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BIOLOGICAL CONTROL OF HARRISIA CACTUS, *ERIOCEREUS MARTINII*, IN QUEENSLAND BY THE MEALYBUG *HYPOGEOCOCCUS FESTERIANUS*

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ABSTRACT

Harrisia cactus, *Eriocereus martinii* Lab., is a major weed in Central Queensland, the State Government spending up to $700 000 a year on control. Four South American insects for biocontrol were introduced from 1974 to 1976; three are established in the field.

The mealybug *Hypogeococcus festerianus* (Lizer y Trelles), first released in 1975, established easily and showed early promise. By 1979, control far exceeded expectations and the use of chemicals was suspended.

The problem of prediction in biocontrol is illustrated by this mealybug, as damage to the plant in Australia greatly exceeds that in South America.

Evaluation methods are discussed and some results shown.

INTRODUCTION

Harrisia cactus was introduced to Queensland during the 1890s and first recorded as a weed in 1935. A control scheme was established by the State Government in 1952, using herbicides, large-scale scrub clearing and deep ploughing, and costing $7 000 000 between 1965 and 1980. Biological control was considered early in the program, but dismissed after a survey in 1958 in the Americas (J. Mann, pers. comm.). A second survey was carried out in 1972 (F.D. Bennett, pers. comm.) and as several promising species were found, a three-year program in South America was undertaken by the Commonwealth Institute of Biological Control under contract to the Queensland Department of Lands.

INSECT SPECIES INTRODUCED

Sixteen species of insects were found to be restricted to *Eriocereus* and related genera, and the following four species were sent to Australia between 1974 and 1976 (McFadyen and Tomley 1978).

Alcidion cereicola **Fisher (Coleoptera:Cerambycidae)**

Native to Paraguay and northern Argentina, with a wide host range within the sub-tribe Cereanae, this stem-boring cerambycid only attacks older, woody stems. Adults live two to six months and lay several eggs a night, inserting them into the stems. Larval tunnelling destroys the vascular tissue, and heavy attack results in the death of all above-ground tissues. Regeneration from the underground tubers, however, is rapid and young stems are not attacked as larvae drown in soft or very turgid stems. In Argentina, parasitism was very low; there was high mortality of young larvae from December to July, apparently caused by the high turgor of the plants during the wet season (McFadyen and Fidalgo 1976).

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First releases were made at Collinsville in 1974 and the beetles rapidly established and dispersed. Large colonies are now present at many sites and are causing or contributing to the collapse of large areas of dense cactus. However, as regrowth is not attacked, *Alcidion* alone does not result in a sufficient degree of control.

Hypogeococcus festerianus **(Lizer y Trelles) (Hemiptera:Pseudococcidae)**
Found on many cacti in the sub-tribe Cereanae, this mealybug occurs over a wide climatic range, from Mendoza in Argentina (33°S and 830 m altitude) to the Paraguayan Chaco (23°S and 70 m altitude). Adults and nymphs congregate on stem and bud tips where feeding arrests cell division locally and causes severe spiralling and distortion of growth. The resulting clusters of knotted stems form protected sites in which the mealybug colonies persist. The mealybug is not at all abundant in Argentina, however, being apparently controlled by a complex of three predators and seven parasites (McFadyen 1979b). At least one of the predators, a cecidomyid, rapidly eliminated colonies in the laboratory and would seem to be a major controlling factor. The situation seems a classic example of the patchy distribution described by Huffaker (1958), where both predator and prey are rare and are seldom encountered together.

In Queensland, colonies established at once after releases at Collinsville in 1975 and increased rapidly, so that laboratory rearing was abandoned in 1977 in favour of collection and distribution of infested stems from the field (McFadyen and Tomley 1978). Several predators attack the mealybug in Queensland but none are effective and on dense cactus enormous colonies build up within one to two years. Stem growth, flowering and fruiting are prevented and ultimately the whole plant dies including the underground tubers, it is thought from exhaustion of carbohydrate reserves. Regrowth from seed or deep tubers, stem fragments, etc. is rapidly infested and killed. By April 1980, many thousands of hectares had been infested with the mealybug.

