STRATEGIES FOR EXPANDING AND IMPROVING OVERSEAS RESEARCH FOR BIOLOGICAL CONTROL OF WEEDS

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Abstract. The following recommendations are made to improve overseas research on biological control agents. Conduct more long-term overseas evaluations. Place much greater emphasis on field host range studies. Carry out more research on impact and efficacy of potential agents. Perform more ecological research overseas on target weed. Adhere to international standards for biological control studies. Document all findings including failures

Key words: pre-release impact assessment, code of best practices, field host range

NEED FOR MORE OVERSEAS RESEARCH

For many, but not all, invasive exotic pests, classical biological control is a management option that should be considered. For pests that are widespread or established in remote areas, classical biological control may be the only viable control technology. The introduction, release, and establishment of the natural enemies of exotic weeds obviously require research in the region where the pest is native. I began conducting evaluations of potential weed biocontrol agents in their native range shortly after receiving my Ph.D. in entomology at the end of 1977 (Balciunas and Center 1981). Most of my career has been spent in international exploration, and I've been fortunate to meet and work with many other entomological explorers from many countries, whose task has been to identify potential biocontrol agents in the native range of the host plant. I've also worked closely with quarantine scientists in USA and Australia. Through this experience, I have gained a personal appreciation not only for what types of overseas research works and what doesn't, but also for which approaches are most likely to be effective.

The dramatic increase in international travel and commerce regrettably has been accompanied by an increase in the introduction of new weeds. Development of biological control agents for some of these new weeds has been a high priority, but the increase in numbers of targets has required the expansion of investment in international research. In some cases, this has been as simple as choosing a location and cooperator and making arrangements for shipment of potential agents. In other cases, extensive and intensive research on the potential agent in its native range is not only desirable, but necessary.

Practitioners of the biological control of weeds, unlike those involved in the biological control of insect pests, have long sought to minimize impacts on non-target species. Evaluations of host-specificity have been routine for almost four decades. Initially, the concern was primarily non-target impacts on commercial crops, but today, potential non-target impacts on native plant species receive the most attention. Host specificity with respect to native plant species usually must be evaluated in quarantine where the release is proposed. This has exacerbated a bottleneck to the expeditious evaluation of potential biological control agents because quarantine space and resources are limited and expensive. Moreover, adequate testing to secure approval for release of a new agent usually will require many years of evaluation in quarantine. In contrast, a single week-long visit to the native host range could easily reveal a dozen species feeding on the target plant. It is more efficient to screen these potential agents for host specificity in their native range, than to tie up scarce quarantine resources in initial evaluations for polyphagy or in nurturing small, non-viable laboratory colonies.

OVERCOMING RESTRICTIONS TO EXPANDED INTERNATIONAL RESEARCH

Although international research on new targets, as well as expanded research on current targets, is highly desirable, a number of factors restrict an expansion in international research. I briefly review two of these restrictions and offer some suggestions to overcome them.

Insufficient Funding for International Research.

Current funding for international research to develop biological control agents for invasive weeds is not only far from optimal; it is below critical levels. We lack the financial resources both to launch projects on new weeds and to successfully address current targets. Significant new funding is seldom available, and current funding is stretched thin. A string of successes in weed biocontrol would stimulate development of further funding; however, few funds are currently available to ensure such future success. The best near-term solution would be to reallocate current resources to increase the likelihood of success for key projects. Fewer, better-funded projects more likely would generate such successes. However, this would mean terminating or delaying projects that appear to offer little chance for success. A weed that has many closely related species native to the area where an agent would be released will require far more effort and funds, and will most likely have fewer acceptable agents, than a weed with few or no close relatives in the region of release.

Weed targets for which other countries already have developed successful biological control agents should be a high priority for support, because much of the international research will have been completed. In 1996, we launched a project targeting Scotch thistle (*Onopordum acanthium* L. – Asterales, Asteraceae). While this was a new target for North America, the Australians had been conducting international research on Scotch thistle for many years, and, by 1996, had cleared and released several promising species. For the U.S. we could concentrate on evaluation of the most promising of these (Balciunas *et al.* 1998). Unfortunately, the first two potential agents evaluated, the weevils *Lixus cardui* Olivier (Coleoptera, Curculionidae) and *Trichosirocalus sp. nov.*, were unsuitable for release in the US because they readily attacked native American thistles (Balciunas, unpublished data). Thus, the use of transfer agents developed for release in other countries is not a panacea; significant additional testing will likely be necessary, especially if the agents had received only cursory initial screening. For instance, the moth, *Cactoblastis cactorum* (Berg) (Lepidoptera: Pyralidae), provided spectacular control of *Opuntia* cactus in Australia, but in the Caribbean, it was found to attack endangered native *Opuntia* cactus in Florida (Pemberton 1995).

