them to be largely sedentary and reluctant to fly. Wherever possible, release sites were chosen to avoid predation by colonies of *Iridomyrmex* spp. (Hym.: *Formicidae*) and *Oecophylla smaragdina* (F.) (Hym.: *Formicidae*; green tree ant).

Releases from the laboratory culture were made between 29 September 1989 and 31 March 1992. Once initial establishment had been achieved at a number of sites, *C. pantherina* adults and larvae were made available to landholders for release onto their own properties. In addition, many landholders redistributed beetles widely from established populations, however these events went largely unrecorded.

Sites were inspected for *C. pantherina* adults, larvae, egg batches and feeding damage one month after the release of beetles, and at irregular intervals thereafter. A number of remote sites were not inspected at all, or only occasionally, whenever the opportunity arose.

Questionnaires

From 1992 to 1994 and again in 1999, questionnaires were sent to landholders who had released or reported *C. pantherina* on their properties. They were asked to assess, the regularity with which *C. pantherina* populations reappeared following the dry season, months of peak activity, changes in the density of *S. acuta*, and whether their expenditure on weed control had changed since the introduction of the beetles.

Seasonal Abundance and Impact

Three sites near Darwin were selected for detailed study. At each site, an area of dense *S. acuta* infestation measuring 25 m x 25 m was set aside from grazing or other artificial

disturbance. A sample consisting of 100 sweeps with a 50 cm diameter net was taken at each site every 3 weeks between February 1992 and June 1995, and the number of *C. pantherina* adults and larvae were counted. Between 1992 and 1995 and again in 1999 *S. acuta* density was measured each February, the middle of the monsoonal wet season, by which time most plants were mature and beginning to flower. All plants within 20 randomly positioned 1 m² quadrats were counted.

