SESSION 2

Failure in Biological Control of Weeds

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What Can We Learn From Biological Control Failures?

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Abstract

While it is the dream that all biological control of weed programs will be successful, it is sometimes necessary to look at programs that have failed to determine what has gone wrong and to attempt to discover new ways of doing things that will avoid failure. By studying programs that seem not to have worked it may be possible to determine what characteristics cause some weeds to be resilient to biological control. Lessons learned from individual programs may eventually show general patterns that will improve the success and predictability of biological control.

Keywords: biocontrol, salvinia, knapweed, tansy ragwort, non-target impacts, plant ecology, host testing

What is failure? Failure in biological control can be attributed to the failure of an unsuccessful agent or to a whole program in which the density of the target weed has not declined. Agents fail when they do not become established, they become established but remain at low density or geographically restricted, or they become established and reach high density, but do not have a negative impact on the density of the target weed. An example of well established but ineffective agents are the gall flies *Urophora quadrifasciata* Frfld. and *U.affinis* (Meig.) introduced to North America on diffuse knapweed, *Centaurea diffusa* Lam., which became established and increased rapidly but did not reduce weed density (Harris 1980a; Harris 1980b; Myers *et al.* 1988). Cinnabar moth, *Tyria jacobaea* L. introduced as a control agent on tansy ragwort, *Senecio jacobaeae* L., also became common at many sites of introduction, but had little impact on the weed density (Myers 1980, McEvoy *et al.* 1993). The target weeds in these cases are resilient to the type of damage caused by the biocontrol agents.

Failure of a whole program for biological control of a weed can occur when all the agents available for release do not measureably reduce the density of the target weed. Failure might be on a local scale where conditions are unsuitable for agents and/or particularly good for the target weed (Julien and Storrs 1996). In some cases the failure may be temporary and be the result of insufficient resources to identify, screen, or disseminate agents. On the other hand failure might be global - no agents have been identified or found to be sufficiently host specific that are capable of reducing weed density.

Another type of program failure that can occur in biological control is the attack of non-target hosts by the introduced agent. In this situation the unwanted side effects associated with the attack of non-target hosts may counteract the environmental value of reducing density of the weed (Louda, *et al.* 1997 and this volume).

Technical failure. Technical failure can occur during the production and dissemination of fungal pathogens for weed control. A rush from field trials to commercalization can lead to subtle procedural changes that can have direr consequences on efficacy (Shearer, this volume). But there are also things that can go wrong involving the release of insects as biological control agents. For example, agents may be released on the wrong species of plant as occurred in the early stages of the leafy spurge program (Harris 1984), at the wrong time of day or year, or they may develop disease while being reared for release. Another technical problem that has occurred is the mixing of two species of agents prior to release. This occurred with the two *Urophora* species on knapweed (Harris 1980a) and the two *Galerucella* species on purple loosestrife, *Lythrum salicaria* L., (Blossey *et al.* 1996).

Host testing might be considered to be "technical failure" if agents are released that attack non-target hosts. However, examples of released agents attacking non-target plants has thus far not been unanticipated from the host selection trials (see discussion in Cory and Myers (2000)). Rather than being a technical failure, attack of non-target hosts by biological control agents has resulted from value judgements on the potential risks associated with feeding damage to native plant species that are relatives of the target weed. To make judgements on whether non-target attacks are acceptable requires an analysis of the cost of the weed and the benefit of controlling it as compared to the environmental cost associated with the potential impact of agents on native species of plants (Harris 1990). This is not a simple process and different interest groups will have different values to apply to the cost-benefit analysis.

Avoiding failure through better agent screening. Reducing the number and increasing the effectiveness of introduced biological control agents is a way to decrease the opportunity for failure (McEvoy and Coombs 1999). If progress can be made toward selecting agents that are more likely to be successful, unanticipated side effects can be avoided. This may involve determining if a weed is seed limited before releasing seed predators (Andersen 1989, Myers, this volume), or determining if an agent has the ability to kill its host plant before introducing it. The successful control of the water fern, *Salvinia molesta* D.S. Mitchell, provides a good example for a retrospective analysis of effective and ineffective control agents. Two species of weevils, *Cyrtobagous salviniae* Calder and Sands, and *C. singularis* Hustache*,* initially thought to be two biotypes of a single species, were found to have slightly different feeding patterns on salvinia (Sands and Schotz 1985). Adult *C. salviniae* feed more on plant buds than do adult *C. singularis*, which feed more on leaves and internodes. But the crucial difference between the two weevil species is that larval *C. salviniae* tunnel through plant rhizomes, nodes and leaves and cause internodes to turn brown and disentegrate. Larval *C. singularis* feed externally and have little impact on the plants. These slight differences in feeding behaviour made the difference between a successful and an unsuccessful control program.

Avoiding failure through better communication, experimentation and evaluation. Many weed problems are global - the same species occur on several different continents. Through good communication successes can be maximized and failures reduced. Therefore, it is crucial that biological control practitioners communicate and cooperate. More experimental study of the types of damage caused by potential agents and of the ecology of the plants (Sheppard *et al.* 1989; Fowler *et al.* 1996) may help to determine the weak points in the plant life history and identify the agents that influence that stage. Of equally great importance is the need to evaluate all biological control programs so that it is feasible to quantify the true impact of agents on the density of the weeds. Simply determining if agents are established and classifying programs as successful, partially successful or unsuccessful, as has been done historically (Julien 1999), does not really allow an accurate evaluation of biological control of weeds. Without critical evaluation we can neither know how successful biological control is nor can we evaluate the failures.

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