Florida State University Journal of Land Use and Environmental Law

Volume 18
Number 2 *Spring 2003*

Article 9

April 2018

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RELEASE OF EXOTIC NATURAL ENEMIES FOR BIOLOGICAL CONTROL: A CASE OF DAMNED IF WE DO AND DAMNED IF WE DON'T?

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The benefits and risks associated with the discipline of biological control have become extremely complex and controversial. To adequately address the topic would require more time and space than we have been allotted here. In fact, the nontarget effect of biological control is the subject of several recent books.[1] Before we attempt to examine and summarize a few of the key points, we should first define some of the relevant terms that will be used in this discussion.

Biological control is the use of living natural enemies to control or suppress pest populations. The most commonly used organisms are predators (or herbivores, in weed biological control), parasitoids, and pathogens. The targets of biological control programs can be insects, mites, weeds, plant pathogens or even vertebrates. For the purpose of this discussion, we will limit the definition of biological control to the intentional manipulation by humans of natural enemies in order to manage pest organisms. We also will use the term 'pest'as it is defined in the Federal Insecticide Fungicide and Rodenticide Act (FIFRA): "Any organism that interferes with the activities and desires of humans." As stated by Norris,[2] "The term pest is anthropocentric, and is defined differently by diverse segments of the human population. There are no pests in an ecological sense; in the absence of humans, all organisms are just part of an ecosystem."

From this premise, it follows that the designation of pest status is relative. What one person considers a pest may not be a pest to someone else. One example might be those big "ugly" worms that are eating my neighbor's beautiful yellow and red flowers. In my

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1. NONTARGET EFFECTS OF BIOLOGICAL CONTROL (Peter A. Follett & Jian J. Duan eds., Kluwer Academic Publishers, Dordrecht 2000); BIOLOGICAL CONTROL: BENEFITS AND RISKS (H.M.T, Hokkanen & J.M. Lynch eds., Cambridge University Press 1995); SELECTION CRITERIA AND ECOLOGICAL CONSEQUENCES OF IMPORTING NATURAL ENEMIES. (W.C. Kauffman & J.E. Nechols eds., Proc. Thomas Say Publ. Entomol. Entomological Society of America, 1992); EVALUATING INDIRECT ECOLOGICAL EFFECTS OF BIOLOGICAL CONTROL (E. Wajnbberg et al. eds., CABI Publishing 2001).

2. ROBERT NORRIS ET AL., CONCEPTS IN INTEGRATED PEST MANAGEMENT (2003).

yard, these same worms are the "beautiful" larvae of the Monarch butterfly that are eating the yellow and red flowers of my butterfly weed. I want them to eat these plants so they will develop into adult butterflies.

There are three types of biological control that use living organisms or natural enemies to suppress target pest populations. These three approaches are Conservation, Augmentation and Classical. Although all three biological control methods are currently used, there are major differences between them especially with regard to the potential for non-target effects.

In conservation biological control, every effort is made to conserve and foster the impact that existing populations of natural enemies have on pest populations. This would include minimizing the use of pesticides or other management tools that have a negative impact on these beneficial organisms, or providing host plants that supply needed resources such as nectar and pollen to adult predators or parasitoids. It also would include establishing refuges where beneficial organisms can maintain viable populations.

An example of conservation biological control is the use of corn plants infested with the Banks grass mite, *Oligonychus pratensis* (Banks). This mite does not feed on ivy or palms, which are the crops that we would like to protect from the most serious pest of ornamental plants, the two-spotted spider mite (*Tetranychus urticae* Koch). The Banks grass mite serves as an alternate host for predatory flies, *Feltiella* spp. that occur naturally on mite infested plants[3] (Osborne et al. 2002). As the populations of this fly establish and increase within the greenhouse on the corn, they move throughout the ornamental crop attacking the pest mite, *T. urticae*.

Augmentative biological-control programs include those where beneficial organisms are mass-produced commercially or field-collected and then released to "augment" the existing populations. These beneficials can be native, adventive (established exotics), species that have been released previously but did not establish and, in some cases, new exotic species. The distinction between augmentation and classical biological-control programs is that species normally used in augmentation programs may not establish permanent populations or they may become established but their population densities are too low or they do not appear at the appropriate time to exert sufficient pest suppression. These

3. RYAN S. OSBORNE ET AL., DEPARTMENT OF ENTOMOLOGY, UNIVERSITY OF FLORIDA, FEATURED CREATURES: PREDATORY GALL MIDGE, NO. EENY-269, available at http:// creatures.ifas.ufl.edu/beneficial/f_acarisuga.htm, (last visited Feb. 22, 2003).

