Integrated control of the coconut bug *Pseudotheraptus wayi* (Hemiptera: Coreidae) on avocado in South Africa

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INTRODUCTION

During 1991 the loss of avocado fruit due to the coconut bug in South Africa already amounted approximately R1.37 million (Erichsen & Schoeman, 1992). The coconut bug was recorded during 1977 for the first time in South Africa (De Villiers & Wolmarans, 1980) and was subsequently recorded on avocados approximately six years later by De Villiers and Van den Berg (1984). According to Van der Meulen (1992), mean damage percentages on early aborted avocados varied from 4.2-9.1% while it varied from 2.1-39.9% on mature fruit at harvest. On some farms damage levels as high as 76.2% were recorded.

According to Dennill and Erasmus (1991), the coconut bug was the biggest insect problem on avocados during the early 1990's and they recorded ±4.7% infestation in the packhouse. According to Bruwer (1999) this is very close to the 5% upper limit which is generally used as a threshold value. Joubert and Claassens (1994) did a survey during 1993 and recorded damage levels of ±1.21-3.14%. Bruwer (1996; 1999; 2005) did a significant amount of work and mention infestation percentages ranging from 2.1% to approximately 13%.

While it is evident that the coconut bug can damage a significant portion of exportable fruit, important aspects regarding the control of this pest, such as early warning, monitoring, as well as potential biological control alternatives, are currently still lacking. The following trials were therefore designed to address some these aspects.

MATERIALS AND METHODS

Determining the economic status of the coconut stinkbug

During 2008/09, 400 fruit (20 fruit from 20 randomly selected trees) on four farms in the Nelspruit / Kiepersol districts were examined *in situ* every fortnight for the presence of coconut bug lesions. This trial started just after flowering in October 2008 and was concluded during March 2009. This survey was followed up with a packhouse survey on three localities during 2009.

During 2009/10 the relative seasonal occurrence of the coconut bug was determined in two orchards with a history of severe damage. The trial site at Nelspruit (25°26'55.73"S 30°58'09.77"E) was surrounded by commercial host plants while the orchard in Tzaneen (23°49'18.55"S 30°10'31.04"E) was bordered by riverine vegetation and avocado orchards. Both orchards were surveyed every fortnight and fifty fruit from five randomly selected trees were examined *in situ* for stink bug feeding damage.

Area wide management of the coconut bug

Six randomly selected avocado, litchi and macadamia trees were sprayed every month with Dichlorvos 1000 g/L EC at the Burgershall experimental station of the Agricultural Research Council – Insitute for Tropical and Subtropical Crops (ARC-ITSC) (25°07'01.94"S 31°05'04.15"E). All insects were collected underneath the trees and subsequently identified up to family level. This survey was started during September 2009 and concluded during March 2010.

To further quantify possible feeding succession of this insect, damage assessments on litchi, mango, guava and avocado trees were also made every fortnight at the ARC-ITSC in Nelspruit. Fifty randomly selected fruit from five randomly selected trees were examined *in situ* during each assessment. This trial also started in September 2009 and concluded during June 2010.

Monitoring

Obstruction traps

Five 1 m^2 bright yellow masonite obstruction traps were covered with a polybuthene sticky coating. The traps were placed ±20 m apart, facing towards riverine vegetation in a historically damaged avocado orchard in the Stads river valley (25°21'45.71"S 30°45'08.09"E).

Five battery powered (A4 sized) sticky traps were also suspended between the rows of avocado trees at this locality. Additionally, a further five traps were placed out in a severely infested mixed cultivar avocado orchard on the premises of the ARC-ITSC in Nelspruit. All obstruction traps were placed out during late January because damaged fruit becomes more numerous during this period (**Figure 1**).

Trap crops

This trial was conducted in two phases. During the winter of 2009 the riverine vegetation in the Stads river valley was surveyed for plants which could act as hosts for the coconut stinkbug.

Promising plants (sunflowers, *Crotalaria capensis* and Rockett) were also planted close to unsprayed macadamia and avocado orchards at the ARC-ITSC in Nelspruit. These plants were regularly surveyed for any stinkbugs, especially when the seed pods were developing.

Diagnostic photos of damage

Adult coconut bugs were confined in screen cages on small, medium and large 'Pinkerton' fruit in an unsprayed mixed cultivar orchard at Nelspruit. Cages were shifted once a week to prevent damage from becoming too severe. All damage symptoms were photographed and described.

RESULTS

Economic status of the coconut bug

Current research support the viewpoint of Dennill and Erasmus (1991) that the coconut bug is the most serious insect pest of avocado in South Africa. However, due to the heterogeneous distribution of this pest, it is rather difficult to make a generalised statement regarding the economic status of this pest. The following results are expected to shed some light on this aspect: When the incidence of damage symptoms of the coconut bug was examined on four farms in the Kiepersol and Nelspruit avocado production regions of Mpumalanga, **Table 1** indicated that damage was not severe, as only 1.59-3.69% of the total number of fruit was damaged at the end of the season.

