Habitat management in control of *Astylus atromaculatus* (Coleoptera: Melyridae) in maize under subsistence farming conditions in South Africa

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Studies were conducted in South Africa to assess the potential role of a habitat management strategy developed for the control of cereal stemborers in control of Astylus beetle. This strategy involves intercropping maize with a stemborer moth-repellent fodder plant (Desmodium) (‘push’), with a stemborer moth-attractive host plant (Napier grass) (‘pull’), planted as a perimeter/trap crop around the plot (‘push-pull’ system). Treatments were habitat managed plots, comprising of ‘push-pull’ and ‘pull’ plots, and maize monocrop plots (control). A combination of choice tests and field trials were employed to evaluate any impact of this system on Astylus beetle colonization of maize fields. Results showed significant reductions in beetle populations in habitat managed plots (>60%). Similarly, there was a significant reduction in beetle capture (>50%) in Desmodium-baited yellow water traps in two-choice tests, although the total number of beetles captured was generally low (<50%). In addition, Desmodium caused a reduction of 11-15% in beetle captures in the multiple-choice tests. Habitat management thus shows potential for use in Astylus beetle management in maize in the affected areas, largely through the barrier effects of Napier grass.

Key words: Astylus, control, habitat management

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Introduction

The spotted maize beetle, *Astylus atromaculatus* Blanchard (Coleoptera: Melyridae) (Astylus beetle), is thought to have been introduced into South Africa from South America around 1916. This pest is distributed throughout the maize and sorghum growing areas of the country (Drinkwater, 1998) and also occurs in Lesotho and Swaziland. Astylus beetle is a polyphagous and opportunistic pollen feeder that utilizes many available food sources (Human & Nicolson, 2003). During the larval stage of its development, damage is caused to planted maize and sorghum seed, resulting in plant stand reduction. Adults feed on silks and kernels at the tip of maize ears and sorghum panicles, with heavy infestations leading to poor pollination and grain yield loss (Drinkwater, 1998). Diarrhoea and death of cattle have also been known to result from intake of large beetle numbers during grazing (Kellerman, Adelaar & Minne, 1972).

Methods currently recommended for the control of Astylus beetle include chemical seed treatment, chemical sprays (Nel et al., 2002), preparation of a fine seedbed and planting during moist soil conditions (Drinkwater, 1998). Although application of chemicals on the crop is effective, there is a continuous high influx of beetles from surrounding areas that re-infect the sprayed crop (Du Plessis & Van den Berg, 2001). Astylus beetle is attracted to yellow colour and yellow traps baited with 2-phenyl ethanol lures have been found to attract and trap significant numbers of the beetle (Estherhuizen, 1997); (Van den Berg et al. 1999). In the current study, a habitat management strategy developed by the International Centre of Insect Physiology and Ecology (ICIPE) and partners for control of cereal stemborers was evaluated for its possible effect on colonization of maize fields by Astylus beetle. In this system maize is intercropped with silverleaf Desmodium (*Desmodium uncinatum* Jacq.) while Napier grass (*Pennisetum purpureum* Schumach) is planted around the field (Khan & Pickett, 2004). The intercrop produces volatiles repellent to gravid stemborer moths (push) while the trap crop is an attractive host (pull) (‘push-pull’ system). Napier grass is also used on its own as a trap crop around maize fields of small-farmers in South Africa to protect the crop against Lepidopterous stem borers (Van den Berg et al., 2001).

The purpose of this study was to determine the impact of habitat management on Astylus beetle numbers in maize fields and to determine the effect of the presence of one of the components of the habitat management system (Desmodium) on the relative attractiveness of flowering sorghum and lure-baited traps to beetles.

Material and methods

Studies were conducted at Potchefstroom (26°43’S, 27°06’E), South Africa, during the cropping season (October to March) of 2002/2003 in fields where large-scale evaluation of the impact of the ‘push-pull’ system and the use of *Bacillus thuringiensis* transgenic maize (Bt maize) on arthropod diversity was done (Midega et al., 2005; Midega et al., 2006). Treatments consisted of six fields measuring 38 m by 35 m laid out in a completely randomized design. Two of these were planted with Bt-maize (Cultivar: Phb33A14), while the remaining four were planted with non-Bt-maize (Phb33A13). The Bt-toxin expressed in this maize makes it toxic to some species of lepidopteran pests that feed on it, with no effect on Astylus beetle.

