

Prevalence of biological control agents on groundsel bush in relation to plant size and survey site

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Summary Groundsel bush has been an invasive plant in Queensland and New South Wales for the past 56 years. In 1963 a biological control program was initiated. Anecdotal evidence suggests that the groundsel bush problem has dramatically decreased. Using field surveys and damage estimates we investigate whether the biological control agents are prevalent throughout the plant's distribution. Our preliminary results demonstrate that the efficacy of biological control agents vary depending on plant size and site conditions.

Keywords *Baccharis halimifolia*, biological control, plant vigour, herbivory.

INTRODUCTION

Groundsel bush (*Baccharis halimifolia* L. Asteraceae) was introduced into Australia in the early 1900s and has been considered an invasive plant in Queensland and New South Wales for 56 years (McFadyen 1972). In 1978 groundsel bush was estimated to occur over a total area of three million hectares severely invading disturbed areas (McFadyen 1978). As an environmental weed it forms dense understoreys in native *Melaleuca* wetlands (Westman *et al.* 1975). A biological control program was initiated in 1963 and since then 14 agents have been released at an estimated cost of \$9.6 million (Page and Lacey 2006).

Seven of the released agents are thought to have established (Table 1). However, there has been no assessment of the incidence and prevalence of the biological control agents on groundsel bush.

Studies have shown herbivores tend to be selective in terms of plant architecture (Rudgers and Whitney 2006), geographic location (Fernades *et al.* 2004), local plant density and size of plant patches (Shea *et al.* 2000). In this study, we assessed damage to individual groundsel bush plants from the biocontrol agents and how plant size and location may affect levels of agent damage.

MATERIALS AND METHODS

Twenty-seven sites (Figure 1) in Queensland and New South Wales were surveyed for damage from biological control agents on groundsel bush. Each site was surveyed once, the Queensland sites in spring (2006) and the New South Wales sites in autumn (2007). Each of these sites will be sampled in the opposite season again in 2008. At each site ten plants were haphazardly selected and their height and widest diameters (perpendicular to one another) were measured, from which the volume could be calculated (as an ellipsoidal volume).

Volume was considered an appropriate measure of size as it is significantly correlated with growth, survival and fecundity (Sims unpublished data) and explains a large proportion of the variance for each of these demographic processes. Each plant was then assessed for typical damage from the biological control agents (Table 1). For each plant, stem boring holes and galls were counted and leaf damage was estimated using a scoring system based on a 0–5 scale

Table 1. Biological control agents of groundsel bush and their damage type.

Biological control agent	Order: family	Year released	Damage type
<i>Oidaematophorus balanotes</i> (Meyrick)	Lepidoptera: Pterophoridae	1969	Stem-boring holes
<i>Rhopalomyia californica</i> (Felt)	Diptera: Cecidomyiidae	1969	Galls
<i>Aristotelia ivae</i> (Busck)	Lepidoptera: Gelechiidae	1969	Leaf skeletonisation
<i>Trirhabda bacharidis</i> (Weber)	Coleoptera: Chrysomelidae	1969	Leaf holes
<i>Megacyllene mellyi</i> (Chevrolat)	Coleoptera: Cerambycidae	1978	Stem-boring holes
<i>Bucculatrix ivella</i> (Busck)	Lepidoptera: Bucculatricidae	1989	Leaf mines
<i>Puccinea evadens</i>		1997	Rust on leaves

where 0 indicated no visible damage and 5 was almost complete coverage. The data were then analysed using Kruskal-Wallis tests and generalised linear models in R 2.2.0. In the generalised linear models the amount of damage was modelled with plant volume and site as the explanatory variables.

RESULTS

All sites surveyed had evidence of leaf holes (0.92 ± 0.06 mean score ± 1 SE), leaf mining (1.32 ± 0.10 mean score ± 1 SE) and stem boring (9.38 ± 2.15 mean number of holes/plant ± 1 SE). All but five sites (Miriam Vale, Mt Perry, Gayndah, Esk and Calliope) had galls (1.85 ± 0.77 mean number of galls per plant ± 1 SE). Leaf skeletonisation (0.26 ± 0.06 mean score ± 1 SE) and rust (0.85 ± 0.15 mean score ± 1 SE) were patchily distributed between sites but no clear pattern was evident in relation to geographical location.

Levels of leaf damage were found to differ between sites using a Kruskal-Wallis test (Leaf mining $P < 0.0001$, leaf skeletonisation $P < 0.0001$, rust $P < 0.0001$, leaf holes $P < 0.0001$).

