The Utilisation of An Invader Cactus Weed as Part of An Integrated Control Approach

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Abstract

After the partially successful biological control programme against *Opuntia ficus-indica* in South Africa, approximately 50 000 ha remains moderately to heavily infested with this weed. Management of these remaining infestations rely partly on the continuous action of the introduced insect enemies and on chemical control methods. However, in the very dense infestations (ca. 8 000 ha) the cost of control is prohibitive. By transforming these dense thickets into manageable plantations, the status of the prickly pear can be changed from a weed to a commercial crop. One method of achieving this involves the mass-rearing of the carminic acid-producing cochineal, *Dactylopius coccus*, for the extraction of a red dye. This has the potential to become a lucrative industry after the recent ban on some synthetic red dyes in certain food, cosmetic and pharmaceutical products, resulting in new demands for natural red dyes. The insects are reared on individual prickly pear cladodes which are picked from infestations and which are suspended in large open-sided sheds. Each cladode is artificially seeded with an optimum number of first instar nymphs. When the females have matured, which is after three to five months, they are removed from the cladodes and collected in containers, using compressed air. The females are killed and dried at 60°C for 2 d before being exported.

Introduction

The phytolcid moth, *Cactoblastis cactorum* (Bergroth) (Lepidoptera: Phycitidae), together with the cochineal insect *Dactylopius opuntiae* (Cockerell) (Homoptera: Dactylopiidae), made the largest contribution towards the spectacular clearance of about 75% of the approximately 900 000 ha once densely-infested with the prickly pear *Opuntia ficus-indica* (L.) Miller (Cactaceae) in South Africa (Annecke and Moran 1978). Except for slight cyclical, increases in the residue cactus populations, the level of control brought about by these insect herbivores has been maintained for over 40 yrs (Zimmermann and Malan 1980). In addition, effective and inexpensive herbicidal control methods have been devised to augment biological control (Zimmermann 1982).

The two insect herbivores, *C. cactorum* and *D. opuntiae* are largely ineffective along the south-eastern Cape coast near Uitenhage, 25.28°E; 33.40°S, where approximately 800 ha of dense prickly pear infestations persist. Clearance of these dense infestations by chemical means is difficult and uneconomical. Since it has been demonstrated that prickly pear will not re-invade areas that have been cleared by biological means (Zimmermann and Malan 1980), the perceived threat of the plant to agriculture has largely abated and the economically beneficial attributes of the plant can be exploited in the remaining dense coastal infestations.

*O. ficus-indica* originated from Mexico where it played a major role in the culture and history of the early Indian civilizations (Hoffmann 1983). For more than 6 000 yrs prickly pear has been cultivated as a multipurpose crop, and because of its usefulness the plant was deliberately spread around the world. In South Africa, some old novel uses are now being promoted which eventually may change the status of the plant: the cladodes are used as stockfeed, the fruits are sold and eaten fresh or preserved as jams or syrups, the young cladodes are marketed as a fresh vegetable known as Nopalitos (Zimmermann and Zimmermann 1987) and, most recently, the plant has also been used as a host for the mass rearing of the cochineal insect, *Dactylopius coccus* O. Costa., for red dye extraction. This paper describes a novel way to exploit commercially the dense stands of prickly pear by mass-rearing *D. coccus* insects and discusses possible conflicts of interest in the commercial exploitation of the weed.
Historical Background

When Ferdinand Cortez landed in Mexico in 1518 he found, beside other riches, a flourishing red-dye industry based on a centuries-old method of extracting carminic acid from *D. coccus* insects that were reared on prickly pear plants (Baranyovits 1978). As a result, a healthy export trade of cochineal dye from Mexico to the Old World developed which lasted for more than 300 yrs.

Following the discovery of the first synthetic red analine dyes in about 1870, the production of cochineal dye dwindled and almost became obsolete, not because of its inferior quality, but because the new synthetic dyes were cheaper and could be produced in larger quantities. Eventually only small breeding cultures survived in Peru and in the Canary Islands where much of the production was used for home industries.

Today the extensive use of many synthetic red dyes in the food, pharmaceutical and cosmetic industries has been questioned for health reasons, and many synthetic products are now being banned by health organisations (Walford 1984). This has resulted in an increased demand for carmine and consequently in the revival of the world carminic acid market which started some 20 yrs ago. Peru and the Canary Islands were the only two countries that could step up their production to satisfy the sudden world demand (Baranyovits 1978). According to leading colour manufacturers the new demand for carminic acid is here to stay and the world production of 400 t dried insects will have to be increased. Utilising the remaining dense prickly pear in South Africa by mass-rearing *D. coccus* for export will not only help to reduce the weed status of prickly pear in South Africa, but may, hopefully, boost the economy of the south-eastern Cape.

