

THE BIOLOGICAL CONTROL OF *OPUNTIA AURANTIACA* IN SOUTH AFRICA: EVALUATION AND EMERGING CONTROL STRATEGIES

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ABSTRACT

Evaluation of this partially successful program began only in 1972, thirty-seven years after the initial release of the cochineal, *Dactylopius austrinus*. Three current approaches are reviewed: (i) quantitative assessments of established natural enemies; (ii) the monitoring of new releases; and (iii) an analysis of the community structure of phytophagous insects on opuntias. This research has provided insights for the biological control of *O. aurantiaca* and may suggest profitable approaches for the assessment of other weed control programs.

INTRODUCTION

In this paper I shall outline the work we have done to assess and evaluate biological control of the pasture weed *Opuntia aurantiaca* Lindley, in South Africa. Biological control of this weed was initiated nearly 50 years ago and a cochineal insect released in 1935. No attempts were made then to assess quantitatively the effects of this release. Presumably the precedent with the biological control of prickly pear in Australia convinced workers at the time that detailed study and assessment of releases was superfluous and unnecessary; consequently all we have today are brief descriptive accounts of what happened when the cochineal was released. Because of this lack of foresight and understanding, biological control was deemed, erroneously, to have failed and South Africa became totally committed in 1957 to an expensive herbicidal control program against jointed cactus (or tiger pear as *O. aurantiaca* is known in Australia).

The problem we have with this weed is probably similar to many elsewhere: the biological control of jointed cactus has been neither a spectacular success nor a hopeless failure. The increasing costs of herbicides and labour have made us look anew at our options in biological control and have forced us to pick up the superficial threads of evaluation which were abandoned so many years ago.

ASSESSMENT AND EVALUATION

Assessment of established natural enemies

I confine my comments to the cochineal *Dactylopius austrinus* De Lotto whose biology and history of introduction to South Africa is now well known (Petrey 1948, Moran and Annecke 1979, Moran and Cobby 1979). *Cactoblastis cactorum* (Berg) does damage *O. aurantiaca* in South Africa but it was never intentionally imported for use against this weed and its effects have not been measured.

Exclusion experiments (Zimmermann *et al.* 1974) have shown 'that cochineal is responsible for the mortality of large numbers of jointed cactus plants especially in the drier areas, that much of the regrowth becomes reinfested by cochineal, and that cochineal limits spread and propagation of the plant by decreasing the production of cladodes' (Moran and Annecke 1979). The latter authors also comment that 'Probably the most important contribution to

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research on *Opuntia aurantiaca* has been the work of Zimmermann (1977, 1979) who developed—at least for certain veld types—an accurate and repeatable technique for assessing and describing infestations. It provides precise data on age-structure of the weed populations and has also been applied for measuring cochineal populations on jointed cactus. The technique permits, for the first time in nearly a century of control by various methods, evaluation of the success or otherwise of control procedures'.

Zimmermann's careful numerical assessment of jointed cactus and cochineal populations permitted measurement of the efficiency of the herbicidal control program against jointed cactus and showed that efficiency is directly related to plant clump size (aggregation). He also showed that the level of plant aggregation is directly related to the percentage of *O. aurantiaca* plants bearing populations of the cochineal insect, *D. austrinus*. The importance of these quantitative studies on the plant cannot be overstressed. From this work Zimmermann (1979) was able to demonstrate that the herbicidal control program in South Africa is in direct conflict to biological control: he has now produced recommendations on the basis of this realization which emphasize the need for: (a) 'research aimed at replacement of the paraffin (kerosene) carrier in the herbicide with substitutes that are cheaper and do not have an insecticidal effect on natural enemies of jointed cactus'; and (b) for research aimed at 'defining "threshold densities" of jointed cactus and cochineal populations which will permit a sensible delimitation into areas suitable for either chemical or biological control' (Zimmermann 1979). This is the first step towards an integration of chemical and biological control of jointed cactus in South Africa, and these recommendations are being put into effect.

Laboratory and field studies on the biology of the cochineal itself have revealed a major shortcoming of this insect as a biological control agent. The effectiveness of *D. austrinus* against *O. aurantiaca* is seriously hampered by the limited dispersal of the wind-blown female crawlers (Gunn 1977, 1978, 1979), so the behaviour of the female crawlers in relation to dispersal has been investigated. These tiny insects show many interesting adaptations to wind dispersal which Gunn (1979) hoped to exploit in experiments using elevated 'towers' designed to improve dispersal of *D. austrinus* crawlers in the field. It is still unclear whether this technique has helped in biological control of the target weed.

