Monitoring and control of coffee bean weevil, *Araecerus coffeae* (Coleoptera: Anthribidae), in southern African citrus orchards

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*Araecerus coffeae* has recently been recovered from citrus fruit in low altitude areas of Swaziland and Mpumalanga province, South Africa. Although this pest is cosmopolitan and therefore not a phytosanitary problem, infested fruit may still be rejected for export due to the presence of live insects. An investigation of alternative host plants showed that the beetles completed their life cycle in fruit from mango (*Mangifera indica*), marula (*Sclerocarya birrea*), Natal mahogany (*Trichilia emetica*), Cape ash (*Ekebergia capensis*), forest toad tree (*Tabernaemontana ventricosa*) and in old sugar cane (*Saccharum officinarum*) stems. The beetles were monitored in citrus orchards using sticky pipe traps containing either a cut orange or caged male *A. coffeae*. Caged virgin female beetles on yellow sticky traps were not attractive. Contact mortality from various insecticides was assayed by dipping adult beetles in diluted insecticide for 30 seconds. The most effective products tested were cypermethrin, deltamethrin, dichlorvos, profenofos and trichlorfon. Other bioassays were conducted in large cages using baits comprising chopped orange and either methiocarb, tartar emetic, trichlorfon or pyriproxyfen as insecticide. Laboratory and orchard evaluations with the insect growth regulators pyriproxyfen, teflubenzuron and triflumuron gave unsatisfactory results. Trials where chopped oranges on the orchard floor were sprayed with tartar emetic were evaluated using traps. This may be the most suitable treatment for IPM orchards, although it did not provide complete control during the evaluation period.

**Key words:** Anthribidae, *Araecerus coffeae*, *Araecerus fasciculatus* s.l., citrus, control, host fruit, monitoring.

*Araecerus coffeae* (Fab.), the coffee bean weevil (CBW), is more often known as *A. fasciculatus* DeGeer but the former name was recently restored by Zimmerman (1994). Although CBW is recognised as a cosmopolitan stored product pest (Childers & Woodruff 1980), it has been recorded as a citrus orchard pest in the USA (Childers & Woodruff 1980; Childers 1982a,b) and Japan (Fujii et al. 1985). In southern Africa, CBW was first noticed as a citrus pest in 1992 on hail-damaged fruit at Tambankulu in Swaziland. Since then it has become problematic in citrus orchards in other low-altitude (lowveld) localities in South Africa and Swaziland. The beetle usually oviposits in citrus fruit that has been slightly damaged but occasionally does so in unmarked fruit. It can complete its life cycle in the fruit and its presence may result in fruit being erroneously culled in the packhouse for lepidopteran infestation. CBW has been recorded as a pest of sugar cane (*Saccharum officinarum* L.) in Brazil (Box 1953) and Cameroon (Nonveiller 1969). Many citrus orchards in the lowveld are adjacent to sugar cane fields or indigenous vegetation. The suitability of sugar cane and other fruits as alternative hosts was, therefore, investigated. The other research objectives of this study were to develop a monitoring technique and control measures for CBW.

**Materials and methods**

**Host plants and rearing**

Small rearing experiments were conducted with different potential host materials which could be found in the same environment as the beetles. The host material was placed in ventilated plastic boxes with adult beetles of both sexes to see whether or not a second generation would be produced.

**Monitoring**

As one of us (GJB) had observed that CBW was attracted to cut citrus fruit, a few different trap designs were evaluated that used cut fruit as an attractant. In one design, pieces of cut orange (*Citrus sinensis* (L.) Osbeck) were placed in a Sensus trap (dry, bucket-type fruit fly trap). In a second design, half a fruit was suspended above a paper plate covered with polybutene. In a third design, a cut fruit was suspended inside a PVC pipe approximately 20 cm long and 10 cm in diameter, with the inside bottom surface coated with polybutene. An attempt was also made to determine whether virgin female beetles were attractive to males in a ‘Delta Valencia’ orange orchard where beetles were known to be present. Five yellow polyvinyl
sticky traps (7.6 × 14 cm), coated with polybutene were fitted with cylindrical cages (2 × 1 cm) pasted to the face of the trap. Five virgin females from a laboratory colony were placed in each cage. Fresh citrus peel was provided as food for the beetles on a weekly basis via a hole in the back of the trap. The traps were hung on the eastern side of different trees for 21 days during April 1998. The eastern side was chosen to avoid the heat of the afternoon sun on the western side that may have caused the polybutene on the traps to run and the beetles to fall off.