Eriocereophaga humeridens **O'Brien (Coleoptera:Curculionidae)**
Restricted to the arid north-east of Brazil, *E. humeridens* attacks several cacti in the sub-tribe Cereanae. The flightless, long-lived adults lay eggs singly on the cactus stems, covering them with a protective layer of mud and faeces. The larvae develop rapidly pupating in cocoons in the stems and emerging as sexually immature adults. The life cycle in Brazil is synchronized with the rainfall, the adults aestivating during the very dry summer and recommencing oviposition with the winter rain. Parasitism of eggs, larvae and pupae reached 75 per cent (McFadyen 1979a).

Releases were first made at Collinsville in 1976 and 1977 and establishment was slow initially. Several colonies are now established, but population increase appears to be slow and damage to the cactus is less than that caused by *Alcidion.*

Cactoblastis **new sp. (Lepidotera:Phycitidae)**
Restricted to *Eriocereus bonplandii* (Parmentier) and *E. martinii, Cactoblastis* has only been found in the Chaco. Its life history and parasites are similar to those of *Cactoblastis cactorum* (Berg) (McFadyen 1980).

An initial laboratory colony sent from Argentina in 1976 died out; a second one in 1978 increased rapidly and large releases were made in 1978 and 1979. Establishment has not so far occurred and it now appears that the larvae do not thrive in the water-stressed cactus typical of Queensland, especially in dry summers such as those of 1978 and 1979.

EVALUATION METHODS

In general, evaluation studies are undertaken to demonstrate the degree of control attained by a biological control agent. If control is effective, the results can be used to show that the reduction in plant density has in fact been caused by the agent and thus to support the use of biological agents in future weed control programs (McLaren and Amor 1979). If control is not or only partly effective, the evaluation results can be used: a) to demonstrate the degree of control which is achieved, which may not be obvious if there is a gradual retreat or loss of vigour by the weed; and b) to show why a particular agent was ineffective and thus suggest what new agents should be introduced or sought. The methods used should be adequate for these purposes, without requiring large amounts of investigators' time.

As discussed by Forno and Harley (1976) for lantana, evaluation is difficult with a perennial plant growing as an impenetrable prickly scrub. Harrisia cactus propagates vegetatively, forming dense clumps, thus in practice it is impossible to define a 'plant' (Chapman 1976); while measurements of biomass are destructive. It was therefore decided to use measurements of percentage cover. The pin methods used for grasses, herbs, etc. were unsuitable for the dense tangles of Harrisia under brigalow scrub associations, and fixed line transects were adopted (Phillips 1959). At each sample area, ten permanent transects each 20 m long were marked out along compass bearings taken from a table of random numbers. On each sample occasion, a line considered to have zero width was laid along the transect and the length crossing live cactus was measured. This method is reasonably objective and thus does not vary greatly between different observers, and it is quick, enabling several sites to be sampled. It does not distinguish between old, large plants, 2-3 m high, and new regrowth only 50 cm tall, although the biomass and seed production of the former will be many times that of the regrowth. However, it was felt that successful control would ultimately result in a reduction in per cent cover as well as biomass (McFadyen and Tomley 1978) and this belief has since been justified. No attempt was made to count insect numbers, which in the case of the stem borers can only be done by destructive sampling, while with the mealybug absolute counts are impossible. Consequently, the presence or absence of the insect on a plant was noted and its abundance recorded on a three-point scale.