Colonization of the host plant by the first stage nymphs (crawlers) is also receiving attention: their success in colonizing a new host plant is drastically influenced by whether or not they have made a dispersal 'flight', by the position and condition of the cladode on the host plant, and by several other biotic and abiotic factors that are still being explored. Eventually I hope to gain an understanding of the ability of cochineal to disperse, colonize and reduce jointed cactus densities under different field conditions, and this will allow a statement on the effectiveness of this insect as a biological control agent.

Monitoring of new releases

This aspect has received high priority in our evaluations. Hoffmann (whose results are reported more fully elsewhere in these *Proceedings*) has carefully monitored releases of *Tucumania tapiacola* Dyar on jointed cactus and has drawn up an informative partial life-table for this species. His study has emphasized the importance of this approach in understanding the deficiencies of some insects as biological control agents against weeds, and in providing a

simple model for predicting the progress of an established natural enemy. We are using the same techniques for pre- and post-release studies on the pyralid moth *Mimorista pulchellalis* (Dyar) which was liberated for the biological control of jointed cactus in October 1979.

The community structure of phytophagous insects on opuntias

Further insights into the biological control of jointed cactus are provided by viewing the insects on the plant in the context of the cactophagous community on opuntias as a whole (Moran 1980). This general approach was discussed by Lawton and Schröder (1978) at the IV International Symposium on Biological Control of Weeds in Gainesville and I believe that it may be instructive in the analysis and evaluation of many programs in the biocontrol of weeds.

My analysis of the *Opuntia*-feeding community was based on the records and observations of Mann (1969) and Zimmermann *et al.* (1979) who listed a total of 122 specialist phytophagous species of insects on 119 species of *Opuntia* in South America. This fauna has been analysed to show the number of insect species in different taxa and to give the average complement of species on large and small opuntias: the size of the host plants was shown to be the determining factor in the number of species of insects that are found on them. The majority of insect species on opuntias are oligophagous within the genus *Opuntia*: borers predominate, and apart from cochineal insects and one species of scale insect, there are no sedentary external feeders on opuntias. The co-evolution of *Opuntia*-feeding insects and their hosts has resulted in life-history strategies in these insects suited to an existence on structurally simple plants where the emphasis has been on the avoidance of predation and parasitism, and where evolution has culminated in guilds of specialist insects to the exclusion of nearly all generalist phytophages (Moran 1980).

Some of the implications of this study for the biological control of alien opuntias, and for jointed cactus specifically, seem obvious:

(a) The 'average' fauna found on low-growing, narrow-jointed opuntias in South America may suggest an 'ideal' complement and balance of insects for importation against jointed cactus. It seems that we need a complex of insects 'packed' onto the plant, chosen on the basis of effective partitioning of resources and lack of competition, and for their ability to damage the plant.

(b) Because few of the cactophagous insects are host-specific, the main effort of exploration should now focus on the insects attacking a broad range of *Opuntia* species and not only on those closely related to *O. aurantiaca*. Precedents abound which suggest that this approach may be useful.

(c) The highly specialized nature of the *Opuntia*-feeding insects suggests that conventional screening procedures could be considerably attenuated without risk. This, as well, is by no means a new idea.

DISCUSSION

These approaches towards an evaluation of the biological control of jointed cactus have helped to achieve a perspective and a partial understanding. What is lacking in this analysis and assessment, however, are data on the plant/insect association gained from observations in the field in South America. For example, we lack information on the density of *O. aurantiaca* at various localities in

different countries; on the numbers and species of insects collected from individual host plants; on the co-existence of various phytophagous insects on *O. aurantiaca*; on the patterns of damage to the host plant by individual species of insects; and on the frequency of occurrence of each of the phytophagous species on jointed cactus in its native land.

These basic data on the interactions between the insect community and the host plant may be vital in guiding research and control strategies, and in further understanding the performance of the introduced natural enemies on jointed cactus in South Africa. Certainly, a fuller evaluation of this biological control program would be possible if this information were available, and I suggest that this may be a problem and a deficiency in the assessment of other weed control programs elsewhere.

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