These preliminary comparisons indicated that the pipe trap was the only practical trap to regularly catch CBW so this system was used in all further monitoring evaluations. Novo & Baptista (1998) showed that both sexes of CBW are attracted to a male aggregation pheromone. Comparisons were therefore made between pipe traps containing a screened canister with 20 male beetles on the southern side of the tree and pipe traps with half a cut orange as an attractant on the northern and southern sides. Trap comparisons commenced on 30 March 1999 with the hanging of traps at Vergenoeg farm (Transvaal Sugar Ltd) near Komatipoort, Mpumalanga. A total of 12 traps was used in four blocks of trees. Two blocks comprised old Valencia trees and two blocks young Delta Valencia trees. Each block was approximately 1 ha in size and one trap was hung in each of three trees spaced approximately 40 m apart along one row in the centre of each block. The traps were cleaned every 7–15 days and the counts converted to beetles per week. Each time the traps were cleaned, they were moved so that the same trap did not remain in the same tree. Cut fruit were replaced at approximately three-week intervals. Male CBWs were replaced when numbers of live beetles in the screened canisters dropped to five. The experiment was terminated on 28 June 1999. Data were log(x +1) transformed and analysed by two-way analysis of variance, with trap type and blocks as main effects.

**Bait bioassays**

As cut citrus fruit was known to be attractive to the beetles, some trials focused on the development of baits using shredded citrus as attractant. The objective was to find a toxicant that could be applied to shredded fallen fruit which is commonly spread to dry on the roads between orchards. In addition, the toxicity of insecticides which may be applied to citrus for the control of other pests had to be determined.

In order to conduct bioassays, a culture of CBW was established using a large cage (60 × 110 × 186 cm), feeding the beetles with cut citrus and providing unripe oranges with shaved patches where the pith had been exposed, as oviposition sites. Rearing conditions were 25 °C, 55–75 % relative humidity and a 12:12 hour light:dark cycle. The oviposition fruit was removed once or twice a week and placed in brown paper bags. When adults emerged they were placed in the culture cage.

The bait bioassay technique involved the dicing of unripe oranges using an onion chopper which produced pieces of approximately 1 cm³. Approximately 110 g citrus pieces were placed in each of eight plastic bowls. Two bowls were used per treatment and the pesticides below were applied using a 2 l pressurised hand sprayer for a one second burst per bowl. Controls were sprayed with water so that moisture levels were similar to the treatments. After spraying, the bowls were hung overnight in large empty cages similar to the rearing cages (one bowl per cage) to dry. Two green oranges with shaved patches were suspended in each cage to provide the beetles with oviposition sites. The next day, 50 beetles of mixed sex were placed in each cage with the fruit. Nine days later the numbers of live and dead beetles were determined and the mortalities corrected according to Abbott (1925).

The first insecticide to be evaluated as a bait was methiocarb at 0.02, 0.04 and 0.08 % a.i.. The fruit was sprayed on 8 January 1999. Using the same technique, a second bioassay was conducted on 20 January 1999 with methiocarb at 0.16 % a.i. and tartar emetic at 0.4975 and 0.995 % a.i.. A third bioassay on 15 February 1999 investigated the use of trichlorfon at 0.0475, 0.095 and 0.19 % a.i.. A final bioassay to evaluate pyriproxyfen commenced on 1 March. However, as this product is an insect growth regulator (IGR) that may only cause mortality at moulting or affect fecundity, the technique had to be modified. Chopped fruit was treated as before with pyriproxyfen at 0.003, 0.006 and 0.012 % a.i. Orchex 796 mineral oil 0.5 % was added to each spray, including the water control spray. The sprayed bowls of fruit were hung in the cages without oviposition fruit. The next day, 50 female and 30 male beetles were placed in each cage. Three days later fresh oviposition fruit was hung in each cage. The oviposition fruit was
removed after seven days exposure to the beetles and placed in paper bags. When adult beetles started to emerge from the fruit, the fruit was placed in ventilated plastic boxes until all adults had emerged. A final count of emerged adults was conducted on 17 May.