In total, two maize fields were allotted to the ‘push-pull’ system by planting silverleaf Desmodium between the rows of maize, with Napier grass planted around the fields. The Napier grass was approximately 2.0 m high at the time of the experiment. One maize field was developed into a ‘pull’ system by planting Napier grass around a block of non Bt-maize.
Each of these had one field planted to maize alone, serving as controls. A method adapted from Smart et al. (1994) and Khan et al. (2001) was used to create plots within the established maize fields. Random paired plots of 5 m by 5 m along perpendicular transect lines bisecting treatments and control fields were demarcated, using six replications in each field.

The impact of habitat management on Astylus beetle numbers in maize

To assess any impact of habitat management on Astylus beetle infestation, counts of adult beetles on maize were done from the six replicated plots in each field described above. At peak flowering, each maize plant in each of the six plots per field was carefully inspected and Astylus beetles counted. Beetles were specifically observed on the ears (silks) and tassels. Data were expressed as mean number of Astylus beetles per plant and plot. The mean number of beetles per plot and per plant was subjected to two-sample t-tests for any differences between habitat-managed treatments and their controls. Means of non-transformed data are presented in tables.

Multiple-choice tests

These choice tests were conducted at peak flowering of sorghum (which is highly attractive to Astylus beetles) to assess the potential repellent effect of Desmodium volatiles on the beetles. This experiment was conducted in a sorghum field at Potchefstroom during the 2002/2003 cropping season. Large fields were demarcated, using six replications in each field. Four traps were spaced 13 m apart. Beetles were trapped over a period of 6 hours between 09:00 and 15:00 before counts were taken. This was done because beetle activity (feeding and walking) was previously observed to be significantly higher during this time of the day compared to earlier of later when beetles largely aggregate and remain in one position (Esterhuizen, 1997).

Data were log-transformed (log10[n+1]) before analysis using Statgraphics 5 Plus (Statgraphics, 2000). Data were subjected to one-way analysis of variance (ANOVA), thereafter pre-planned orthogonal contrasts were run to test for the effect of Desmodium in repelling the beetles, the effect of the volatile in attracting the beetles and any effect of Desmodium in masking the attractiveness of the volatile. Means of non-transformed data are presented in tables.

Two choice tests

This experiment was conducted to determine the effect of the presence of Desmodium on the relative attractiveness of the traps baited with 2-phenylethanol, to Astylus beetles. This study was conducted in a greenhouse using a cage measuring 2.6 m × 1.3 m × 1 m, covered with a mosquito netting mesh of 2 mm. Two yellow water traps were baited with 2-phenylethanol lures to enhance their attractiveness as described above. Each trap was placed above a cylindrical cage 0.3 m high and 0.2 m in diameter. One cylindrical cage contained a potted Desmodium plant, so that the trap above it was situated in plumes of Desmodium volatiles. The other cylinder contained a pot without a plant. One cylinder with its trap was positioned at each end of the cage. One hundred beetles were released at the centre of the cage from a Petri-dish and left for 24 hours before traps were emptied and numbers determined. This was repeated 10 times. A two-sample t-test was used to analyse data.

**Table 1** Mean (±S.E.) number of Astylus beetles per plot and plant under the habitat managed and maize monocrop systems

<table>
<thead>
<tr>
<th>Cropping system</th>
<th>Habitat managed plot</th>
<th>Maize monocrop</th>
<th>t-value</th>
<th>P-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean number of Astylus beetles per plot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Push-pull/Bt-maize</td>
<td>45.2 (13.4)</td>
<td>453.3 (71.1)</td>
<td>-6.3</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Push/pull/Non Bt-maize</td>
<td>252.3 (11.7)</td>
<td>648.8 (49.1)</td>
<td>-8.8</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Pull/Bt-maize</td>
<td>69.3 (10.5)</td>
<td>280.2 (44.1)</td>
<td>-4.6</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Mean number of Astylus beetles per plant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Push-pull/Bt-maize</td>
<td>0.5 (0.2)</td>
<td>5.2 (0.3)</td>
<td>-13.5</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Pull/pull/Non Bt-maize</td>
<td>1.3 (0.2)</td>
<td>5.3 (0.4)</td>
<td>-8.6</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Pull/Bt-maize</td>
<td>0.6 (0.2)</td>
<td>3.5 (0.4)</td>
<td>-8.1</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Results and discussion

