Agents that reduce seed production – essential ingredient or fools folly?

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Introduction

Seed and flower feeders are routinely used in the biological control of weeds, with the aim of reducing a weed’s invasiveness. In many cases these agents are used in preference to agents that attack the vegetative parts, either to avoid conflicts of interest (where vegetative parts of the plant are of value) or because they are frequently host-specific and easy to rear. Although some reproductive feeders have been used very effectively in weed biological control, debate continues about whether our expectations for flower and seed feeders are realistic. Some of the uncertainty stems from the lack of case studies to quantify the effect of the agents on the population dynamics of the target weeds.

A workshop, with 32 attendees, was held to investigate issues surrounding the use of reproductive feeders as biological control agents. Specific aims were to identify the role of flower and seed feeders in biological control, examine evidence for impact, and to discuss means of obtaining further evidence of impact, especially for reduced rates of spread. Attention was focused on insects and pathogens (here nominally included as “feeders”) that specifically target buds, flowers or seeds. Natural enemies, such as gall-formers and defoliators that indirectly impact on reproduction were not considered because their impacts are too easily confounded with other effects such as reduced growth rates. Below we summarize some of the general themes that were explored during the workshop, and synthesize the contributions made by workshop participants.

Possible impacts

The direct effects of reproductive feeders include: reduced seed production, increased seed mortality, altered seed quality (e.g. weight, dormancy characteristics), altered seed dispersal characteristics (e.g. Rhinocyllus conicus deforms inflorescences and prevents detachment of undamaged seeds from pappus), and altered timing of seeding. These direct effects can potentially result in a wide range of impacts on weed populations, including:

• reduced density of seedlings and/or mature plants
• reduction in the distributional range of the weed
• altered age structures
• reduced population growth rates (e.g. longer periods required to form dense stands in newly invaded areas)
• slower rate of range expansion
• slower rates of reinvasion following disturbance (such as from clearing)
• reduced competitiveness, allowing greater opportunities for desirable plant species to compete with weed
• increased effectiveness of other control agents or control methods.
• more effective management opportunities such as monetary savings, and less habitat disturbance when other control options are exercised (Moran et al. 2004)

What types of plant are good targets for reproductive feeders?

The discussion surrounding the identification of these impacts centred on the life history traits of the plant and the invasion/reinvasion phase following disturbance under which the above impacts may be observed. As a result, we attempted to explore factors that indicated weeds that were better targets for biological control using agents that disrupt reproduction. Some of the factors that were identified as favouring the chances of achieving some success with reproductive feeders include:

• low plant fecundity (e.g. a plant with a few large seeds as opposed to many small seeds)
• long maturation period

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• limited ability to undergo asexual reproduction
• low seed viability
• limited seed longevity (i.e. limited dormancy)
• density dependent dispersal of seeds
• seed, rather than micro-site, limitations on seedling recruitment rates
• low flower:seed ratio (at least for flower feeders feeding on annual species; there was uncertainty whether this is important for perennial species)

No agreement could be reached about the importance of the following:
• dispersal mechanisms
• duration of seed availability on the host plant
• frequency of disturbance in the weed’s habitat (disturbance frequency is an environmental factor whose importance depends on the life history characteristics of the agent)

What types of insects or pathogens are good/bad agents?
This was identified as a large, potentially fruitful area of inquiry. However, it was not dealt with in detail during the workshop.

Demonstration of impact on rate of spread
There are already some dramatic examples of high seed predation resulting in significant decreases in plant populations (e.g. Louda & Potvin 1995, Hoffmann & Moran 1998). Such impacts are relatively easily verified, and provide evidence for the potential of reproductive feeders in biological control. However, reduced rate of spread (including range expansion, formation of thickets in new areas and rates of recovery of infestations) due to reproductive feeders have not yet been demonstrated for any weed, even though it is expected to occur. Reduced rate of spread is a highly desirable outcome of biological control, so significant impact by biological control agents may therefore not be getting acknowledged.

One of the reasons for the impact of reproductive feeders on rates of spread not being studied may be difficulties in demonstrating impact. However, the workshop identified at least two potential approaches:

• Comparison of spread rates before and after the release of the agent. Limitations include a requirement for long-term survey data, and potential confounding effects of other factors that might be altering spread rates (e.g. vertebrate herbivores; changing land uses; variable climate) and factors affecting recruitment success (e.g. disturbance regimes).
• Modelling of dispersal. Models offer the most likely method for estimating the impact of reproductive feeders on rates of spread. By integrating the available knowledge on the population dynamics of the plant, establishment rates of the plant, damage functions of the agent and the population dynamics of the agent, the model can project the likely impact of the agent on rates of spread. For the same reasons that the direct measurement of the effects are difficult to measure due to confounding effects, such models are likely to be difficult to comprehensively validate.

A priority is to identify systems where biological control agents are likely to be having an impact on rates of spread, and where such impact is likely be relatively easy to demonstrate. Some systems, such as long-lived woody weeds that occur in arid systems where major dispersal and recruitment events are episodic are likely to be especially difficult (Kriticos et al. 1999).

Conclusions
Reproductive feeders can potentially impact upon weeds in diverse ways. It is important that any significant impact is clearly demonstrated, so that the benefits of biological control can be acknowledged. Reduction in rates of spread is one impact that may be occurring, has not yet been clearly demonstrated, and is likely to be difficult to quantify. Research into techniques to quantify impacts of reproductive agents on the rate of spread of weeds will be challenging and useful.

Overall, relatively few flower or seed-feeding biological control agents appear to have a significant impact on weed populations. The process of identifying suitable targets for reproductive feeders, and identifying suitable agents, has received relatively little attention, and remains a fruitful area of inquiry. Given the costs and risks of importing agents, research to provide guidelines for the appropriate use of reproductive feeders should be a high priority.

References