**Contact or residual bioassays**

Bioassays to determine the effect of 14 foliar insecticides on CBW involved the following methods. Beetles of undetermined age and sex were exposed to insecticides in glass vials (20 ml volume). Each vial contained 30 beetles and five vials were used per insecticide treatment. All bioassays were conducted at 25 ± 2 °C. Insecticide mixture (1 ml) was placed in each vial and the beetles shaken lightly in the insecticide for 30 seconds. The insecticide was then poured off and a piece of paper towel placed in the vial to absorb the remaining liquid. The vial was then capped and mortality was determined after 24 hours. Beetles were considered alive if they assumed an upright position within five minutes of removing them from the vial. Treatment mortalities were corrected for control mortality using Abbott's method (Abbott 1925).

In order to evaluate the residual effect of the IGRs pyriproxyfen and teflubenzuron, a different method was required owing to more delayed toxicity. Unripe Delta Valencia fruit was shaved in a few places to provide oviposition sites and then dipped in a carbendazim solution (0.0275 % a.i.) to prevent decay. Once the fruit were dry they were sprayed with either teflubenzuron at 0.003 % a.i. or pyriproxyfen at 0.003 % a.i. and after a further drying period, each fruit was placed in a paper bag with 20 beetles (10 of each sex) for 14 days. The two IGRs were compared with untreated controls in two separate experiments using five replicates per treatment. The numbers of second-generation beetles recovered after 66 days (teflubenzuron) or 68 days (pyriproxyfen) were determined.

**Orchard applications of IGRs**

CBW was monitored in 12 mature ‘Star Ruby’ grapefruit (Citrus paradisi Macf.) orchards near Komatipoort using pipe traps containing cut citrus fruit (one per orchard) from the beginning of April 1999. The traps were cleaned once a week and the numbers of beetles recorded. Four orchards were sprayed with teflubenzuron (0.003 % a.i.) and six with triflumuron (0.0048 % a.i.) at the end of March, whereas two orchards were left unsprayed. The sprays were applied from the ground at full cover as part of a commercial operation. The total number of beetles trapped per orchard during the 13 weeks after the traps were placed, were compared.

**Orchard evaluation of bait**

An experiment to evaluate baits was conducted in the old Valencia and young Delta Valencia orchards where beetles were being monitored with traps and where fallen fruit were being routinely shredded. Two blocks in each orchard were used. Two cut-fruit pipe traps and one male CBW pipe trap were used per block. The block showing the highest beetle trap counts in each orchard was selected for the bait treatment. Fallen fruit was shredded and scattered along two sides of each orchard but not within the orchard. Approximately 50 kg of shredded fruit was scattered alongside the old Valencia orchard every second week. The first application of tartar emetic 0.995 % a.i. was sprayed on the fruit on 19 May 1999 using a high-pressure hand gun. As few fruit had fallen in the young Delta Valencia orchard, three piles of 5 kg fruit each from the old Valencia orchard were squashed on either side of each treated block and sprayed. This procedure was repeated in both orchards on 1 June and 15 June as freshly fallen fruit had to be sanitised. Numbers of trapped CBWs were totalled for all three trap types per block and expressed as the total count per week for each interval during which the traps were operating. A separate analysis of variance was conducted for each orchard. Trap counts were log(x + 1) transformed before analysis.