Scarcity of Suitable Overseas Laboratories or Collaborators

While ecological theory and the successes of biocontrol research suggest that effective biocontrol agents are most likely to be found in the native range of the target weed, few overseas laboratories specialize in biological control research, and they seldom are located near appropriate areas for survey. War, civil unrest, and natural catastrophes, such as a massive earthquake, flood, or volcanic eruption may restrict access to appropriate areas. If sufficient funds are available, stationing an American scientist in the appropriate region is often the most efficient strategy. Research and exploration can be focused on the priorities of the home laboratory and the scientist easily can be relocated when the project is completed or the location proves unrewarding or inhospitable. Since it is difficult to persuade mid- or late-career scientists to commit to a lengthy overseas assignment, young scientists are frequently assigned such projects. Domestic surveys of natural enemies already present for the weed in its new range will familiarize the scientist with the target host and appropriate collecting techniques, and will help him/her to discriminate among types of damage to the target before he/she goes overseas. It will also allow a supervisor to assess the capabilities of the scientist before assignment to a distant, foreign location. When lack of funds or staffing constraints prevent assignment of a staff scientist, local scientists may be contracted to conduct the desired research. Although salaries and research costs are likely less, more supervision and communication are required to assure successful completion of the project. The supervisor should plan annual site visits and the local scientist should visit the US laboratory to better understand the status of the pest and its biology where it is invasive and to interact with U.S. cooperators. When local biological control experts are available, their collaboration can facilitate a successful project considerably to the benefit of both cooperating laboratories. For example, Stefan Neser, at South Africa's Plant Protection Institute, has contributed substantially to the search for potential biological controls for Cape Ivy (also known as German ivy, (*Delairea odorata* Lemaire, synonym *Senecio mikanioides* – Asterales, Asterales)) in its native home. With his guidance this project quickly compiled a complete list of herbivores and began evaluations of some of the most promising (Balciunas 2000a).

If local scientists are unavailable, trained scientists from a third country may be hired to conduct the research in the desired region. USDA-ARS maintains biological control laboratories in Australia, Argentina, and France and their staff regularly conduct surveys in areas far distant from their laboratories. Likewise, biological control specialists from CABI Bioscience, based in London and Switzerland, can be contracted to conduct research almost anywhere. However, those organizations may require reimbursement for all costs, including salaries and overhead.

Some projects rely on short exploration trips by staff scientists to the native range of the target host to produce likely candidates for quarantine research. I do not recommend this approach because it is not an efficient use of scarce quarantine resources and because it is less likely to produce effective biological control agents.

RECOMMENDATIONS FOR IMPROVING OVERSEAS BIOCONTROL RESEARCH

Growing concern about the safety of biological control, coupled with the need for more biocontrol successes mandate that international research be appropriate and efficient. Since research funds are scarce, it is also important that international research not only be productive in the development of new biocontrol agents, but also that agents are successful at limiting the spread or impact of the target plant. The following recommendations are made for conducting overseas biological control research that is both efficient and effective.

Invest in long-term research.

Overseas research can be divided into two categories: 1) opportunistic, short-term forays, and 2) long-term research. While I sometimes dismiss short-term forays as "grab-and-run", there will always be a role for quick studies. Frequently, the best sites for intensive surveys and long-term research cannot be determined from the literature making personal inspection of potential long-term study sites necessary. For example, because the native range of hydrilla is broad comprising the tropical parts of Asia, Australia, and Africa, I made three, 6-month trips between 1981-82, repeatedly collecting natural enemies in these regions (Balciunas 1985). Northern Australia was selected as the best location for long-term research on several potential agents.

However, projects that rely solely on short trips to the native range of the target plant to supply potential agents and preliminary data are (in my view) 'penny-wise and pound foolish.' When untested agents are only sporadically available, their evaluation in quarantine will proceed slowly. Only the most easily collected and reared are likely to receive sufficient evaluation to support a release request. This approach gambles that a suitable agent will be found before funds and interest in the project fall below critical levels.

By contrast, long-term projects can complete the extensive surveys necessary to document completely the natural enemies of the target host. A short list of potential agents can then be prepared and methodically evaluated, both in the field and in quarantine. For example, a 5-year survey of melaleuca (*Melaleuca quinquenervia* (Cav.) Blake – Myrtales, Myrtaceae) trees in Australia yielded over 400 herbivores (Balciunas *et al.* 1995); we were able to recommend nearly 30 as deserving further study.