programs are often used in unstable and/or annual cropping systems such as greenhouse-grown crops, strawberries, or some vegetable, fruit or field-grown crops. This approach also has been used effectively in stable aquatic ecosystems for the biological control of alligatorweed, *Alternanthera philoxeroides* (Mart.) Griseb, in the northern part of its range where the climate is too cold for the alligatorweed flea beetle, *Agasicles hygrophila* Selman & Vogt, to become permanently established.[4]

These organisms are not relied upon to survive from season to season. They are expected to exert control during a single growing season or for a relatively short period of time after their release. Sometimes large numbers of a biological control agent are released (inundative strategy) to supplement the small numbers already present, in expectation of a greatly increased effect. This is sometimes likened to a pesticide but in this case they are living organisms. The inundative approach is commonly used with some microbrial plant pathogens (bacteria, fungi, or viruses) or macrobial pathogens (nematodes) that are mass produced, formulated, standardized and applied as bioherbicides or biorational products. For example, DeVine® is a fungus that has been used for over 20 years to selectively control stranglervine, *Morrenia odorata,* in citrus groves. *Paecilomyces fumosoroseus* is a fungal pathogen that was discovered by L. S. Osborne in a University of Florida greenhouse and patented by the University. It is currently registered as a pesticide in Europe and the United States. Other well known examples include *Bacillus thuringiensis* (Bts) and entomopathogenic nematodes.

Augmentative biological control is often used to manage mites on many crops. The predatory mite, *Phytoseiulus persimilis* is mass reared by commercial insectaries worldwide. One palm grower we have worked with in South Florida now produces between 1 & 2 million *P. persimilis* each month. These predators are released into his palm crops on a weekly basis to control *T. urticae.* These releases replace the weekly application of pesticides to manage this pest. In reality, the predators are being used as a biological "pesticide". These predators have been released for more than 20 years in many different crops without any reports of negative impacts. They are rather poor competitors and very few cases exist that report their establishment in natural situations.

Classical biological control programs rely on the importation and release of exotic natural enemies into an area in which they are

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4. Gary Buckingham, G.R., *Biological control of aquatic weeds, in* PEST MANAGEMENT IN THE SUBTROPICS: BIOLOGICAL CONTROL- A FLORIDA PERSPECTIVE 413-80 (David Rosen et al. eds., Intercept 1994).

not already present for the purpose of establishing a permanent population of the organism. The classical approach is the most controversial form of biological control and is usually what people are referring to in discussions about non-target ecosystem effects and the risks to native fauna and flora from the inappropriate introduction of natural enemies. A recent and environmentally benign example of a classical biological control program for a pest insect is the release of parasitic wasps for the control of the pink hibiscus mealybug, *Maconellicoccus hirsutus*. This pest has devastated agriculture in various Caribbean islands. It feeds on more that 300 host plants and has killed 100 year-old trees.

Pink hibiscus mealybug was found in South Florida in June 2002. The initial infestations were found in residential areas in South Broward County. Regulatory officials from the state and federal governments had limited ability to enter private properties to inspect or manage this pest. This limited access was the result of the citrus canker programs. Public concern with the canker program and legal challenges to inspectors entering private property without search warrants for each property greatly reduced their ability to respond in timely fashion. Biological controls and the release of natural enemies appear to have been the only option to manage this serious pest. Predators and parasitoids don't respect property lines and search for prey with impunity. The wasps that were released, *Anagyrus kamali* and *Gyranusoidea indica*, are very host specific and die if they can't find pink hibiscus mealybugs to attack. These wasps to not attack people, plants or other pests. They are mass produced in Puerto Rico and California and released into the South Florida infestations by the United States Department of Agriculture and the Florida Department of Agriculture & Consumer Services. It is too early to determine what impact these releases will have.

The primary concern with the release of exotic natural enemies for classical biological control of arthropod pests and weeds is the potential for unforeseen or unintended environmental effects.[5] For example, the full impact to native Opuntia cacti in North America from the intentional introduction of the Argentine cactus caterpillar *Cactoblastis cactorum* in the Caribbean for biological control purposes, and its unanticipated arrival in Florida in 1989 has yet to be realized. In the preface of the book by Follett and Duan,[6] the crux of the controversy is succinctly stated as follows:

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5. E. TENNER, WHY THINGS BITE BACK: TECHNOLOGY AND THE REVENGE OF UNINTENDED CONSEQUENCES (1996).

6. NONTARGET EFFECTS OF BIOLOGICAL CONTROL vii (Peter A. Follett & Jian J. Duan eds., Kluwer Academic Publishers, Dordrecht 2000).

