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An Active Approach to the Use of Insect Biological Control for the Management of Non-Native Aquatic Plants

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ABSTRACT

Today, the use of insect biological control for the management of aquatic and wetland plants is typically a rather passive procedure from the viewpoint of resource managers. Insects are released, usually by researchers, with little or no direct input or effort by management personnel. However, the effectiveness of biological control could be enhanced if resource managers took an active role in its use. Four steps should be utilized in order to achieve a more active approach to the use of biological control. These include gaining an understanding of the insect agents, initiating yearly surveys to determine insect population levels and immediate and long-term impact, supplementing the insect populations if surveys reveal low numbers, and developing integrated procedures to minimize impact of the varied management techniques to one another. Utilizing a more active approach increases the awareness of biological control techniques and should result in increased effectiveness.

Key words: Information systems, integrated pest management, waterhyacinth, alligatorweed, hydrilla, waterlettuce.

INTRODUCTION

Over the last 38 years, the use of biological control for the management of non-native aquatic and wetland plant species has expanded tremendously. Since 1959, 18 insect species have been released for the management of several species of aquatic and wetland plants including alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb.), waterhyacinth (*Eichhornia crassipes* Mart. (Solms)), waterlettuce (*Pistia stratiotes* L.), hydrilla (*Hydrilla verticillata* (L.f.) Royle), purple loosestrife (*Lythrum salicaria* L.) and melaleuca (*Melaleuca quinquenervia* Cav. Blake). Currently over 20 insect agents are being tested in overseas laboratories and quarantine facilities to determine impact to these same plant species. In addition, active release and monitoring programs for insect agents of hydrilla, waterlettuce, melaleuca, and purple loosestrife continue (personal communication Dr. T. Center, USDA, ARS, Fort Lauderdale, FL, Dr. G. Buckingham, USDA, ARS, Gainesville, FL, and Dr. Al Cofrancesco, WES, Vicksburg, MS).

The first practical use of host-specific insect agents for the management of problem aquatic plants in the United States began in 1964 with the release of the first of three insect species for the management of alligatorweed (Coulson 1977). In the following years, dramatic and often complete control of alligatorweed, comparable to that observed with herbicides, was recorded at various sites across the southeastern US (Coulson 1977, Vogt et al. 1992, Cofrancesco 1988). By releasing a small number of insects (usually less than 500) at a site a noticeable suppression or complete elimination was achieved in only a matter a months. Even more significant, declines in alligatorweed infestations continued for years with little additional input from resource managers in the form of supplementary insect releases or the use of more traditional management techniques. The only exceptions occurred at the more northern limits of the US alligatorweed distribution. In these areas continued releases were necessary because the insect populations did not persist from year to year, apparently due to continual sub-freezing conditions. The alligatorweed biocontrol program was a remarkable success and was, in part, responsible for continued interest and enthusiasm for research into the use of biological control for other aquatic and wetland plant species.

Waterhyacinth was the next plant species targeted for biological control beginning in 1972. Three agents, including two weevil species in the genus *Neochetina* and the moth *Sameodes albiguttalis* Warren, were released. Active participation by resource managers was the norm in the early years of waterhyacinth biocontrol and cooperative projects between state and federal agencies were initiated. One of the better publicized was the "Large-Scale Operations Management Test (LSOMT)" in Louisiana (Sanders et al. 1985). This project was a joint cooperative venture between the US Army Engineers Waterways Experiment Station (WES), the US Army Corps of Engineers New Orleans District, and various state agencies, to initiate releases over large areas with subsequent evaluation of the insect and pathogen biocontrol agents of waterhyacinth. It was soon realized, however, that the control achieved with the waterhyacinth insects was significantly different than that observed for alligatorweed. While large-scale reductions and virtual elimination of waterhyacinth were observed at some sites, the more typical scenario involved reduction of plant height, decrease in flowering (i.e., number of seeds produced), a decrease in the seasonal growth of the plants, and impacts that took years instead of months to occur (Center et al. 1990).