This situation quickly changed when the relative seasonal occurrence of coconut bug damage was analysed on these farms. According to **Table 2**, the pooled damage percentage was negligible immediately after flowering, but steadily increased to approximately the 9% level during March 2009.

Table 2 also highlighted the variability regarding damage between the respective farms (range 1.67-13%). This variability also occurred within orchards. In most cases prominent infestation gradients were discernible and the highest incidence of damage occurred along the edges of the orchards, especially where the avocado trees were bordered by natural bush or macadamia orchards. Coconut bugs appeared to be highly gregarious and often a single tree is severely infested amongst a number of uninfested trees. Damage may also even be confined to a specific limb in a tree.

Unfortunately this makes monitoring of these insects very difficult. Due to the elusive nature and patchy distribution of these insects, the estimated experimental error scouts make during their weekly bug assessments is therefore expected to be relatively big.

Damage assessments of fruit in the packhouse reconfirmed the observation regarding the heterogeneous distribution of these insects (**Table 3**) (range 1.3-11.98%). Edwards and Heath (1964) indicated that pest status is normally reached when damage reaches 5% loss of marketable fruit. According to Table 3, average damage at three packhouses was marginally higher than 5%. This observation supports the finding (4.7% damage) of Dennill and Erasmus (1991), as well as a subsequent survey conducted by Erichsen and Schoeman (1992). If results from these three surveys are considered, it can be concluded that the damage inflicted by the coconut appears to have reached an equilibrium. When these damage percentages are con-

Table 1. Incidence of the coconut bug on a number of farms in the Nelspruit and Kiepersol regions of Mpumalanga.

Farm	Damage on tree (%)	Number of fruit examined	Damage on aborted fruit (%)	Number of fruit examined	Total damage (%)	Total number of fruit examined
Farm 1	127 (3.53)	3600	8 (14.55)	55	135 (3.69)	3655
Farm 2	72 (1.64)	4400	5 (1.11)	450	77 (1.59)	4850
Farm 3	117 (3.66)	3200	1 (0.05)	200	118 (3.47)	3400
Farm 4	30 (0.77)	3900	1	400	31 (0.72)	4300
Total	346 (0.6)	15100	15 (1.36)	1105	361 (2.23)	16205

Table 2. The relative seasonal abundance of fruit damaged by the coconut bug on a number of farms in the Nelspruit and Kiepersol regions of Mpumalanga.

Month	Farm 1		Farm 2		Farm 3		Farm 4		Total	
	Number of damaged fruit (%)	N	Number of damaged fruit (%)	N	Number of damaged fruit (%)	N	Number of damaged fruit (%)	N	Number of damaged fruit (%)	N
Oct	6 (0.75)	800	1 (0.13)	800	2 (0.25)	800	0	400	9 (0.32)	2800
Nov	12 (1.5)	800	3 (0.38)	800	0	400	1 (0.13)	800	16 (0.57)	2800
Dec	7 (1.75)	400	2 (0.25)	800	4 (0.5)	800	2 (0.25)	800	15 (0.54)	2800
Jan	6 (1.5)	400	3 (0.38)	800	7 (1.75)	400	6 (0.75)	800	22 (0.92)	2400
Feb	21 (5.25)	400	24 (3.0)	800	52 (13)	400	16 (2.0)	800	113 (4.71)	2400
March	75 (9.38)	800	39 (9.75)	400	52 (13)	400	5 (1.67)	300	171 (9.0)	1900

sidered, it must be taken into account that prematurely aborted fruit as well as severely damaged fruit, which are normally discarded on the farms, were not considered. The true damage potential for the industry is therefore estimated to be significantly higher than 5%.

Area wide management of the coconut bug

Incidence of damage on the two early maturing crops reached a maximum just before the crops became physiologically mature (mango – late October and litchi – late November). Distribution of damage in the guava and avocado orchards was very heterogeneous but is expected to peak later in the season, just prior to physiological maturity.

Maximum damage recorded for the various crops was: (mangoes 11.6%, litchis 68%, avocados 24.4% and guavas 27.6%). According to **Figure 1** it was evident that when damage was decreasing in the mango and litchi orchards, a concomitant increase was observed in the guava and avocado orchards. This would indicate that some degree of succession of damage may occur if more than one of these crops is planted in the immediate vicinity of each other.

Although no coconut bugs were recovered in the avocado orchard with the knockdown sprays, approximately 23% of all insects recovered consisted of sucking bugs (Hemipterans). Dominant species include *Nezara* spp. and variegated bugs (Pentatomidae), cotton stainers (Pyrrhocoridae) and spittle bugs (Cercopidae), which seems to indicate that the complex of sucking bugs is bigger than previously anticipated.