The Cochineal *Dactylopius coccus*

*D. coccus* is one of nine species in the family Dactylopiidae, and all are restricted in their host range to the Cactaceae (De Lotto 1974). Several species have been successfully utilised in the control of important cactus weeds (Moran and Zimmermann 1984). All of the nine *Dactylopius* spp. have carminic acid in their body fluids and this, presumably, serves as a deterrent against parasitoids (from which the family is entirely free) and predators (Eisner et al. 1980). *D. coccus* is the largest of the cochineal species and has the highest percentage carminic acid content by weight (19%). It can only survive on varieties of *O. ficus-indica* but was at one stage reportedly reared on *Nopalea cochinfoliifera* (L.) Salm-Dyck (Baranyovits 1978).

The mature, sedentary females are approximately 5 mm long and lay up to 300 eggs which hatch within 1 to 2 hrs of being laid. The mobile crawlers disperse, mainly by wind, to new cladodes or plants where they settle. The female crawlers take up to five months in winter and three months in summer to mature. Adult cochineal males are small, inconspicuous winged insects that resemble white flies. They do not yield carminic acid and play no role in the rearing process other than fertilizing the females.

Technique for Mass-rearing *Dactylopius coccus* on *O. ficus-indica*

In common with other cochineal species (Moran and Hoffmann 1987), *D. coccus* is easily washed from its host by rain and is therefore unable to survive in climates with even relatively low rainfalls. In Peru and the Canary Islands, *D. coccus* survives in the open and feeds on established plants because the climate is hot and dry. In the south-eastern Cape of South Africa the mean annual rainfall is approximately 480 mm which is evenly spread throughout the year, and *D. coccus* has to be reared under shelter. This is done by picking fully mature terminal cladodes which are then seeded artificially with cochineal crawlers before they are suspended from wire-hooks inside large (90 cm²) rearing sheds. After approximately three months in summer and five months in winter, the mature females are ready to be harvested. They are easily removed using a jet of compressed air which blows the insects off the cladodes into a collecting container. Some of these females are allowed to reproduce and their crawlers are used to seed fresh cladodes. All surplus females, including
those that were allowed to reproduce, are killed and dried for 3 d at 60°C before they are exported.

Preliminary data indicate that the annual production of dried cochineal for a 90 m² rearing unit is estimated at 75 kg and, valued at the current world price of US $ 30/kg, this amounts to a gross income of US $ 2 250.

Current research is aimed at improving this yield. The following aspects are receiving attention:

1) The high loss of 80% or more of the immature and mobile crawlers after the new cladodes have been seeded, is cause for concern. Studies on the dispersal and settling behaviour of the crawlers are envisaged that will hopefully lead to improved and more even settling;

2) The optimum rearing temperatures of females have not yet been clearly defined. Also, the conditions that lead to periodic excessive decay of cladodes are unknown and are receiving attention;

3) Contamination of the culture by D. opuntiae (Cockerell) that was imported for the biological control of O. ficus-indica, can interfere with rearing of D. coccus, and methods are being devised to prevent this.

There are approximately 800 ha densely infested with O. ficus-indica in a relatively confined area in the south-eastern Cape alone which is suitable for this proposed mass rearing of D. coccus. According to conservative estimates, three to four rearing units can be maintained for every hectare infested with prickly pear.

Conflict-of-interest

It is uneconomical to control dense prickly pear infestations (± 1 000 trees/ha) chemically. The potential gross income from 1 ha dense prickly pear can exceed US $ 8750/yr which includes an estimated amount of US $ 2 000 for the fruit. The utilisation of prickly pear may therefore encourage landowners to protect or even propagate prickly pear which will then be in conflict with Section 29 of the Conservation of Agricultural Resources Act of South Africa no. 43 of 1983. This Act prescribes methods of controlling or the eradication of prickly pear and prohibits the selling or transportation of any propagule of the plant that may promote its spread. This conflict may be avoided by promoting the planting and cultivation, if necessary, of acceptable spineless varieties, which are also easier to handle. However, as the purpose of this project is to promote the utilisation of dense infestations of the spiny prickly pear, any expenses incurred in cultivating prickly pear in these areas, would automatically erode the profit margin to the extent that it becomes uneconomical.

The extensive utilisation of the prickly pear as suggested here could however further discourage the introduction of any new cactophagous insects for its biological control in South Africa. The introduction of such new natural enemies is already complicated because of their threat to spineless cactus plantations (most spineless varieties are merely biomorphs of O. ficus-indica).

Conclusions

The biological control campaign against prickly pear in South Africa was only partially successful; small remnant infestations still exist in some parts of the country. Effective and inexpensive chemical control methods are available to reduce these infestations. Only a small area has remained so densely infested that it may be regarded as harmful and uneconomical to control.

The introduction of methods that economically utilise prickly pear will complement the programme of integrated control where methods are rationalised in all possible ways to improve the cost benefit ratio (Kluge, Zimmermann and Harding 1986).
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References