Biological control (Follett and Duan are probably talking about Classical biological control) has many benefits including essentially permanent management of the target species, no harmful residues, nonrecurrent costs, host specificity, and for successful programs, a favorable cost-benefit ratio. In addition, it may be one of the few methods for reducing pest numbers over a broad geographical range. Now, biological control practitioners are on trail to justify the use of introduced organisms given the potential for unintended environmental effects. Important areas of concern include the irreversibility of alien introductions, the possibility of host range expansion to include innocuous native or beneficial species (nontargets), dispersal of the biological control agent into new habitats, and the lack of research on the efficacy and environmental impact of previous biological control programs.

The debate over nontarget effects has been polarized strongly between biological control advocates and conservationists. The strict conservationist's point of view of no intentional introductions of alien species whatsoever has proved hard to defend because evidence for nontarget effects of arthropod biological control introductions is thins and often circumstantial. As a result, some biological control practitioners have been quick to dismiss the importance of adverse nontarget effects. However, the lack of available information appears to reflect the difficulties in evaluating the impact of biological control agents, which include the need to anticipate where nontarget effects may occur in order to gather pre-impact data, as well as our poor attempts at documenting nontarget effect after agent introductions.

In the United States, Executive Order 11987 requires the U.S. Department of Agriculture, in cooperation with the Department of the Interior, to restrict the introduction of exotic species unless it has been determined that the introduction will not have and adverse effect upon the natural ecosystem."

Unfortunately, this scrutiny is not being applied to all of the pathways by which exotic organisms gain entry into the United States as exemplified by the monthly establishment of alien arthropods in Florida.[7] It is only being applied to the pathway where scientists apply for permits to import and possibly release natural enemies of pests that gain entry via these other routes. As a result, a double standard does exist because of liberalization of international trade and conflicts between different segments of society (a different but related topic which will not be discussed here).

The key point that we would like to make in this discussion is that pest control is inherently risky. There are various tactics used to manage pests. Biological, physical and cultural controls have always been considered safe relative to the use of broad-spectrum pesticides. These other tactics have all come under closer scrutiny in the last few years because of their potential to have undesirable side effects. Managing agricultural pests with any tactic should be viewed in the context that 30% of all crops are lost to pests in developed countries. This is in spite of our best efforts to manage them. The losses in other countries are probably significantly higher. If we are going to feed the rapidly increasing human population that is expected to reach 8.9 billion by 2050,[8] we cannot afford to sustain this level of losses to pests. Biological control, and specifically classical biological control, is one of the essential weapons needed in this battle.

We would like to emphasize the fact that the importation of exotic biological control agents should be carefully scrutinized to prevent the importation, release and possible establishment of natural enemies that pose a risk to nontarget organisms. Governments are reviewing these issues and revising current regulations or developing new ones in an effort to "restrict the introduction of exotic species unless it has been determined that the introduction will not have an adverse effect upon the natural ecosystem." The risks associated with an introduction should be measured against the benefits and risks associated with other control tactics or against what could reasonably be expected by not intervening at all. It is obvious that other control tactics may not last as long nor pose the long-term threat to the environment that establishing an exotic organism may cause, but they all represent significant risks especially in the minds of the general public.

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7. M.C. THOMAS, THE EXOTIC INVASION OF FLORIDA, at http://www.doacs.state.fl.us/~pi/enpp/ento/exoticsinflorida.htm (last revised Aug. 8, 2000).

8. *See* the agricultural database of the Food and Agricultural Organization of the United Nations, at http://apps.fao.org/default.htm (last visited Feb. 22, 2003).

At the local level, the University of Florida's Institute of Food and Agricultural Sciences developed and implemented a protocol in October 2002 for reviewing permit applications for biological control agents before their release in Florida. The purpose of the review process is to make sure that the faculty member proposing the release of the biological control agent addresses important questions regarding nontarget issues and whether biological control is appropriate for the intended target pest. Clearly, this is a step in the right direction because it provides an opportunity for peer review of the petition.

The primary issue most naturalists have with exotic natural enemies is that they have the potential to permanently impact vulnerable native organisms, which can lead to irreversible ecological consequences, or revenge effects.[9] Given this concern, how do we evaluate potential risks prior to release so that a benefit-risk analysis can be conducted? Currently, the science does not exist that would allow analysis for more than a limited number of ecosystems, if any. The desire is there, but the necessary funding and coordination for such a monumental task does not exist. An alternative approach would be to consider a protocol for guiding the development of biological control programs that was recently proposed by Howarth[10] and is based on a framework developed by Bax.[11] The adoption of this 14-step flowchart or the development of an objective scoring system for arthropod pests similar to that proposed for selecting weed targets[12] could improve biological control success while ensuring that questions of safety and conflicts of interest are addressed.