RESULTS

Results obtained at three of the first release sites are shown in Figure 1. At all three sites, the 1978 to 1980 levels are significantly ($P < 1\%$) lower than in 1977. In 1977, there was significantly ($P < 1\%$) more cactus at Dingo Bore B site where *Alcidion* was not present, than at the other two sites where *Alcidion* was released in 1974. However, by 1979 and 1980 there was significantly ($P < 1\%$) more cactus at the Dingo Bore site A where mealybug had only been present since 1978 and death of cactus from mealybug attack has not yet occurred, than at the other two sites where mealybug was released in 1975 and cactus first began to die in summer 1977/78.

Where mealybug has been present for three or more years, the reduction in per cent cover has been spectacular. Much of the ground is now bare earth; grasses may now colonize this, but competition by other plants is not a factor. As per cent cover is now near or at zero at two sites (no living cactus on the transect lines), 10 x 10 m quadrats have been marked out using the transects as a base line, and counts made of plant number and total stem length. Plants are defined as a rooted stem; it is feasible to count these once cover has fallen below

RESULTS

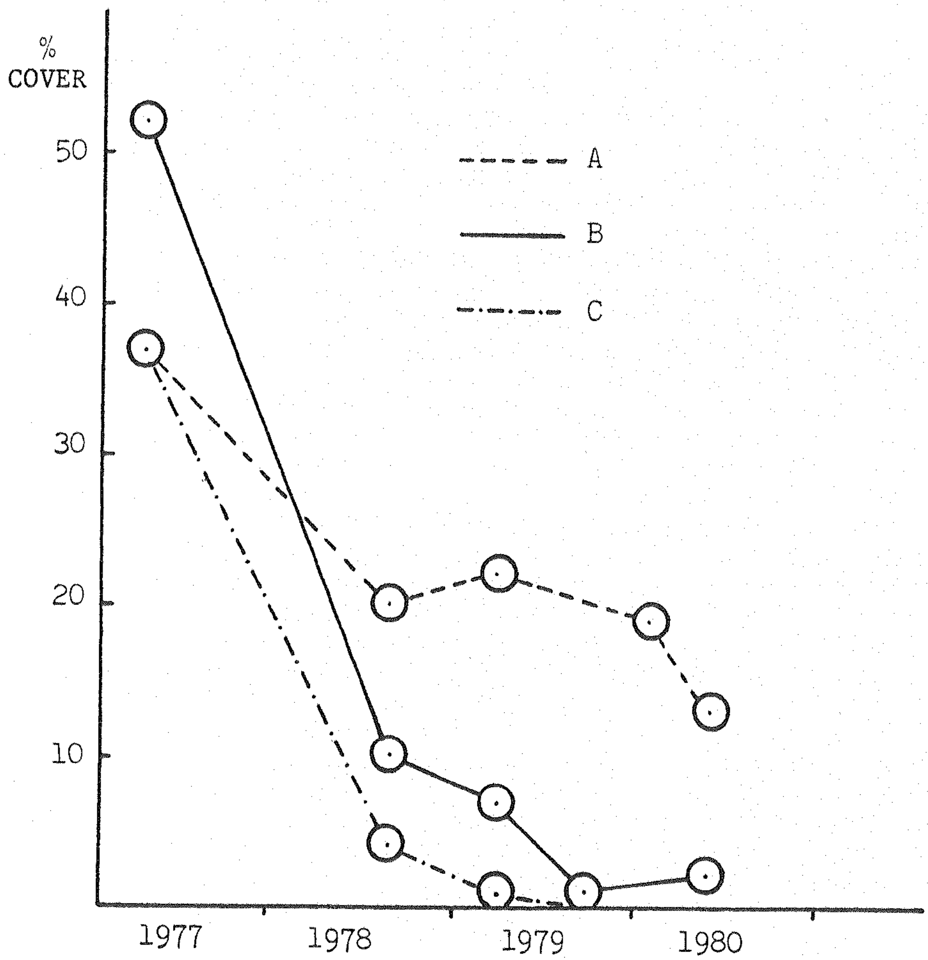

Figure 1. Changes in percentage cover by Harrisia cactus at three sites in Collinsville

A – Dingo Bore site A (*Alcidion* released 1974, mealybug present 1978)
B – Dingo Bore site B (mealybug released 1975, *Alcidion* present 1978)
C – Stony Hill (*Alicidion* released 1974, mealybug released 1975)

10 per cent. These counts are only available from August 1978, but at the Stony Hill site there are now 19 plants in the 1000 m^2 examined (190 plants/hectare) with a total stem length of 1.6 m (16 m/ha). In 1956, one year after herbicide treatment, counts of regrowth gave a total of 140 000 plants/hectare (T. Cole, pers. comm.), this may be considered successful control!

