

Comparing methods of selecting effective biological control agents for weeds

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Summary

Three methods of assessment of the effectiveness of biological control agents: 1) scoring agent's attributes; 2) statistical analyses, and 3) the ecoclimatic approach are compared by listing the group of attributes that agents should possess to be effective based on each of the three methods. It is concluded that the ecoclimatic approach would select the most effective agents and distinguish between similar related effective and non-effective agents when the other two methods would fail to do so.

Introduction

During the past twenty years three methods of assessing the effectiveness of biological control agents for weeds before introduction have been developed.

- 1) by scoring certain biological attributes that the agent possesses itself or *vis-a-vis* its host plant on a scale for each attribute and then adding the scores (7,8).
- 2) by statistical analyses of past programs to correlate the establishment and level of control achieved after introduction by each agent with attributes of the agents themselves and *vis-a-vis* their weed hosts (1,2,3,4,10).
- 3) by an ecoclimatic approach whereby the agents are selected on their ability to reduce high populations of the target plant in its region of origin and to maintain that low level in an ecoclimatic situation as similar as possible to that of the weed infested region (15,16).

The attributes that the most effective agent should possess when selected by using each of the three methods are compared here.

1. The Scoring Method

Harris (8) first laid down both the attributes of an agent itself and *vis-a-vis* its weed host that should be scored and the scoring within each attribute. Subsequently this method has been modified in the light of experience, other workers recommendations and changes to the scoring of attributes (7).

Based on Harris's (8) original scoring system the most effective agent would be:- a large, widely distributed, highly fecund, multivoltine, oligophagous, colonial feeder which destroys the plant's vascular system (and/or seeding capacity for annuals and biennials) throughout the growing season (or seeding period) but which is heavily parasitized, predated or diseased by specialised natural enemies.

The chief differences as regards the attributes of the most effective agent between Harris's (8) original scoring method and Goeden's (7) modifications is that there is no longer a stress on large, oligophagous agents and based on Wapshere's (15) recommendations the scoring of the agent should take into account ecoclimatic similarity between the native range of the agent and

the weed infested region. Other than this the attributes of the most effective agent are basically the same.

Harris (8) also indicated that leaf miners or gall formers should not be selected. Because in the interim some gall formers had been found to be effective Goeden (7) raised their status but leaf miners were still regarded as ineffective. Because some highly specific agents had proved effective his scoring does not rank oligophagous agents as highly. Neither selected any particular taxonomic group(s) of insects as more effective than others.

2. The Statistical Analyses

The attributes of an effective agent listed here are a combination of the characteristics that correlated with establishment and successful control in successive analyses (1,2,3,4). The agents on *Opuntia* spp., on *Lantana camara* and on other weeds were analysed separately but as there are only minor differences the successive analyses and the analyses for the three weed groups have been combined to give one list of attributes. Only the correlation analysis in Julien *et al.* (10), concerning the insect families of the agents, is relevant here and Crawley's (1,2,3,4) correlations later produced very similar results.

Based on the correlations the most effective agent would be:- a small, widespread and abundant, highly fecund, multivoltine, rapidly developing, colonial feeding dactylopiid, curculionid, chrysomelid, cecidomyiid or pyralid which causes per organism little individual damage to the plant.

However, Crawley (1,2,3,4) did not detect any correlation between the mode of attack and biological control success. That the agent should do little damage as an individual to the plant appears to be counter-intuitive but according to Crawley (1,2) it is because small agents tend to have a high rate of natural increase and can readily build up damaging populations on their plant host.

3. The Ecoclimatic Approach

The attributes of an effective agent using the ecoclimatic approach are based here on the scheme for estimating effectiveness in Wapshere (16).

On this scheme the attributes of the most effective agent would be:- the organism that most causes target plant populations to decline from a high level to a low one and if possible maintains the plant at that low level in an ecoclimatic situation as similar in regard to as many other ecological factors as possible to that of the weed infested region. In order to select the organisms involved in the population reduction of the target plant, high infestations of the plant are searched for and/or created and then studied.

No selection of a particular type of agent nor of a particular mode of feeding is made *a priori*.

Discussion

A direct comparison can be made between the attributes of the most effective agent based on the scoring method (7,8) and those, derived from the correlation analyses (1,2,3,4). Except for the selection of agents that are particularly damaging to the plant's vascular system and/or are most individually damaging to the weed in the first case and selection of agents that cause little individual damage and from the families of insects which possess the most effective agents in the second, there is a general concurrence between the two sets of attributes.

It is more difficult to make a comparison between the ecoclimatic approach and the other two methods except to point out that Goeden (7) adds control of host in the native range as evidence of effectiveness and includes ecoclimatic similarity as one of his attributes. The ecoclimatic approach would also select, as effective, small agents which build up damaging populations on their host plants. Because the ecoclimatic approach measures whether such effective attributes as the agent possesses can be realised under the ecoclimatic situation where control of the weed is desired it is a more direct measure of effectiveness than the two other methods.

Basically, the scoring method is not effective in separating unambiguously the several agents which are clearly damaging on any particular weed (16). Since the attributes selected by correlation analyses are mostly similar there is no reason to suppose that that method is any better in this regard. Another difficulty with the correlation method is that it is a statistical exercise and only applicable on average. It is quite possible, occasionally, to have a weed which is controlled in its home range in an ecoclimatic situation closely similar to the infested region by an agent which would not have suitable attributes as given by the analyses.

Confirmation of the value of the ecoclimatic approach is provided by one attribute not used in the comparisons above. The scoring method includes and the statistical analyses confirm that agents that have been already successful elsewhere are more likely to be successful when released in a new region (1,2,7,8,9,10). Modifying that statement to include that the agent should be successful in controlling the weed in its home range as well (7) recognises the value of the ecoclimatic approach.

The two other methods would not have separated the ineffective *Cyrtobagous singularis* from the effective *C. salviniae* for the control of *Salvinia molesta* (4). However, if the *Cyrtobagous* species in sub-tropical Brazil (5,6) had previously been studied on dense *S. molesta* growing in nutrient rich lakes, i.e. the ecoclimatic situation where control was desired in Queensland, Australia (11, 12), it would almost certainly have been found to reduce the target plant to low levels particularly now that it is known that high nutrient levels increase the rapidity of control of *S. molesta* by *C. salviniae* (13,14). Thus, the ecoclimatic approach would have selected the Brazilian *Cyrtobagous* species as the most effective agent to control *S. molesta*.

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