These impacts are a decided benefit. For example, reduction of plant height allows easier access by various forms of transportation including those associated with herbicide

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applications. Cost of chemical treatments is reduced since smaller plants require less herbicide for control. In addition, decreased seed production reduces future plant problems, especially in those areas where drought and subsequent water level fluctuations promote the growth and development of waterhyacinth seedlings. Insect feeding also decreases the production of daughter plants by destroying the apical meristems. This in turn diminishes yearly plant production, effectively reducing population size. Such is the case in Louisiana, where seasonal growth was reduced from a high of over 400,000 hectares per year to lows of only about 80,000 hectares (Center et al. 1990).

Unfortunately, the tremendous success with alligatorweed apparently fostered the unrealistic expectation by resource managers that the use of biological control technology always results in complete and long-lasting suppression or elimination of the target plant species. However, the type of "complete" control observed in the case of alligatorweed is not observed for the majority of insect biocontrol agents (Harley and Forno 1992, Hoffmann 1995). In most cases, when an insect biological control agent is used for weed management, measurable control occurs only after a period of years, not months, as was observed for alligatorweed. In addition, the complete elimination of the target plant is not anticipated, but rather the growth potential, seed production, or plant stature is impacted, thereby leading to long-term decreases in the plant infestation; exactly what was observed for waterhyacinth. Biocontrol is a suppression technology that, in most cases, reduces population growth and stresses the target plant. Reduced plant vigor coupled with adverse environmental conditions and/or the integrated use of other management options, results in smaller population size of the target plant, hopefully below what is considered the problem threshold.

Just as in the case of herbicides and mechanical control, the use of biological control requires, at the minimum, some continued input from resource managers to achieve measurable impact. The passive approach taken by resource managers today may be the result of what they observed with the application of the alligatorweed agents; i.e., they expected that all biological control procedures would take the same minimal input to achieve such outstanding success. It may, however, be related to the less than expected results observed with the waterhyacinth agents in comparison with alligatorweed. Whatever the reason, today almost all of the applied uses of biocontrol, including releases and subsequent monitoring, are performed by biological control researchers, a daunting task especially considering the vast acreage's associated with even one target plant species. Only limited expenditure of time and energy are put forth by resource managers.

Because of these misconceptions and the more passive role taken by resource managers in applying the use of biological control, this paper will address procedures and techniques that would allow the use of insect biocontrol in existing aquatic plant management programs in a more active manner. Such procedures should, over time, increase the effectiveness of biocontrol and assure that traditional control measures are used in such a manner to minimize impact to biocontrol activities.

PROCEDURES TO ACCOMPLISH THE ACTIVE USE OF BIOCONTROL

As indicated previously, resource managers use insect biocontrol for the management of aquatic plants primarily through passive efforts. Insect agents are released at a small number of sites, primarily by biocontrol researchers, with only limited participation. No effort is put forth to monitor the sites for establishment, let alone for future increases in the insect populations and their subsequent impact to the plants. To gain the most benefit from biocontrol a more active approach should be taken.

But how does one accomplish the active use of biocontrol and how does it fit in with today's existing management approaches? The existing biocontrol agents should be viewed as resources and should be managed and manipulated for the ultimate goal of achieving a higher degree of effectiveness. There are four steps to an active use of biocontrol including: 1) knowledge, 2) survey, 3) supplement, and 4) integrate. By applying these steps a more effective use of biocontrol, and hence, a higher degree of stress and damage to the target plants, can be achieved.

Knowledge

The first step to using any new control technology is to gain a thorough comprehension of its basic concepts, an understanding of the different types of control techniques available, and a knowledge of how to apply these control procedures correctly and effectively for each plant species. This is not unlike learning the correct and safest procedures for applying a herbicide or use of a particular type of mechanical harvester.