DISCUSSION

At the present time, this project appears to be a major success. Other methods of control, chiefly herbicides, have been discontinued since September 1979. Because the spray gangs are now employed spreading mealybug, control costs are still relatively high, but it is expected that the Harrisia cactus scheme in Collinsville will ultimately be phased out completely, at a saving to the State Government of at least $700 000 per year, the 1978/79 budget of the scheme. There is also an enormous saving to landholders, one of which had budgeted $46 000 for Harrisia control in two properties in 1978/79. Their costs are now reduced to the employment of one man to spread mealybug for perhaps a year.

There are still possible problems, mainly the survival of the mealybug when all the cactus in an area has been killed. At present, it seems that mealybug and *Alicidion* together destroy the cactus so completely that within four to five years there are virtually no above-ground stems left alive. Seed does not survive beyond four years, but deep tubers may develop new stems after all the mealybug in the area is dead. It is not yet known if re-distribution after several years may be needed, or if enough mealybug will survive on isolated plants. However, even if periodic re-distribution does become necessary, the program is still a success.

The success with this mealybug illustrates the difficulty of predictions in biological control of weeds. As stated, in Argentina the mealybug is controlled by parasites and predators and it was obvious that in the absence of these, very large populations might develop. However, based on the damage caused in Argentina, it was thought that the effects would be limited to the prevention of growth and reproduction, sufficient ultimately to control the plant, but neither swift nor spectacular (McFadyen unpubl. data). In the event, very large populations of the mealybug maintained for two or three years can kill even the largest plants outright. This was impossible to predict from its performance in its native area and the artificial production of such populations in the field in Argentina would have been impossible in the presence of the predators, even with the frequent use of insecticides and even had three years been available for such studies. Climate is not thought to be a factor, as in Argentina the mealybug occupies a very wide climatic range and it is also effective, although slower, in southern Queensland. Dispersal was seen as a possible problem, but in fact has been much better than anticipated. As shown in Figure 1, the cerambycid, *A. cereicola*, was released at Dingo Bore in 1974 and the mealybug was released a few months later about 0.75 km away. The mealybug and *Alcidion* arrived at the other sites more or less simultaneously in 1978, even though the cerambycid adults fly fairly readily. Apart from the normal wind dispersal of crawlers, the mealybug is thought to be carried on the coats of kangaroos and feral pigs, and is also dispersed on small pieces of infested cactus broken off and rolled around by pigs feeding on the underground tubers.

Another example of poor prediction is the *Cactoblastis* sp., which it now appears is not adapted to the dry cactus occurring in Queensland. In Argentina

Cactoblastis sp. occurs only in the eastern Chaco where annual rainfall is 1090 mm, far more than the 650 mm recorded at Collinsville. However, as *Cactoblastis* in the Chaco is found everywhere its host cacti, *E. bonplandii* and *E. martinii*, occur there was no reason to suspect that climate limited the *Cactoblastis* but not the cactus.

These examples demonstrate some of the problems in prediction in biological control. As the understanding of biological control increases, prediction will undoubtedly improve, but it seems to be inherently impossible to anticipate all possible effects of climate, parasites, etc. with the result that predictions may never be more than educated guesses. As the introduction of several species at once has still never been shown to be harmful, it would be wrong to delay the introduction of any otherwise suitable agent because of an 'educated guess' that it seems unlikely to be effective.

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