The arguments and attacks against the current and past practices of classical biological control programs are both compelling and provocative. On the surface, they are very convincing. But the critics fall into the same trap that they accuse biological control practitioners of. They are myopic and are not looking at the whole picture. They de-emphasize one important and significant component of this puzzle, the human component. Humans are going to react to threats against themselves or their

9. TENNER, *supra* note 5, at 346.

10. F.G. Howarth, *Non-target effects of biological control agents*, *in* BIOLOGICAL CONTROL: MEASURES OF SUCCESS 369-403 (G. Gurr & S. Wratten eds., Kluwer Academic Publishers, Netherlands, 2000).

11. N. Bax, et al., *Conserving Marine Biodiversity: The Control of Biological Invasions in the World's Oceans*, CONSERVATION BIOLOGY (forthcoming).

12. *See* D.P. Peschken, & A. S. McClay, *Picking the target: a revision of McClay's scoring system to determine the suitability of a weed for classical biological control*, *in* PROCEEDINGS, EIGHTH INTERNATIONAL SYMPOSIUM ON BIOLOGICAL CONTROL OF WEEDS, 2-7 FEBRUARY 1992 137-43 (E. S. Delfosse & R. R. Scott eds., Lincoln University 1995).

interests whether they are perceived or real. Actions will be taken utilizing whatever tools are available. We would like to believe that we would take into account any negative and unintended damage to the environment, nontarget organisms, neighbors or even ourselves. Does history demonstrate these concepts to be foremost or even components of people's decision making process? Do we worry about soiling other people' s nests let alone our own when dealing with a threat?

In our opinion, questioning the safety of releasing exotic biological-control agents is valid and possibly long overdue. However, the importance of this one aspect of the exotic organisms issue is dwarfed by the overall impact that invasive organisms and their management have on our environment. We should probably be asking the following questions: How serious are the environmental, social and economic consequences of the establish-ment and management of invasive organisms?

In spite of significantly more than 100 years of successful biological control utilization, there is still a reliance on the unilateral use of chemicals to solve our pest problems. Pesticides and their unwanted and unanticipated impacts are often poorly documented. The impact they have on organisms other than the target pest cannot be separated from some of the negative impacts that are attributed to the use of certain biological controls. This does not mean that the arguments presented by such authors as Stiling and Simberloff,[13] Lockwood[14] or Strong and Pemberton[15] are not valid. As Strong and Pemberton[16] 16 (2001) state: "Restraint is the key to safe biological control. Judicious winnowing of potential targets comes first. Not every invasive species is a threat, and note every pest is appropriate for biological control." This should be the mantra of every proponent of biological control!

Scientists, regulators and ultimately society must make critical decisions based on a limited database. One fact is clear, established exotic pests will continue to be a problem. During the period from 1970 to 1989, Florida averaged the importation and establishment

13. Peter Stiling & Daniel Simberloff, *The frequency and strength of nontarget effects of invertebrate biological control a gents of plant pests and weeds*, *in* NONTARGET EFFECTS OF BIOLOGICAL CONTROL 31-43 (Peter A. Follett & Jian J. Duan eds., Kluwer Academic Publishers, Dordrecht 2000).

14. Jeffrey Lockwood, *Nontarget effects of biological control: What are we trying to miss?*, *in* NONTARGET EFFECTS OF BIOLOGICAL CONTROL 15-30 (Peter A. Follett & Jian J. Duan eds., Kluwer Academic Publishers, Dordrecht 2000).

15. D.R. Strong, & R.W. Pemberton, *Food webs, risks of alien enemies and reform of biological control*, *in* EVALUATING INDIRECT ECOLOGICAL EFFECTS OF BIOLOGICAL CONTROL 57-79 (E. Wajnbberg, J.K. Scott & P.C. Quimby eds., CABI Publishing 2001).

16. *Id.* at 70.

of one exotic arthropod a month.[17] This trend continues and during this past year it probably surpassed this average. Many of these exotic arthropods are invasive and cannot be ignored. Those faced with dealing with the impact of these species will use whatever tools available to mitigate any negative impact they may have. Pesticides will continue to be used and exotic natural enemies will be imported and released. Expedient choices will be made and some will have a negative result on nontarget organisms. As scientists, we must continue discussing these issues and strive to make appropriate and ethical decisions based on the best science available. As Ehler[18] (2000) has stated, "In future projects, a "sensible balance" may well include a given level of impact on nontarget species in the recipient community. If we cannot reach a sensible balance between economic reality and environmental ethics, then classical biological control may become an endangered scientific discipline."

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17. M.C. THOMAS, THE EXOTIC INVASION OF FLORIDA, at http://www.doacs.state.fl.us/~pi/enpp/ento/exoticsinflorida.htm (last revised Aug. 8, 2000).

18. Lester E. Ehler, *Critical issues related to nontarget effects in classical biological control of insects*, *in* NONTARGET EFFECTS OF BIOLOGICAL CONTROL 11 (Peter A. Follett & Jian J. Duan eds., Kluwer Academic Publishers, Dordrecht 2000).