**Results and discussion**

**Rearing and host plants**

Although CBW is not recognised as a pest of sugar cane in South Africa, it may be associated with sugar cane in the lowveld and it was able to complete its development in sections of sugar cane stems. CBW also completed its development on fruits from mango (Mangifera indica L.), marula (Sclerocarya birrea (A. Rich.) Hoehst. subsp caffra (Sond.) Kokwaro), Natal mahogany (Trichilia emetica Vahl), Cape ash (Ekebergia capensis Sparrm.) and forest toad tree (Tabernaemontana ventricosa Hochst. ex A. DC.) During the rearing studies, it was found that male CBW reared on...
citrus at 25 °C could live for as long as 156 days ($LT_{50} = 104$ days, $n = 80$) whereas the females did not live longer than 144 days ($LT_{50} = 105$ days, $n = 71$).

**Monitoring**

The sticky cards with virgin females did not catch any beetles. The number of beetles caught per week by pipe traps over all four blocks is presented in Fig. 1. When data from all sampling dates were combined, the cut fruit trap in the northern position caught significantly ($P < 0.05$) fewer beetles than either the cut fruit trap in the southern position or the male trap in the southern position. The combined dataset showed no significant difference ($P > 0.05$) between the male trap and the cut fruit trap in the southern position. The difficulty in rearing beetles, selecting males and placing them in containers in the traps is not justified by the degree of attraction achieved. The cut-fruit pipe trap hung on the southern side of the tree is, therefore, recommended as a monitoring tool, provided the cut fruit is changed at least every three weeks.

**Bait bioassays**

The results from the first three bioassays (Table 1) showed that trichlorfon was ineffective against CBW. Tartar emetic and methiocarb gave high corrected mortalities at the highest concentrations used and good suppression at the second-highest concentrations. However, the highest methiocarb concentration was 20 times the registered dosage for the control of citrus thrips (*Scirtothrips aurantii* Faure), whereas the highest tartar emetic dosage was only 2½ times the concentration registered for thrips (Nei et al. 1999). The high concentration of methiocarb would not be practical due to the high cost of the treatment. Pyriproxyfen had no appreciable impact on numbers of emerging CBWs relative to the control (control 33.5%, treatments from 23 to 44.5 % emergence).

**Contact or residual bioassays**

All the carbamates (formetanate, methiocarb, methomyl and pirimicarb) as well as endosulfan, provided negligible control of CBW (Table 2). The organophosphates were more effective, with the exception of the lower rate of mevinphos. Abamectin and prothiofos caused more than 80% mortality while the pyrethroids (cypermethrin and deltamethrin), dichlorvos, trichlorfon and profenofos caused more than 90% mortality. The mortality caused by dichlorvos may have been unnaturally high due to fumigation within the vial. This may
have also occurred with trichlorfon because it caused much higher mortality in this bioassay than as a bait (Table 1). The mean control mortality for these bioassays was 2.2 %. The IGRs pyriproxyfen and teflubenzuron reduced numbers of second generation beetles by 54.7 and 40.8 %, respectively. This would be inadequate for commercial control.

Orchard applications of IGRs

Foliar sprays of citrus with triflumuron and teflubenzuron did not suppress numbers of beetles present in the orchards. The numbers of beetles trapped in the two untreated orchards during the 13-week monitoring period were 29 and 54. Numbers trapped in the six orchards treated with triflumuron ranged from 25 to 116 and in the four orchards treated with teflubenzuron, from 14 to 64. It appears, therefore, that there will be little benefit in the control of CBW from IGR applications used for other pests. The use of traps in these orchards also showed that the fruit used as an attractant in the trap should be replaced after three weeks to remain attractive.

Orchard evaluation of bait

Spraying exposed, shredded fruit with tartar emetic was effective in reducing numbers of trapped beetles in the treated blocks to lower numbers than in the untreated blocks, even though the blocks destined for treatment had higher numbers of beetles than the untreated blocks before treatment (Fig. 2). However, post-treatment differences only became significant at the time of the last post-treatment count, and complete control was not achieved during the evaluation period. As the beetles are strong fliers and there may have been immigration from surrounding untreated orchards, it is reasonable to assume that the use of this type of baiting over a wider area may provide adequate control.