Results

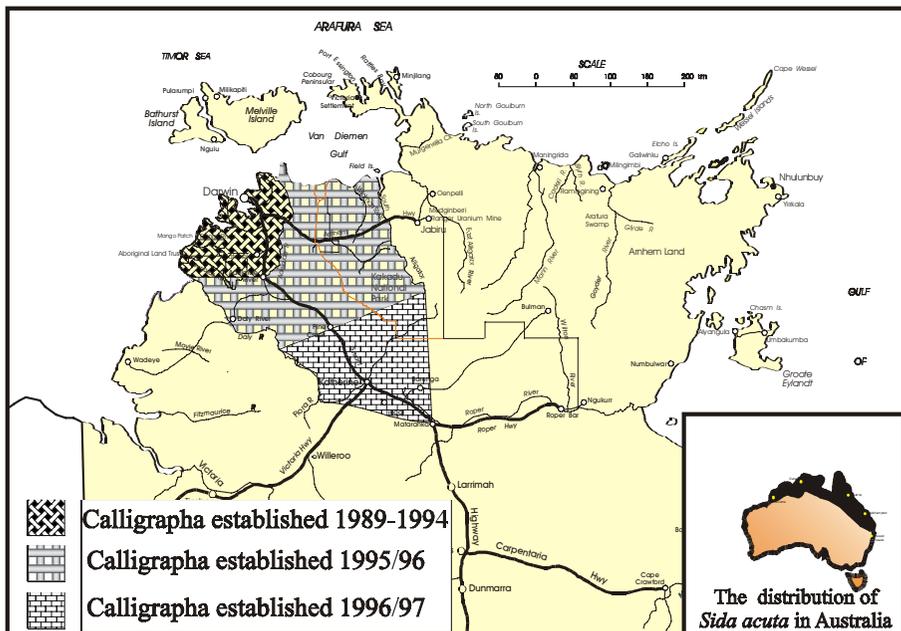
Release and Establishment

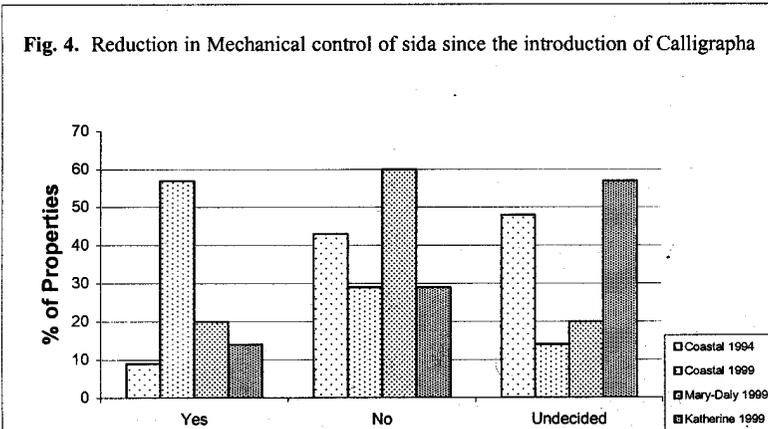
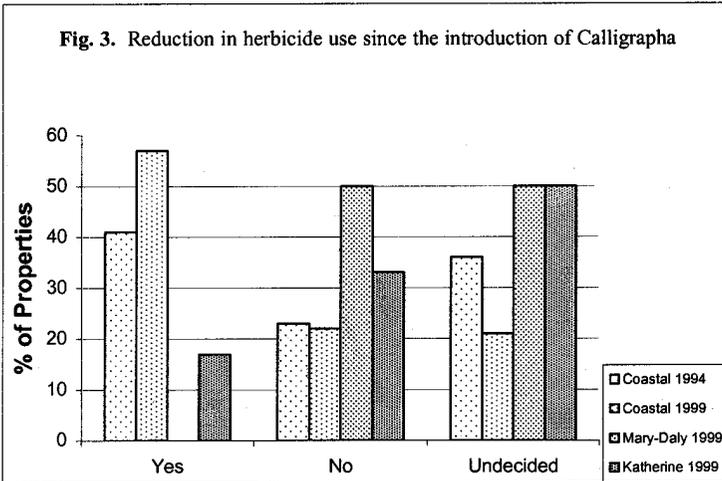
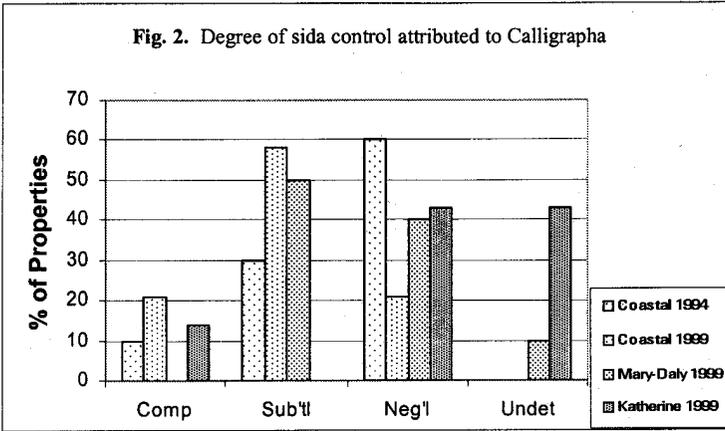
A total of 53,000 *C. pantherina* adults were released into the field in the Northern Territory from laboratory cultures. There were 344 releases at 80 sites. In addition there was much unrecorded redistribution by landholders. Populations built up quickly north of Adelaide River Township and west of the Adelaide River (Fig.1) during the first (1989/1990) wet season, and spread from the points of release as slowly-advancing fronts of defoliation, clearly visible from some distance away (*cf.* Lonsdale *et al.* 1995).

With the onset of the dry season in June 1990, *C. pantherina* disappeared from most sites although small populations persisted where *S. acuta* perennated in moist areas. Populations began to reappear in November 1990 as *S. acuta* germinated with the first rains of the wet season. This trend was repeated in subsequent years, with the number of sites colonized or recolonized increased each year. By the 1998/99 wet season *C. pantherina* colonized most sites on an annual basis.

