

## Alien Invaders in Hawaii: Prospects for Remediation Using Biological Control

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The Hawaiian islands are subject to a very high rate of arthropod invasions that severely impact agricultural, forest, medical, and urban landscapes, costing many millions of dollars in damage and control costs, and threatening the health and integrity of endangered species and natural ecosystems. For at least 100 years classical biological control has been a powerful tool used to fight these invasives and to remediate some of the damage that they cause. However, in recent years, for a variety of reasons, it has become more difficult to carry out biocontrol projects in the state, and the rate of natural enemy introductions has plummeted. The last two decades have seen a very sharp decline in the number of parasitoids released in the field, coinciding with a greatly heightened awareness of their possible impacts on non-target species.

For practitioners of biological control it can be discouraging and disheartening at times to try to overcome the obstacles to success in a reasonable time frame. On the other hand, however, there are some real advantages to carrying out biological pest control in the islands, and on balance these must not be taken for granted or we run the risk of losing one of our most powerful technologies for pest control. In this short paper I will review both the positive and negative factors affecting the prospects for biological control in Hawaii, and will give some concrete recommendations for improving these prospects given intelligent prioritization of available funding.

Foremost among the reasons for the slowdown in biocontrol projects is a heightened concern for protecting the safety of non-target species. Despite the fact that several recent studies have confirmed the excellent safety record of thorough, well-planned natural enemy importations by trained entomologists, biocontrol practitioners still operate under the cloud of suspicion from mishaps of indiscriminate introductions (vertebrates, snails, and generalist arthropods) carried out by untrained individuals with no state supervision early in the last century. The nature of the Hawaiian fauna, which in many taxa evolved in isolation from robust guilds of predators and parasitoids, makes it uniquely susceptible to perturbation by virulent imported natural enemies.

This has led to demands for ever more stringent host range testing of newly imported natural enemies in quarantine, and consequently greatly added costs for conducting biocontrol programs. For example, during a recent project in which state entomologists imported an Aphidiid parasitoid (all species of which in the entire world are known to be host specific to aphids) the demand for non-target testing was so insistent that scientists ended up conducting host-range tests with psyllids (of course with negative results).

The length of time it requires to get field release permits often exceeds the normal 3 year maximum cycle of most grant programs, making it more difficult to obtain funding for biocontrol projects. In addition, the restrictions and lack of balance have discouraged some trained experts from even attempting needed biocontrol programs.

As the cost of lengthy quarantine testing increases, the benefit/cost ratio for projects decreases, in some cases falling beneath the threshold for viability given the small size

of most crops throughout the state. If one assumes that the cost of conducting a classical biocontrol project is relatively constant regardless of the acreage of the crop to which it is applied, then large or very valuable crops (such as oranges in California, with 194,000 acres) will have much greater payback in benefits than smaller crops (such as macadamia nuts in Hawaii, at 18,000 acres). Even smaller crops will have a hard time justifying the high costs of research that lengthy quarantine testing entails.

Quite apart from the real non-target issues that must be addressed by research, there are severe bureaucratic obstacles to obtaining the necessary permits for field release of biocontrol agents, at both the State and Federal levels. The Federal regulating authority, USDA-APHIS, has statutory authority only to regulate plant pests, and it has a hard time justifying how a host-specific insect parasitoid can be considered a plant pest. Given the recent break-up of APHIS into plant protection and Homeland Security divisions, a high turnover of personnel, and a lack of efficient communication with their state counterparts, the Federal bureaucracy adds untold time and expense to many biocontrol projects, frustrating those who are attempting timely response to pest invasions. On the State side, a redundant listing process and the elaborate review of every detail by the state Attorney General's Office similarly confounds any hopes of action in a short time frame.

Another problem in Hawaii is a relative lack of quality quarantine space in which to conduct the required research. The main facility, the Hawaii Dept. of Agriculture Quarantine in Honolulu, is an older building that is not well compartmentalized, has a lack of greenhouse space, and is insufficient to meet the needs of the current pest influx into the state.

Finally, on the negative side, there is generally a poor perception of the practice of biological control by the lay public in Hawaii, based in large part on the errors of untrained individuals 50 years ago or more, and by the negative press in newspapers, magazines, and legislative testimony that has followed suite. This negative perception, fueled by conservationists justifiably frustrated by mistakes of the past, feeds back to funding, permitting, and legal agencies that respond by instituting more stringent rules and requirements for conducting programs.