To use biocontrol effectively and actively you must first understand basic ecological concepts such as population growth. This includes factors affecting population growth and what factors, both abiotic (i.e., weather, climate, temperature, etc.) and biotic (i.e., mortality, reproduction, maturity rates, etc.), that regulate and maintain populations at realistic sizes. In addition, an understanding of how general types of biotic factors interact to keep populations regulated is needed. These include intra-specific biotic factors such as reproductive rates, mortality, and maturity rates, and inter-specific factors, which include competition, i.e., the interaction between the insect agents (i.e., herbivores) and their impact to the target plant.

In addition to these basic ecological concepts, it is necessary to gain more knowledge concerning the agents themselves. One critical aspect is the ability to identify each type of insect agent, its feeding damage and its long-term impact to the plant population. The ability to perform such identifications is complicated by the fact that there are native insects that feed and damage the same target plants. Native species can easily be confused with the introduced insects since they and their feeding damage superficially resemble those of the introduced species. However, with adequate training such identifications can be made easily and accurately.

Several training aids are available for gaining the knowledge needed to use biocontrol more actively. These include training courses offered yearly by the Center of Aquatic Plants in Gainesville, FL, and one offered on demand by the

US Army Corps of Engineers District, Jacksonville or by researchers at WES. In addition, WES researchers have recently developed a CD-ROM entitled the "Noxious and Nuisance Plant Management Information System (PMIS) that contains identification and damage information on each of the introduced insect agents (Grodowitz et al. 1996). This system also contains information on the use of more traditional management techniques including both chemical and mechanical control technologies. Another CD-ROM (entitled the "Aquatic Plant Information System", APIS) is being developed and will be released in early to mid 1998. This system will contain computer-based identification strategies and information on the insect herbivores, both native and introduced, that feed on 18 commonly encountered aquatic plants. APIS will also contain information on the identification of over 60 aquatic and wetland plant species as well as detailed information on chemical and mechanical control techniques. In addition, the most appropriate person to contact for each plant species is included.

Information on these systems can be obtained by contacting:

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In addition to the short courses and computer-based information systems there are also numerous technical reports, journal articles, and videos available from a variety of sources. Center et al. (1990) has a concise listing of the most pertinent literature available on the use of biological control for aquatic plant management and represents a good starting point. WES-published material can be obtained by contacting:

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Survey

The next step in developing an active biocontrol program is to initiate surveys not only of the aquatic plant populations but also of the introduced insect agents. Surveys are important because they reflect past, present, and future population levels of the insects. It is not unusual to find population levels of many of the insect agents to be non-existent or extremely low at certain sites; levels that would not afford any persistent damage and stress to the target plant. Hence, surveys allow resource managers to estimate population abundance/status of the insect agents and make adjustments in population size through supplemental releases, if needed.

The reasons why agent levels decrease vary between insect species. Some factors include a wide range of adverse environmental conditions including extreme temperatures, prolonged water level drawdowns, changes in nutritional composition of the plants due to changes in water quality, and wholesale removal of plants. This last factor occurs because of large-scale herbicide applications or mechanical removal. Since the insects, most probably the immature stages, are intimately tied to the plant for food and shelter, any large-scale removal of the plants drastically impacts the insect biological control population (Grodowitz and Pellissier 1998, Grodowitz and Cofrancesco 1990).

Procedures for surveying insect biocontrol agents are quite variable and are dependent on the insect species in question. They are used to determine presence or absence of the insect agents or to provide more detailed information on population size. Surveys that sample for actual population size are more complicated but provide a tremendous amount of useful information. Typically, population size measurements are based on a unit area such as a 1/4 m^2 or on a per plant basis. What complicates the interpretation of the survey results is that insect populations do not remain constant but are continually changing temporally, with such changes related to seasonal and site characteristics as well as the nutritional composition of the plants (Center and Van 1989, Grodowitz et al. 1997). When interpreting survey results, population dynamics as well as the percentage of parous (or fully reproductive individuals) must be taken into account before making decisions regarding the release of additional agents at a given locality (Grodowitz and Cofrancesco 1990).

While the design of surveys for insect biocontrol agents is beyond the scope of the present paper, more detailed information can be obtained from specific insect biocontrol researchers or from the variety of information systems, courses, and journal articles discussed previously under the "Knowledge" section.