Astylus beetle counts per plot and per maize plant were significantly lower in the habitat-managed plots than in the control (maize monocrop) plots (P<0.05), with >60% reduction in beetle numbers in the former (Table 1). These results showed a marked reduction in beetle numbers in habitat-managed plots, even though the overall beetle populations were low during the season. Astylus beetle is known to be poorly attracted to green-coloured objects (Van den Berg et al. 1999) and a possible explanation to the trend observed in the current study could be that Napier grass acted both as a visual and a mechanical barrier to the immigrating beetles. Napier grass may act strongly as a barrier under field conditions when host seeking beetles colonize maize fields from surrounding areas.
The surrounding Napier grass completely obscured the flowering/silking maize plants, making them invisible to the immigrating beetles that do not fly high enough, resulting in low beetle numbers colonizing the maize crop in these systems.

Various complex blends of volatile plant compounds leave the plant surface and are transported away by wind. In the atmosphere around maize leaf surfaces more than 90 components have been detected (Buttery & Ling, 1984). Although not measured in the current study, it is known that higher plant densities reduce wind speed in agroecosystems (Bottenberg & Irwin, 1992). The associated plants in the ‘push-pull’ and the ‘pull’ fields may have reduced the speed/turbulence of wind in the plots, thereby interfering with the release and transport of the volatiles from maize used by Astylus beetle adults in locating the flowering and silking hosts. This interference may have either failed to provide a sufficient concentration gradient for the continuous release and transport of the volatiles from the maize surface, mechanical blockage of the volatiles by the Napier grass, together with the low wind speed, or both. The effect of Desmodium on the beetles was not significant (Table 2). Moreover, the presence of Desmodium did not significantly reduce the attractiveness of the traps baited with the lure (Tables 2 and 3). In the two-choice tests however, the mean number of beetles captured per trap was significantly lower (P<0.05) in lure-baited traps with Desmodium (12.3%) than in the lure-baited traps alone (26.6%). This could possibly be attributed to the presence of Desmodium. However, since the overall capture of beetles was low (<50%), the data need confirmation.

### Table 2 Mean (±S.E.) number of Astylus beetles captured per trap in the multiple choice test inside a sorghum field

<table>
<thead>
<tr>
<th>Trap design</th>
<th>Mean number of Astylus beetles captured per trap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water trap</td>
<td>143.9 (22.3) b</td>
</tr>
<tr>
<td>Water trap + Desmodium plant</td>
<td>126.5 (17.7) b</td>
</tr>
<tr>
<td>Water trap + lure*</td>
<td>350.6 (47.0) a</td>
</tr>
<tr>
<td>Water trap + Desmodium + lure</td>
<td>315.8 (47.5) a</td>
</tr>
</tbody>
</table>

F-value 10.9

P <0.01

Means followed by different letters are significantly different at P=0.05.

Lure = 2-phenylethanol

### Table 3 Pre-planned contrasts on the effects of Desmodium and lure in repulsion and attraction of Astylus beetles, respectively, to the traps in the multiple choice tests (P=0.05)

<table>
<thead>
<tr>
<th>Effect</th>
<th>Contrast/test</th>
<th>Probability level (P-values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desmodium in repelling beetles</td>
<td>Water trap vs. Water trap/Desmodium</td>
<td>0.7369</td>
</tr>
<tr>
<td>Lure in attracting beetles</td>
<td>Water trap vs. Water trap/lure</td>
<td>0.0003</td>
</tr>
<tr>
<td>Desmodium in masking attractiveness</td>
<td>Water trap/lure vs. Water trap/Desmodium/lure</td>
<td>0.5027</td>
</tr>
</tbody>
</table>

### Acknowledgements

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### References


STATGRAPHICS PLUS, 2000. Stagraphics, a Manugistics product, Manugistics, Inc. Rockville, Maryland, USA.