Herbicidal control in relation to distribution of *Opuntia aurantiaca* Lindley and effects on cochineal populations

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Summary: Resume: Zusammenfassung

Five main points have emerged from this study: (i) populations of the cactus *Opuntia aurantiaca* Lindley are highly aggregated; (ii) searching efficiency of spray teams applying herbicides is low because they fail to locate small isolated plants; (iii) searching efficiency is positively correlated with aggregation of the target plant; (iv) the presence of the cochineal *Dactylolius austrinus* De Lotto is also positively associated with aggregations of the host plant and; (v) consequently, cochineal populations are selectively eliminated by current spraying techniques to the detriment of biological control. The implications of these findings are discussed in relation to future strategies for chemical and biological control of the weed.

La lutte chimique en relation avec la distribution d'Opuntia aurantiaca Lindley et ses effets sur les populations de cochenilles

Cinq points se dégagent de cette étude: (1) les peuplements de cactus *Opuntia aurantiaca* Lindley présentent une très forte densité; 2) l'efficacité des équipes de traitement, malgré leur minutie, est faible parce qu'elles n'arrivent pas à localiser les petites plantes; 3) cette efficacité est en relation directe avec la densité de peuplement de la plante visée; 4) la présence de la cochenille *Dactylolius austrinus* De Lotto est aussi en rapport direct avec la densité de la plante hôte et, en conséquence. 5) les populations de cochenilles sont sélectivement éliminées par les techniques courantes de pulvérisation, au détriment de la lutte biologique. Les implications de ces découvertes sont discutées en relation avec les modalités futures de la lutte chimique et biologique contre les mauvaises herbes.

Introduction

Jointed cactus (*Opuntia aurantiaca* Lindley), a native of South America, is a major problem in South African pastures. Unlike the familiar, large, tree-like opuntias, *O. aurantiaca* is a low-growing plant comprising many narrow cladodes which are readily dislodged. The cladodes are covered in numerous long barbed spines which are injurious to livestock. Propagation of the plant is entirely vegetative and every dislodged cladode or fruit has the potential to root and grow.

Control of the weed is partly achieved by spot-spray applications of hormonal herbicides, a method which is both expensive and time-consuming. Although reports on weed control measures frequently state that the cactus has been 'eradicated', 'effectively controlled' or 'cleared' from pastures by the use of herbicide treatments, these impressions have never been subjected to critical assessment. One aim of the present study therefore, was to assess quantitatively the efficiency of spray operators in detecting and treating jointed cactus in relation to the size and distribution of the target plant.

The cochineal insect, *Dactylolius austrinus* De Lotto, is also very important in certain areas in reducing population densities of *O. aurantiaca* (Petley, 1948; Mann, 1970). This biological control agent however, may be killed either by the paraffin carrier in herbicide sprays or as a consequence of death of the host-plant following chemical treatment. Thus a further aim of this investigation was to establish the effects of herbicide treatments on cochineal populations.
Materials and methods

The experiments were done in the Eastern Cape Province of South Africa near Grahamstown (26° 7'E, 33° 8'S). The pasture consisted of grass and low-growing shrubs, dominated by the bush *Pentzia incana* (Thunb.) Kuntze, known as 'false karroid broken veld' (Acocks, 1975).

A total area of 6 ha was selected for spot-spray application of the iso-octyl ester of picloram, with illuminating paraffin (kerosene) as the carrier. Because the herbicide usually takes several weeks to produce visible symptoms on jointed cactus, Waxolene oil solvent dye (lg/l) was added to the spray solution. By comparing numbers of dyed and undyed plants a few days after spraying, efficiency of the spray team could be assessed.

Jointed cactus and cochineal counts were made before and after spraying in ninety randomly-selected permanent transects (each 25 × 2 m). Each of the 50 metre squares per transect was assessed individually, using a 2 × 1 m frame divided across the centre and moved along the transect as counting progressed. All results were expressed as density of cactus plants per m² or as numbers of plants in the total 4500 metre squares sampled.

Previous analyses of the reliability of the sampling technique (Zimmermann, 1977) established, firstly, that this method of non-destructive, in situ counts on permanent transects gave a far higher degree of reliability than randomly selected transects because the inter-transect variation was very high. Secondly, it was found that the 95% confidence intervals about the mean were minimal with samples comprising more than thirty transects and this gave a reliable estimate of cactus densities in the areas surveyed. Lastly, it was shown that the counts made by different individuals on the same transects did not differ significantly (<5% variation).

Four categories of *O. aurantiaca* plants were counted: (i) individual unrooted cladodes which had been dislodged from the parent plant; (ii) small rooted plants each comprising less than five cladodes; (iii) medium plants comprising five to ten cladodes and (iv) large plants with more than ten cladodes. The presence or absence of cochineal colonies was recorded for each plant category.

The spray team comprised permanently employed, experienced spray operators. They did not know that their performance was being assessed and they were not aware of the significance of the small pegs denoting the transect lines.

Results

Distribution of the plant. *O. aurantiaca* distributions are highly aggregated and show a close fit to the negative binomial (Fig. 1). In other words, there is a very significant tendency for the cactus to occur in clumps. This is understandable in a
Plant that relies on vegetative propagation from cladodes that fall close to the parent plant. Dispersal of dislodged cladodes over long distances by animals and floodwaters occurs less frequently.

**Efficiency of herbicidal control.** Efficiency of the spray team was found to be low. Table 1 shows that about 21% of the single cladodes, 32% of small plants and about 12% of the medium-sized plants were overlooked during herbicide applications. The spray operators were always 100% efficient in locating and treating large plants.