Supplement

The third step in developing an active approach to the use of biological control is based on the information obtained from the surveying methods. If population levels of the agents are low then it may be necessary to release more individuals into the area to supplement or augment the existing population. Recent studies with *Neochetina eichhorniae* (Warner), the mottled waterhyacinth weevil, have shown that supplementing weevil populations significantly increases stress and impact to the plants by quickly raising the population level of the introduced insect species (Center and Jubinsky 1989). Studies conducted with *Hydrellia pakistanae* (Deonier), the Asian leaf-mining fly, have indicated that large, often-repeated releases provide the most damaging effects over the long-term (M. Grodowitz, Vicksburg, MS, unpublished data).

Specific procedures for releasing insect agents vary for each species and can not be discussed in any great detail within the context of this paper. However, certain rules are applicable for all species. First, only utilize high-quality individuals that have not been stressed by the collecting or shipping methods. It is imperative that the insects are kept at relatively constant temperatures, typically below 22C. They must be shipped at relatively low densities to avoid stress due to overcrowding. When possible, ensure that the insects are relatively free of disease. Also, continue monitoring the site after the releases have been made to substantiate that the insects have become established, population levels are increasing, and that additional releases are not warranted.

Obtaining insects for release can be time and labor consuming. However, once a suitable site with high insect population levels has been located collecting can proceed quickly. An alternative method is to purchase the insect species from a reputable dealer. Such dealers are quite rare but available in the Florida area. Prices may appear high but considering the cost for locating the insects, travel, collecting time, and handling, the cost is typically quite reasonable.

Integrate

Integrating biocontrol technology with existing, more traditional, control technologies is probably one of the most important factors in ensuring a viable and active biocontrol program. It makes little sense to use a variety of control methods if one or more interferes or directly impacts the use or effectiveness of another. It has been documented that certain control methods can have an adverse impact on the population size of the insect biocontrol agents (Haag 1986a, Haag 1986b, Grodowitz and Pellessier 1989, and Grodowitz and Cofrancesco 1990). One of these is the use of chemical control methodologies, but any method that removes large quantities of plants relatively quickly would produce the same results. For example, while the chemicals used in the management of aquatic plants are not directly toxic to the biocontrol agents, their use removes, relatively quickly, large quantities of plants from a specific location. Since one or more life stages of the insect agents are directly tied to the plant for food, shelter and, hence survival, such large-scale plant removal kills large numbers of agents, thereby decreasing the population size and ultimate impact to the target plant.

But such impacts can be easily reduced or eliminated. For years many aquatic plant biocontrol researchers (Wright and Center 1984, Center et al. 1990, Grodowitz and Cofrancesco 1990) have recommended leaving unsprayed plants to act as conservation areas or harborage for the biocontrol agents. Such harborage areas ensure the survival of the insect agents and act as a nursery area for further dissemination and spread of the agents when the plants have regrown after the herbicide application. Integration of all existing control measures is simple common sense; utilize all of the available control methods to maximize management benefits and apply them in a manner that minimizes impact to one another.

SUMMARY

In summary, an active biological control program makes good management sense. It allows the most effective use of a long-term suppression technology, which maximizes control of the target plant. While biological control will never be the ultimate answer for all of the current non-native aquatic and wetland plant problems, it does serve to stress the plants, reduce growth and plant production, and provide long-term suppression, and any reduction in plant biomass is a very positive outcome. But this will only happen if biocontrol is applied in a logical and active manner that maximizes its effectiveness.

In addition, it is important to gauge the effects of a particular agent based on the understanding that biological control is a long-term suppression technique; a technique that typically does not provide complete elimination of the target plant. The effectiveness of a biological control program must be reviewed in light of the specific impacts caused by an agent and of how they can be utilized to maximum potential. Effectiveness should not be measured in terms of complete eradication or elimination, which is an unusual situation at best. To do so places an unrealistic expectation on the use of biological control and negates the positive aspects of the technology. Biological control is a particularly effective management option especially when considered as a long-term suppression method and should be considered an integral part of a management plan.

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