Prediction and Practice in Biological Control

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Summary
Evaluating the potential of a new biological control agent is notoriously difficult when it has not been introduced anywhere else previously. Attempts to find order amid the complexity of plant herbivore systems have produced generalisations, hypotheses and empirical point scoring systems. As more case studies become available, analyses in hind sight tend to strengthen some generalisations and weaken others, but fundamentally they are only generalisations and have very limited value for predictive purposes. Guidelines for prediction may never be available in the form currently expected and the approach to the problem requires reorientating. More consideration needs to be given to ecological principles rather than ecological theory and to the biology and ecology of the weed.

Introduction

The majority of agents imported and released for biological control of weeds do not achieve that aim. Some do not establish, others establish, but have little or no effect on the status of the weed. This is a continual source of frustration and a waste of resources, yet attempts to do better are notoriously difficult and make little progress, to the extent that many workers feel it is not worthwhile, preferring to rely on release of the agent as the only valid test of finding whether it will be successful. This brief account looks at why predictability needs to improve, why several attempts to see some order in the system have failed and how the approach might be changed.

Why Prediction?

Efficient use of resources

Looking at recent examples from CSIRO, each biological control agent has taken from one to six years, with a norm around two years, to study its biology and host-specificity, to import it through quarantine and to rear it and make initial releases. This is a considerable investment of facilities and research time, and if invested in an ineffective agent represents a wastage of the scarce research dollar. This wastage tends to be accepted because we are unable to do better, but this hardly justifies not trying to do so.

Quarantine justification

Apart from a waste of resources, the inability to predict outcomes can be irresponsible, or at the least, a hindrance to programs, if there are any quarantine risks attached to an introduction. A slight risk might be considered justified if a beneficial outcome, in terms of control, can be predicted with some confidence; otherwise it might not.

It is also important to note that the more that prediction involves better knowledge of the weed agent system, the more it also enables integrated management of a weed to be contemplated based on biological control, but in combination with other options.

Prediction from generalisations

Universal truths have tremendous predictive power and attempts to improve prediction in biological control have often centred on a search for such truths, or at least some order, in a very complex field of ecology. This search has often taken the form of analyses of large data banks (e.g. 8) and the discovery of correlations that become generalisations that in turn are used for predictions.

This approach has a very basic flaw. There is a major difference between finding that the majority of successful agents have a certain characteristic and saying that only agents with that characteristic are likely to be successful.

A recent summary of some of the generalisations proposed in recent literature points out that whether it is the supposed greater chance of success of agents with higher rates of increase (2), the supposed higher rate of success against inbreeding weed species (1) or the suggested greater effectiveness of agents forming new associations with a host (7), in each case there are many successful agents that do not conform to these predictions (4). In practice, to try to use such proposals in choosing agents would risk seriously under-rating potentially effective agents.

The impression is that in the desire to establish some theoretical base that can be used to guide the practice of biological control, assistance should be sought in generalised ecological theory, whether it be plant genetics, plant architecture, the evolutionary consequences of specialisation or theories of r and K selection. However, while biological control has provided a significant amount of data for ecological theory, there has in fact been little effect of ecological theory on biological control practice (3).

Point scoring systems

A more pragmatic approach that has tried to take into account a much broader range of attributes of a potential biological control agent is the point scoring system first proposed by Harris (6) and later modified by Goeden (5). Harris had the specific aim of predicting successful agents and rated a number of attributes of the agent to give an overall score. However, biological control workers have tended to dispute the categories used and the rankings given. Goeden (5) increased the number of categories, revised the rankings in the light of more recent knowledge and introduced the concept of three phases, corresponding to three different times during the study of an agent, when its attributes might be rated. This author's revision is an improvement, but there are two basic problems: there is almost no attention given to the ecology of the weed and several of the categories considered are still based on generalisations.

A different approach

Both the correlation-based approach and the point scoring system are too superficial. There is a need to return to basic ecological principles and develop a methodology that is robust enough to cope with the variety of situations that exist. It requires a slightly different philosophy. When Crawley (3) concludes that there are certain characteristics that seem to render some weeds difficult to control, rather than saying that weeds with inaccessible carbohydrate and protein reserves are difficult, one needs to be asking how such reserves are important in the dynamics of the weed and how does a particular agent affect these reserves. As an example, one could consider such a weed, perhaps a herbaceous perennial, and an agent that does not directly damage these reserves.

Typically, such a weed persists from season to season by carrying over reserves that are used to produce the new season's growth. They may also be used to produce spurts of growth at particular times, e.g. stem production, and to produce regrowth after damage. They are normally built up or renewed during the active growing season.

If there were 100% loss of reserves in each season, the population would not persist. It could no longer be a perennial. One might therefore ask, at what % loss per season would the population start to decrease? Depending on the species, a 30% loss might mean only approximately 30% of available shoots regrow, or 30% of mature plants die each year for instance. The rate of recruitment from seedlings or other propagules would need to be considered along with the relation between age and reproductive status.

For the agent, is the damage it produces a single event that requires the use of reserves to produce replacement growth, does it require the continued use of reserves to repair continued damage or to support "physiological sink" growth e.g. galls, or does it decrease the efficiency with which reserves are renewed, or perhaps a combination of two of these?.

In the case of the first possibility, it would be important to know whether the weed can make good its losses before the next damage occurs and whether there any environmental constraints on this process, natural or externally applied. The aim is obviously to try to answer the question of whether the agent can produce a long term decline in the reserves, either alone, or in combination with some other factor.

Such a set of questions could be arranged in the form of a computerised key, such that only the relevant ones are considered for a given situation. Some other examples are given elsewhere (4). The aim would not be to assign a score, but to rate an agent in terms of its probability in producing a certain level of reduction of the weed's population density.

Application

To a biological control practitioner, any proposal involving a long series of questions requiring knowledge of the biology and ecology of the weed and the agent is likely to meet immediate resistance on the basis of lack of knowledge and lack of time and resources to aquire that knowledge.

However, if the reasons for needing to predict efffectiveness are considered, there is a sequence in time implied. The more difficult considerations, with regard to justifying introduction and manipulating the system, come after increasing amounts of time have been spent and there has been greater opportunity to aquire additional knowledge. In a parallel manner, this is what Goeden (5) had in mind when he introduced his three phases into the point scoring system. There is no doubt that if one has no knowledge whatsoever of the weed's status in its country of origin, any hope of prediction is forlorn. However, as soon as there is some, the questioning might commence, no doubt with a lot of gaps at first, but it would at least increasingly point out what was the important information required. This in itself, would be a significant advance if we are to make biological control a more predictive science.

References

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