Recommendations

Further, large scale evaluation of chopped citrus sprayed with tartar emetic should be conducted with the use of cut-fruit traps to determine when to start baiting. Based on the use of traps at Vergenoeg, one trap per 2 ha block would probably be adequate to determine when CBW becomes a threat. An intervention threshold could not be determined from the data gathered in the above experiments but a suggested guideline would be that if more than one CBW is caught per trap per week, baiting should commence by spraying shredded fruit on the orchard floor with tartar emetic (0.995 % a.i.). For late-maturing citrus cultivars this may entail bringing fallen fruit from early-maturing orchards and shredding it in the late-maturing orchard. Removal of split, damaged or mummified fruit from citrus trees will also assist in controlling CBW. If sugar cane fields are close to citrus orchards, old stems in the field or along the roadside should be removed. Although cypermethrin is registered for use in South Africa on citrus in spring against citrus thrips (Nel et al. 1999) and was effective in bioassays against CBW (Table 2), its use in mid-summer as a foliar spray would be

### Table 1

<table>
<thead>
<tr>
<th>Treatment*</th>
<th>Corrected mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tartar emetic 0.4975</td>
<td>86.9</td>
</tr>
<tr>
<td>Tartar emetic 0.995</td>
<td>97.1</td>
</tr>
<tr>
<td>Methiocarb 0.02</td>
<td>33.1</td>
</tr>
<tr>
<td>Methiocarb 0.04</td>
<td>70.5</td>
</tr>
<tr>
<td>Methiocarb 0.08</td>
<td>92.6</td>
</tr>
<tr>
<td>Methiocarb 0.16</td>
<td>97.7</td>
</tr>
<tr>
<td>Trichlorfon 0.0475</td>
<td>0.0</td>
</tr>
<tr>
<td>Trichlorfon 0.095</td>
<td>1.9</td>
</tr>
<tr>
<td>Trichlorfon 0.19</td>
<td>0.0</td>
</tr>
</tbody>
</table>

*% a.i.

### Table 2

<table>
<thead>
<tr>
<th>Treatment*</th>
<th>Corrected mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abamectin 0.00027</td>
<td>88.5</td>
</tr>
<tr>
<td>Cypermethrin 0.002</td>
<td>99.3</td>
</tr>
<tr>
<td>Deltamethrin 0.0005</td>
<td>98.6</td>
</tr>
<tr>
<td>Dichlorvos 0.1</td>
<td>98.6</td>
</tr>
<tr>
<td>Endosulfan 0.095</td>
<td>4.8</td>
</tr>
<tr>
<td>Formetanate 0.0375</td>
<td>0.7</td>
</tr>
<tr>
<td>Methiocarb 0.016</td>
<td>0.0</td>
</tr>
<tr>
<td>Methomyl 0.09</td>
<td>5.6</td>
</tr>
<tr>
<td>Mevinphos 0.02</td>
<td>7.4</td>
</tr>
<tr>
<td>Mevinphos 0.05</td>
<td>61.5</td>
</tr>
<tr>
<td>Pirimicarb 0.04</td>
<td>0.0</td>
</tr>
<tr>
<td>Profenofos 0.05</td>
<td>93.8</td>
</tr>
<tr>
<td>Prothiofos 0.048</td>
<td>80.8</td>
</tr>
<tr>
<td>Trichlorfon 0.076</td>
<td>95.9</td>
</tr>
</tbody>
</table>

*% a.i.
disastrous from an IPM viewpoint as this is when the contribution from natural enemies is most critical. Without their natural enemies, population increases of various mealybugs, red scale (*Aonidiella aurantii* (Maskell)) and citrus red mite (*Panonychus citri* (McGregor)) would very likely occur close to harvest when further pesticide applications cannot be used due to residue restrictions.

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**References**


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