Establishment of *C. pantherina* west of the Adelaide River and the Douglas-Daly

Fig. 1. The distribution of *Calligrapha pantherina* in the Northern Territory





Region, south of Adelaide River Township (Fig.1) did not occur until the 1995/96 wet season. Recolonization of sites after the dry season has been regular since. Some 15,000 adults and larvae were released at 30 sites in the Katherine region in 1989. However *C. pantherina* was not recorded in this region until the 1996/97 wet season. It has recolonized many sites in 1997/98 and 1998/99 wet seasons.

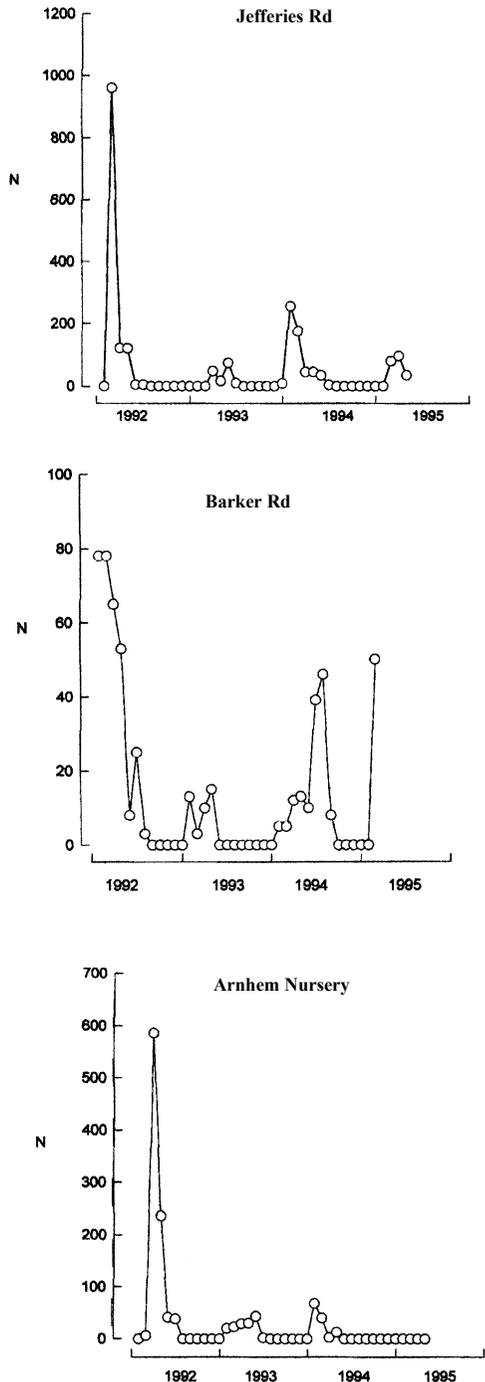
Questionnaires

A total of 64 replies to the 1992-94 and 1999 questionnaires were received from landowners in the coastal and sub coastal regions near Darwin, where *Calligrapha* has been established longest. By 1999 *Calligrapha* was returning annually to 79% of respondents in this region compared with 5% in 1994. Prior to 1994, 40% of respondents attributed complete or substantial control (*cf* Hoffmann, 1995) of sida to *Calligrapha*, by 1999 this had increased to 79% (Fig.2). In addition proportionally more landowners reported a reduction in herbicide and mechanical treatment costs in 1999 than 1994 (Figs.3 and 4).

Savings on herbicide treatment costs of between AUS\$300 and \$3,000 per annum were reported and up to \$1000 on mechanical treatment annually. Other respondents reported up to 100% savings on control costs without specifying amounts. In 1999 several respondents reported reductions in sida infestations, the largest being from 200ha to 20ha.

Many respondents reported the replacement of dense *S. acuta* infestations with native or introduced pastures. Another benefit noted was that *Calligrapha* controlled sida on prop-

Fig. 5 The seasonal abundance of *C. pantherina* at 3 sites in the Northern Territory



erties where it would have otherwise been unmanaged, reducing reinfestation of managed properties. Further benefits were seen to health and the environment from a decreased reliance on chemicals.