Once an overseas laboratory is established, host-specificity testing can usually be conducted far more easily in the native host range than under the restricted, containment conditions of a quarantine facility. Extensive host range tests overseas eliminate inappropriate agents, and speed up the quarantine testing for good agents.

Emphasize Field Research Overseas.
While laboratory host-range tests conducted in the native host range are desirable, field evaluations of the host range are even more valuable. In Australia, we routinely not only tested the host range of a potential agent under laboratory conditions, but also regularly conducted field surveys of related species and other potential hosts for these same insects (Balciunas *et al.* 1994, 1995, 1996). These field data were critical clarifying ambiguous laboratory tests (such as a low reproduction rate on a non-target host) and eventually in gaining release approval for agents that would have been eliminated otherwise.

Conduct More Research on the Efficacy of Potential Agents.
Most practitioners of weed biocontrol feel that an agent is safe if it has a negligible impact on non-target species. However, ecologists are now finding that some of these presumably <u>safe</u> agents can have deleterious ecological impacts. For example, gall flies (*Urophora* spp. – Diptera, Tephritidae) released to control some knapweeds have become extremely abundant on the knapweed target, but have failed to reduce the knapweed populations. Fortunately, there has been no evidence of a direct impact on non-target plants. However, there is now good evidence that field mice (*Peromyscus* sp. Rodentia, Rattidae) are using the abundant overwintering *Urophora* pupae as their primary winter food, and that this has led to markedly higher populations of field mice (Pearson *et al.* 2000).

To me this confirms the need to emphasize an agent's efficacy as much as we do its safety. An ineffective agent not only can cause unpredictable changes to the food web and the environment, but its development also wastes scarce biocontrol resources that could have been devoted to better agents. Determination of probable impact is difficult to do in the lab, but sometimes possible under field conditions overseas. In Australia, we demonstrated that insects at natural, ambient levels, quickly inhibit growth of *Melaleuca* saplings by comparing the growth rates of saplings that had been sprayed with insecticides, with those that had not been sprayed (Balciunas and Burrows 1993).

Conduct More Research on the Biology and Ecology of Target Weed in its Native Range.
In its native range, the target weed is frequently innocuous and sometimes uncommon; almost always little known about its biology and ecology. Research in the native range of

the weed could reveal the weak points in its life cycle and allow us to choose more effective agents. Better knowledge of the weed's distribution and environmental requirements in its native range can help us predict additional localities that are susceptible to invasion (Balciunas and Chen 1993).

Adhere to International Standards for Research in Host Countries

Overseas researchers must familiarize themselves with the rules and regulations for collecting, testing, and shipping specimens in each of the countries that they visit. Failure to do so may lead to unpleasant outcomes, not only for them and their project, but to scientists who follow.

Recently, I helped to formulate a Code of Best Practices for workers in the field of biological control of weeds. In July 1999, delegates attending the Xth International Symposium for Biological Control of Weeds ratified this Code (Balciunas 2000b). Like other practitioners, overseas researchers should adhere to the principles outlined in the Code (Table 1). We are receiving increased scrutiny from ecologists and the general public. Adherence to the Code not only will make our subdiscipline safer, but will assure its greater acceptance by the public.

Document Findings and Failures.

Each weed biocontrol project may require decades of research and turnover of staff is inevitable. Likewise, old targets may receive new attention, especially when they invade new regions. Thus old research is valuable to new scientists. While all scientists have an obligation to document their research, this is especially critical in our discipline. Much research may be repeated because the original findings, including failures, were not documented adequately in accessible literature. While refereed journals are preferred, symposium and conference proceedings are a good outlet for data and observations that are of local interest.

ACKNOWLEDGEMENTS

I thank the organizers for allowing me to share these personal observations.

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Table 1. Code of Best Practices for Classical Biological Control of Weeds (as approved July 9th, 1999, by the delegates to the X International Symposium on Biological Control of Weeds, Bozeman, Montana)

1. Ensure that the target weed's potential impact justifies release of non-endemic agents
2. Obtain multi-agency approval for target
3. Select agents with potential to control target
4. Release only safe and approved agents
5. Ensure only the intended agent is released
6. Use appropriate protocols for release and documentation
7. Monitor impact on target
8. Stop releases of ineffective agents, or when control is achieved
9. Monitor impacts on potential non-targets.
10. Encourage assessment of changes in plant and animal communities
11. Monitor interaction among agents
12. Communicate results to public