However, all is not pessimistic in the prospects for biological control to remediate pest invasions. For one thing, Hawaii has a rich and strong tradition in the practice of classical biocontrol, with more introductions of natural enemies than any other place in the world (with the possible exception of California). Out of 681 natural enemies introduced, 254 are established and contributing to pest control, with complete control of 38 insect species and 7 weed species; and substantial control of another 143 insects and 3 weeds. This translates to tens of millions of dollars of savings annually, with no additional inputs, and also accounts for huge reductions in the amount of toxic chemical pesticides that otherwise would have been sprayed into Hawaiian ecosystems each year. Thus to a large extent state, federal, and university entomologists recognize and appreciate that biocontrol is a largely safe and eminently cost effective method that is usually given serious consideration soon after a new arthropod or weed pest becomes established in the state.

Hawaii also has a strong contingent of entomologists with ample biological control training and experience that, combined, can bring a huge amount of expertise to bear in conducting both safe and effective biocontrol programs. For a relatively small state, we have a broad array of institutions, including the University of Hawaii at Manoa, several linked USDA-ARS laboratories, the Bishop Museum, the state Dept of Agriculture Biological Control Division, a USDA-APHIS lab, and an Institute of Pacific Islands Forestry that all have active biocontrol researchers.

Also on the positive side, the unique Hawaiian fauna gives us an opening to conduct some biocontrol programs with a great deal of confidence in the safety of natural enemy

introductions against certain taxa. Because the native arthropod fauna is generally depauperate, there are entire families of insects missing in the islands, which greatly simplifies the conduct of biocontrol when an invasive from one of those families becomes established. An example of this is the Aphididae—of which there are neither endemic nor indigenous species in the state. Therefore host specific aphid parasitoids can be released with minimal risk of non-target impact, in a way that would be impossible in the more rich and complex insect fauna of the mainland U.S. In fact, the state regulatory authorities have recognized this and issued full release permits in advance for all species in the sub-family Aphidiinae (Braconidae) and the genus *Aphelinus* (Aphelinidae), cognizant of their host specificity to aphids.

When biological control was practiced exclusively on agricultural lands, it was sometimes seen as though farmers and environmentalists were on opposite sides of the fence concerning the safety and utility of this technology to fight invasive pests. Increasingly, however, conservationists are recognizing that biocontrol is the safest, most practical, and most cost effective method, (in fact, at times the only method) that can be used to fight invasive species in broad areas of natural habitat in which chemical pesticides are not a viable option. This perspective is leading back to a more balanced view of biocontrol in which the risks and benefits are not viewed without a context, but, rather, in contrast to the risks and benefits of other options for pest control, including the option of doing nothing.

What are the immediate prospects for using classical biological control to manage invasive species in Hawaii? In large part it depends on the taxonomic affinities of the invasive pest. A newly invasive aphid, for example, since it has no close relatives in the islands, would be fairly easy to address in a biocontrol context. A tephritid fruit fly would be of intermediate difficulty: challenging because there are known related non-target tephritids of concern, but do-able because we have a great deal of experience and knowledge of the non-target biology, susceptibility, and protocols for host range testing in quarantine (Duan and Messing 1996). However, for new pests that are closely related to taxa with a large and diverse array of endemic species (such as some families of Lepidoptera and Hemiptera), it will be very difficult to gather enough data in quarantine to address all the possible non-target concerns necessary to get field release permits in the course of one scientist's career. Only with exceedingly tight host-specificity (always a possibility, given the wondrous biology of many insect parasitoids) can we hope to find a natural enemy that is safe to release against an invader that has close endemic relatives.

There are several things that can be done to improve the prospects for biocontrol in the state, given the right priorities. Firstly, increased financial support should be given to systematists, who provide us the essential framework we so often need for pest, natural enemy, and non-target taxonomic questions. Secondly, we should streamline the permit bureaucracy, maintaining a strong level of biological review but minimizing the extent to which the regulatory framework lacks efficiency, rationality, transparency, accountability and ecological meaning. Third, we should lobby hard for increased quarantine space that could be available to all cooperators working together to fight invasive species in the state. Finally, increased attention should be paid to educating the lay public about the advantages of biological control; not only the economic benefits to farmers and consumers, but the environmental benefits of reducing invasive species' impact and minimizing the output of toxic chemicals into Hawaiian ecosystems.

There is every reason to believe that with perseverance and adaptability in the face of the current challenges, classical biological control can continue to make enormous contributions to the economic and ecological well being of the Hawaiian Islands.

**Literature Cited**

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