Several respondents in both the 1994 and 1999 surveys reported that, although *C. pantherina* was very damaging, completely defoliating all plants within an infestation, its impact occurred too late in the season to prevent seeding. In some situations *S. acuta* was controlled by *C. pantherina* but was replaced by other undesirable weed species.

Seasonal Abundance

From 1992-95, populations of *C. pantherina* peaked between late February and early May, coinciding with the mid to late wet season. Populations then declined virtually disappearing by June before reappearing in November (Fig.5). At all three sites, *Calligrapha* presence in the 1991/92 wet season was associated with a significant decline in the sida density in the following year. At two sites the reduced densities were maintained for the duration of the study. At site 2 where *Calligrapha* numbers were much lower in 1994 and 1995 the sida density rebounded to above 1992 levels. Sampling these sites in 1999 showed that sida levels had decreased even further and that sida had been replaced by the improved pastures Buffalo clover (*Alysincarpus vaginalis*), Verano (*Stylothanthus hamata*), Pangola (*Digitaria eriantha*), as well as native herbs and grasses.

Discussion

The coastal and sub-coastal plains near Darwin were the first areas to be successfully colonized by *Calligrapha* (Fig.1) and it is here that its impact has been greatest. These areas closely match the climate near the centre of the native range of *C. pantherina* (Heard and Gardener 1994). Further inland, in the Douglas-Daly and Katherine Regions colonisation did not occur until the mid to late 1990's. These areas with their greater extremes of temperature, lower humidity and more erratic rainfall are a poorer climate match. As a result successful colonisation of these areas may have required some acclimatisation by *Calligrapha* or several, successive, favourable wet seasons.

S. acuta usually behaves as an annual in northern Australia, although it occasionally perennates on moist sites. Seeds germinate at the start of the wet season in November and December (Mott, 1980) and plants senesce following the cessation of rain in about May or June. Adult beetles must then survive until the first rains of the next wet season trigger germination. Forno *et al.* 1992, have shown that adult beetles can survive in the laboratory without food for three months but the rainless period in northern Australia can last six to seven months.

Perennating sida is found on moist refugia near the coast, especially in irrigated gardens and orchards near Darwin, around farm dams and on the fringes of sub-coastal swamps. It is not surprising, therefore, that *C. pantherina* established in the coastal and sub-coastal regions first. A higher density of release sites and informal network of beetle distribution also contributed.

A field experiment conducted near Darwin (Lonsdale *et al.* 1995), demonstrated that defoliation by *C. pantherina* could reduce annual seed production by an order of magnitude, and reduce weed density in the following year by about one third. They predicted that if the level of herbivory was maintained weed density would continue to fall to some undetermined equilibrium dependent on the searching efficiency of the beetle.

The reduction in weed density following defoliation by *C. pantherina* has been shown

here to be widespread but not universal. The sites that were monitored between 1992 and 1995 showed a decrease in *S. acuta* density of between 58% and 78% in the year following first defoliation by *C. pantherina*, although densities rebounded at site 2 in subsequent years to above the initial density. *S. acuta* can respond to a decrease in density by increasing seed production (Lonsdale *et al.* 1995). A reduction in grazing pressure by the beetle can then allow a rapid return to high weed densities. By 1999 however the *sida* densities had been reduced by between 84% and 99% of the original densities and introduced pastures and native herbs and grasses dominated the sites.

Responses to the questionnaires indicated herbivory by *Calligrapha* has significantly reduced *sida* infestations and costs of control in many situations throughout the coastal and sub-coastal region surrounding Darwin. This is not universal however. The level of control is determined by when *Calligrapha* reinvades after the dry season. Populations that reinvade in November and December will have a much greater impact on seed production than those arriving after January.

Maintaining a caged population, throughout the dry season on irrigated *sida* will enable land holders to redistribute the insects early in the wet season as soon as *S. acuta* germinates or re-shoots. These populations will then reach damaging levels in time to impact on the plants flowering and seeding capabilities enhancing the impact of this insect.

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