The smaller plants are often hidden under grass and low bushes which must in part explain the low searching efficiency of the spray team. If this were the only or overriding cause, however, a high correlation would be expected between the amount of ground cover and searching efficiency. Percentage ground cover (Fig. 2) was assessed visually for each of the 4500 metre squares. Using pre- and post-herbicide treatment data for isolated plants only (to eliminate any influence of aggregation) no significant correlation was established between searching efficiency and ground cover (Fig. 2). Clearly some other factor is of major importance.

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**Table 1 Efficiency of spray teams in treating O. aurantiaca plants with herbicide**

<table>
<thead>
<tr>
<th></th>
<th>Single cladodes</th>
<th>Small plants</th>
<th>Medium plants</th>
<th>Large plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of plants in 4500 metre squares prior to treatment</td>
<td>3777</td>
<td>5381</td>
<td>346</td>
<td>31</td>
</tr>
<tr>
<td>No. of plants remaining untreated</td>
<td>805</td>
<td>1694</td>
<td>41</td>
<td>0</td>
</tr>
<tr>
<td>Percentage untreated plants</td>
<td>21·3</td>
<td>31·5</td>
<td>11·9</td>
<td>0</td>
</tr>
</tbody>
</table>

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Searching efficiency in relation to the distribution of the target plant. The distribution of *O. aurantiaca* in the field is highly aggregated (Fig. 1). It is clear that if aggregation were total, i.e. if all individual plants were found in clumps, searching efficiency of spray teams would increase greatly because no isolated plants would be missed and clumps would be easily located. Conversely, if individual plants were isolated and randomly distributed, searching would be extremely difficult and treatment efficiency would fall markedly, especially in the case of smaller plants. The importance of clumping as a determinant of searching efficiency is illustrated in Fig. 3. The correlation between searching efficiency and clump size was highly significant (*P* < 0.001) for individual cladodes and smaller plants and significant (*P* < 0.05) for medium-sized plants.

Treatment efficiency was also greater than 80% for the medium-sized plants (which are easily visible), and where these were aggregated in clumps of more than five individuals efficiency was 100% (Fig. 3).

**Herbicide treatments and host-plant distribution in relation to cochineal populations.** All large plants were eliminated by herbicide treatment (Table 1)
Fig. 3 Percentage searching efficiency of the spray team as a function of aggregation (clump size) of *O. aurantiaca*

Table 2 Number and percentage of *O. aurantiaca* plants bearing populations of the cochineal, *D. austrius*, before and after herbicide treatment

<table>
<thead>
<tr>
<th></th>
<th>Individual cladodes</th>
<th>Small plants</th>
<th>Medium plants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>With cochineal (%)</td>
<td>Total</td>
</tr>
<tr>
<td>Before treatment</td>
<td>3777</td>
<td>1267</td>
<td>33.5</td>
</tr>
<tr>
<td>After treatment</td>
<td>805</td>
<td>114</td>
<td>14.1</td>
</tr>
</tbody>
</table>

Fig. 4 The percentage of *O. aurantiaca* plants bearing populations of the cochineal insect *D. austrius* as a function of plant aggregation (clump size)
so that all cochineal died on these plants. Pre- and post-treatment counts of the smaller plants showed a marked reduction in the percentage of cochineal-bearing plants after spraying (Table 2).

If cochineal insects were randomly distributed on their host plants (irrespective of plant size or the degree of aggregation), then a reduction in host numbers following herbicide treatment would result in a proportionate reduction in the number of plants bearing cochineal. The percentage of cactus plants bearing *D. australinus* would be expected to remain unchanged. However, a significant positive correlation was found between the presence of cochineal and the degree of aggregation of the host-plants (Fig. 4). For individual cladodes and small plants the correlation was significant at $P<0.001$ and at $P<0.05$ for medium-sized plants. Bearing in mind that the efficiency of herbicide treatment is also correlated positively with aggregation of the cactus (Fig. 3), the marked reduction in the percentage of cochineal present after herbicide treatment (Table 2), is explained.

Discussion

These findings have clear implications for rationalizing the herbicidal and biological control programmes against *Opuntia aurantiaca* in South Africa. It is now opportune to define areas where (i) reliance should be placed on chemical control—that is, areas where the insect natural enemies are contributing little to jointed cactus control—and (ii) those areas that are suitable for manipulation to improve the existing degree of biological control or for release of new imported natural enemies.

In ‘chemical control areas’ spray teams should be instructed to direct their attention only towards large plants and clumps of the weed. Efficiency of control would then be increased while money and time expended would decrease. The present study has shown that it is unproductive even to attempt to search for and spray small plants and individual loose-lying cladodes.

In areas delimited for biological control, herbicide spraying against jointed cactus should cease because the large plants and clumps that are most effectively controlled chemically comprise the main reservoir for cochineal populations. In these areas the effect of *Dactylopius australinus* could be improved by enhancing dispersal of the insect (Gunn, 1977) or by other methods.

This discussion does not imply that the broad categorization, once achieved, should be permanent. On the contrary the decision to use either chemical or biological control procedures in any one area should be based on frequent assessments of jointed cactus and natural enemy population densities in the field.

This study has indicated that a premium should be placed on research aimed at (i) 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; (ii) defining ‘threshold densities’ of jointed cactus and cochineal populations which will allow a sensible delimitation into areas suitable for either chemical or biological control; (iii) establishing the relative effectiveness and costs of chemical and biological control; and (iv) importation of new natural enemies for use against jointed cactus in South Africa.

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References


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