Generalised linear models with quasipoisson errors indicated that both plant volume and site (interaction and independent effects) significantly affected the number of stem-boring holes ($P < 0.0001$) and galls ($P < 0.02$). At 24 of the 27 sites surveyed, the number of stem-boring holes increased with increasing plant volume (Figure 2). It was not possible to distinguish between the damage observed by the two stem-boring insects, therefore their affect is combined.

At 19 of the 27 sites, the number of galls observed increased with increasing volume (Figure 3).

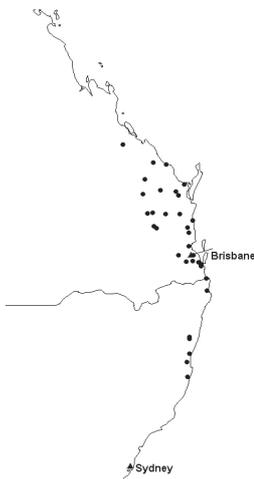


Figure 1. Sites surveyed for groundsel bush biological control agents.

DISCUSSION

Our results show that the biological control agents of groundsel bush remain widely established almost 40 years after initial releases, although the levels of damage are variable between sites and between plants of different sizes.

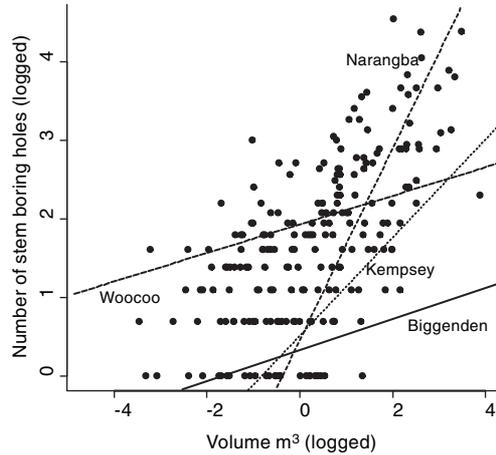


Figure 2. The number of stem-boring holes counted per plant in relation plant volume (m^3). Lines are intended as examples of the positive trend found at four of the sites surveyed.

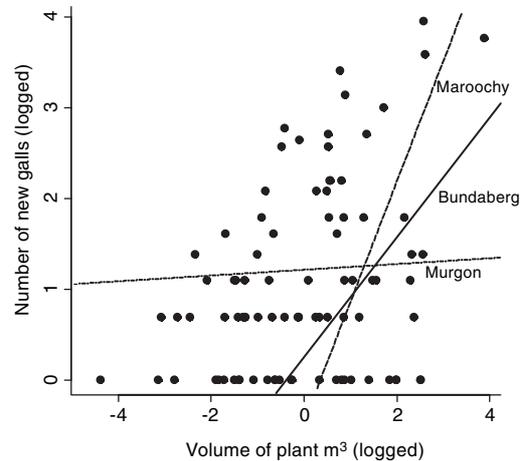


Figure 3. The number of galls counted per plant in relation to plant volume (m^3). Lines are intended as examples of the positive trend found at three of the sites surveyed.

The distribution and abundance of most species is influenced by a number of factors including climate, predators and resource availability so it is not surprising that we found differences in damage levels between sites. This has implications for the success of a biological control program because agents may only be successful at sites with certain abiotic and biotic characteristics. This variability in results clearly demonstrates the need for evaluation programs to be conducted on the entire distribution of the weed.

Damage produced by stem borers and gall inducing insects was positively correlated with plant size. This result provides evidence of the plant vigour hypothesis, which suggests that large, vigorously growing plants or plant parts are preferred by herbivores, particularly galling insects (Price 1991, Dhileepan 2004). Bezemer *et al.* (2006) also found a similar pattern with larger *Senecio jacobaea* being more suitable for stem borers and leaf miners. Larger plants appeared to host more stem-borers although it was difficult to determine how recently stem-boring damage occurred. Therefore, increasing herbivore damage may simply be explained by the fact that older/larger plants have had longer to accumulate damage. However, larger/older plants also have larger stems which enable more stem-borers to forage on the resources available. Levels of herbivory may also be a direct result of oviposition choice where female oviposition preference may be correlated with plant size (Price 1991).

Overall, our results indicate that the agents are still present and damaging groundsel bush plants. Further research is currently being conducted on how damage levels impact on plant performance, including experiments that exclude the agents. Once completed, both studies together will provide an accurate evaluation of the long-term efficacy of the groundsel bush biological control program.

ACKNOWLEDGMENTS

CRC for Australian Weed Management fund this project. Niels Hintzen and Sarah Chilton for field assistance. Jennifer Finn and an anonymous reviewer for manuscript comments.

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