

BIOLOGICAL CONTROL OF PURPLE LOOSESTRIFE IN NORTH AMERICA

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INTRODUCTION

In recent years, interest in a biological method to control problem plants in natural areas in the United States has grown (US Congress 1993). All federal agencies must comply with standards to reduce the use and dependence on chemical control of weeds. But, biological methodologies are not readily available, nor have they been well-endorsed or financially supported. Despite an excellent safety record (Harris 1988; Crawley 1989), skepticism concerning the safety and effectiveness of exotic insect introductions for weed control remains high among the general public, administrators, and even scientists. The successful control of *Hypericum perforatum* (Huffaker & Kennett 1959) and others that followed, have demonstrated that long-lasting, cost-effective, environmentally sound and effective control programs, can be implemented. But, despite an increase in the number of programs initiated, the ability to select and to establish control agents has not progressed to a point where the rate of success has improved (Crawley 1989). Basic questions about the kind of herbivore species to introduce, impact of single and multiple species herbivory, and release strategies, remain unanswered. The control program targeting purple loosestrife (*Lythrum salicaria* L.), a Eurasian wetland perennial responsible for the degradation of many prime wetlands throughout temperate regions of North America (Thompson et al. 1987; Malecki et al. 1993), is intended to emphasize the need for research investigations during pre- and post-release phases of the program.

THE CONTROL AGENTS

Detailed investigations in Europe began in 1986 with surveys for potential control agents and investigations about their life-history, distribution, impact, and host-specificity (Blossey 1993; Blossey et al. 1994a, b; Blossey and Schroeder 1995; Blossey 1995b). Biological attributes of herbivores (host specificity, fecundity, impact, etc.), have served as guidelines for selection of control agents (Harris 1973; Goeden 1983); however, such characteristics are often difficult to observe in the field. Therefore, species proposed for introduction were selected based on information about (a) impact on the target weed in the field, (b) host specificity, (c) distribution, and (d) feeding niche on *L. salicaria*.

Six species were selected as the most promising control agents for further investigations. These were a root-mining weevil, *Hylobius transversovittatus*, attacking the main storage tissue of purple loosestrife; two leaf-beetles, *Galerucella californiensis* and *G. pusilla* capable of completely defoliating individual plants and entire *L. salicaria* populations; a flower feeding weevil *Nanophyes*

marmoratus; a seed feeding weevil *N. brevis*; and a gall midge, *Bayeriola salicariae*, attacking leaf and flower buds.

Demonstrated host specificity is of overriding importance before any control organism can be released. During the screening program for purple loosestrife, we conducted various tests and compared results of different methods (Blossey et al. 1994a, b; Blossey and Schroeder 1995). After initial host specificity screening results became available, a questionnaire concerning the potential impact of this program was sent to the Departments of Agriculture and Natural Resources in 32 states (Blossey et al. 1994a). The questionnaire asked for the occurrence, special concerns (rare or endangered) and ecological importance of *Lythrum alatum* and *Decodon verticillatus*, two plant species where some feeding by potential control agents had occurred. The questionnaire asked whether respondents would favor a release of biological control agents over a potential negative impact on *D. verticillatus* and *alatum*. While the majority fav releases, responses ranged from extreme opposition to enthusiastic support (Blossey et al. 1994a). Often a split occurred between the two agencies in a state, with the most common concern being lack of sufficient information to appropriately evaluate danger to native plants. This, and the second most commonly expressed concern, that the introduction of another exotic species might create another problem similar to purple loosestrife, illustrate the necessity to assess and publish the impact on target and non-target host plants after insects have been released. Without scientific evaluation, the safety of biological control will remain subject to doubt and if public concerns are not taken seriously, suffer further restrictions. Conflict resolution will always be a part of biological control, and only sound scientific analysis can offer guidance to necessary decisions. For example, based on the available information, one of the agents under consideration, *B. salicariae*, because of a wider host range, was not proposed for introduction (Blossey and Schroeder 1995).

Based on the available knowledge at the time of introduction of the first control agents in 1992, the following predictions emerged (Malecki et al.1993): (1) all species will become established throughout the current range of *L. salicaria* in North America; (2) the root feeder *H. transversovittatus* and the two leaf-feeders *G. Calmariensis* and *G. pusilla*, will be most important in reducing large populations. The flower and seed feeders will stabilize smaller populations, further reducing seed output in such a way that not every disturbance will lead to a new outbreak of *L. salicaria*; (3) combinations of agents will have greater control effect than any species alone; (4) control of *L. salicaria* will be achieved more rapidly in mixed plant communities with competition for space and nutrients; and (5) purple loosestrife abundance will be reduced to 10% of its current level over 90% of its range.

NORTH AMERICA—1992 TO PRESENT

Despite a long history of using insects for weed control and a considerable improvement in procedures, only about 60% of released agents become established (Crawley 1989). The influence of factors such as agent taxonomy, climatic pre-adaptations, number of individuals released, numbers and timing of releases, predators, and weather conditions in determining the fate of releases, lack scientific evaluation and are largely observational (Crawley 1989; Lawton 1990). In the control program against *L. salicaria*, agents were collected from climatically different source populations and releases occurred across North America. Experiments were started to determine the best release procedure. Agents became established across the entire continent regardless of the

source populations, the number of agent releases, time of release, stage released, or whether caged releases or openfield releases were conducted (Hight et al. 1995).

Harris (1981) proposed that biocontrol agents be considered stress factors; the aim being to increase stress load until the balance is tipped towards the disadvantage of the target weed population. Myers (1985) argued that frequently good control has been achieved by a single agent replacing another less successful one. Introducing several control agents could potentially result in the suppression of a formerly successful species by a competitively superior species (Ehler and Hall 1982). Crawley (1989), however, could not find any evidence that multiple species introductions have ever led to the replacement of effective agents by economically less successful ones. On the contrary, agent combinations were recently reported to be more destructive to plants than a single species alone (Fowler and Griffin 1995). Masters et al (1993) found that spatially separated herbivores interact via their common host plant. Root-feeders showed a reduced performance if their host plant was simultaneously attacked by an above-ground herbivore. Above-ground herbivores showed improved performance on plant individuals simultaneously attacked by a root-feeder. Whether these interactions have any influence on the success of weed biocontrol in systems where above- and below-ground herbivores were released needs further study. We are currently conducting these experiments for the *L. salicaria*-*Galerucella*-*Hylobius* system. This is a good example of how an on-going biological control program can benefit from simultaneously conducted basic research, and vice versa.

Mass rearing is often an integral part of a biological control program since control agents are generally in short supply. A major concern has been potential negative side effects of laboratory mass rearing (e.g., adaptations to rearing conditions) and reduced quality of the produced insects (Hopper et al. 1993). We have experimented with various field and laboratory mass rearing techniques (Blossey and Hunt 1997), and found a reduced fecundity and increased mortality associated with increasing duration of artificial rearing conditions. We now prefer to mass produce all species outdoors for one generation and allow subsequent overwintering. Between 1994 and 1996, over 400,000 leaf-beetles were shipped to 26 different states and Canada to collaborators in a wide range of organizations (universities, State Departments of Agriculture and Natural Resources, National Wildlife Refuges, Bureau of Reclamation, Tennessee Valley Authority, and Animal Plant Health Inspection Service); many have started their own mass rearing program. We believe that we need to be concerned about the quality of insects released, not the quantity, and recommend outdoor mass rearings. Releasing fewer, but fitter, individuals might be a much more successful approach and quality control should accompany every mass rearing program.

Increased attention is given to follow-up studies to monitor target plant and control agent populations. The lack of published evaluations might (hopefully) reflect the lag time between releases and documented successes since the biocontrol community has long agreed on the necessity of these studies (Schroeder 1983; Sheppard 1992). The future of biological weed control is intimately linked to the demonstrated safety and efficacy of our programs. For example, releases of control agents against *L. salicaria* in the state of Wisconsin were only allowed once the Department of Natural Resources agreed on a monitoring plan for insect and plant populations.

An important consideration is the many different ways to monitor insect or plant populations. Our goal has been to develop standardized monitoring guidelines sophisticated enough to allow valuable

scientific evaluation, but at the same time, simple enough to allow participation by wildlife managers or their staff with little guidance. Preliminary versions of a monitoring guide have been tested in 1995 and 1996, and a final version will be distributed by the end of 1997.

THE MAGIC FORMULA FOR SUCCESS?

A number of factors have contributed to the rapid growth of a coordinated biocontrol effort for purple loosestrife in the United States. *L. salicaria*, based on its rapid spread, projected range, and severity of impact, was identified among the most harmful non-indigenous species in the United States (US Congress 1993). This designation created interest for improvements in management approaches, including biological control, across the entire continent. From its inception, the biological control program against *L. salicaria* has been a multi-agency effort. The overseas exploration by the International Institute of Biological Control was conducted in association with the USDA Agricultural Research Service (ARS), and the US Fish and Wildlife Service.

The initial success of the interagency effort led to the formation of a scientific advisory group (Purple Loosestrife Working Group, [PLWG]), with representation from several US federal and state agencies, universities, and Canada. Since 1986, this working group provided continual guidance on all aspects of our biological control program.

One of the major accomplishments has been to keep federal and state agencies actively involved, informed through internal annual reports, and through participation in decision-making processes. This broad-based involvement has facilitated maintenance of secure funding since 1985. Particularly important was the ability to pool resources from a variety of sponsors, thus, in the absence of major grants, the cooperation across political and agency boundaries has been extremely beneficial. Once the first insects became available in 1992, they were distributed to 7 states and to Canadian cooperators. Workshops held in Colorado and Minnesota in spring 1993 introduced interested agencies to life-history of control agents, mass rearing techniques, follow-up studies, and monitoring techniques. In addition to regular meetings of the PLWG, we now conduct annual planning meetings for the future of the control program.

Purple loosestrife is not an agricultural weed. People actively involved in the control program are often resource managers, essentially a new audience for biological weed control. Their willingness to participate in basic research has enabled us to implement a scientific approach to the entire program with the intention to improve biological control as a science. The leadership provided by Cornell and the willingness to share research results has created a unique cooperative environment that allowed the program to move forward at a fast pace. Last, but not least, early results indicate that the selected control agents are going to be effective.

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