Spray timing and relative seasonal abundance of insects

The orchard at Nelspruit is regarded as a worst case scenario as it is surrounded by a range of alternative host plants. The threshold of 5% was already reached by the end of November 2009. Although an insecticide application during this time will reduce damage, it will not completely stop subsequent incursions of bugs from adjacent orchards. Beta-cyfluthrin EC 50 g/L is only registered as an early season application but Acephate SP 750 g/kg is registered for general use. Usage of this chemical will also be restricted to the mid-season (Dec – Jan) in order to avoid chemical residues on fruit on export markets.

Due to the heterogeneous dispersal patterns of coconut bugs, random selection of scouting trees will give very inaccurate results. It is therefore suggested to scout the perimeter of the orchard for damage as well as for the coconut bug.

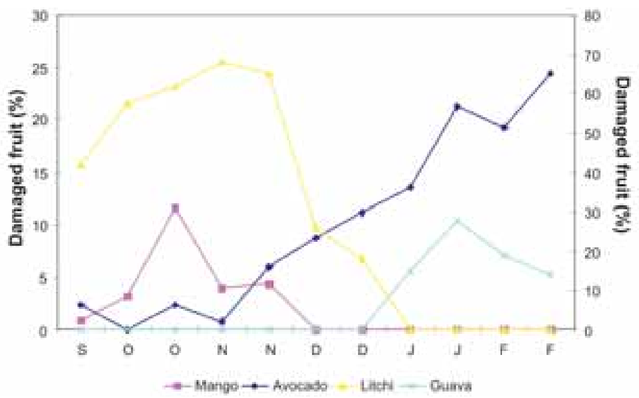

Figure 1. Relative seasonal occurrence of damaged fruit of important subtropical crops which may act as alternative hosts for the coconut stinkbug.

Monitoring

Trap crops (field survey)

Avocados in the Stads river valley have historically been severely affected by the coconut bug. The following plants were located which could act as trap crops:

- *Crotalaria capensis* – small / medium sized shrub, very common in the valley. Flowers are yellow which could be attractive to the bugs. This tree belongs to the family Papilionoideae and the cylindrical seed pods mature during January to May. Seeds were collected in the field and in the National Botanical Garden in Nelspruit and trees will be planted out in the field next to avocados and / or macadamias during April/May 2010.
- *Crotalaria* sp. – small shrub growing in the road reserve in the Stads river valley. This plant flowers during February / March. Seed will be collected once the pods are mature.
- *Solanum incanum* (gifappeltjie) – where this weed grew near avocados, severe stinkbug feeding damage was observed on the bright yellow fruit. Seeds collected from these plants germinated poorly and it was decided to rather evaluate plants in the field during the autumn of 2010.

Trap crops planted next to avocado and macadamia

- *Crotalaria juncea* – (Sunn hemp) – seed was planted early December and the first stinkbugs (green vegetable bugs – *Nezara viridula*) were observed feeding on the pods during the first week in March 2010. Plants are very hardy and were not affected by antelope.
- *Helianthus annuus* – Sunflowers – Seed was planted during early December and large numbers of an unidentified stinkbug (Pentatomidae) was observed feeding on the distal part of the seed heads.

Table 3. Coconut bug damage assessments at three packhouses in the Nelspruit and Kiepersol regions during 2009.

	Total number of fruit sampled	Fruit infested with coconut bug (%)
Packhouse 1 (Nelspruit)	2013	93 (4.62)
Packhouse 2 (Kiepersol)	1377	165 (11.98)
Packhouse 3 (Nelspruit)	2304	30 (1.3)
Total	5694	288 (5.06)

- *Eruca vesicaria* – Rockett – plants required frequent irrigation and will not be suitable as a trap crop.

Yellow obstruction traps

Despite catching a large number of Hemipterans, none of the sticky traps were able to catch a single coconut bug. It is therefore suggested to discontinue this study.

Diagnostic photos of damage

Damage symptoms differ significantly according to when the fruit was damaged. Immature avocados abort if sufficient coconut bug damage occurs early in the season (**Figure 2A**). When avocados are medium sized and cell division is still actively taking place, infested fruit are able to repair coconut bug damage to some degree. The result is asymmetrical fruit with characteristic feeding scars (depressions) at the feeding site (**Figure 2B**).

When physiologically mature, fruit are damaged by the coconut bug. Damage symptoms are slightly more difficult to distinguish. Freshly damaged fruit normally have a dark water soaked lesion at the feeding site and if this damage becomes older, the epidermis of the fruit tend to crack horizontally (**Figure 2C**). White sugary exudates are normally evident at the feeding sites (**Figure 2E**), but these sugars may wash of during rain and are therefore not always a good indication of infested fruit (**Figure 2F**). When the epidermis covering the horizontal cracks are removed, concentric water soaked lesions are normally revealed (**Figure 2D**). Old damage on mature fruit may resemble hail damage (**Figure 2G**) and mature fruit may even abort prematurely if the infestation is sufficiently severe (**Figure 2H**).

CONCLUSIONS

The observation by Dennill and Erasmus (1991) that the coconut bug is economically the most important insect on avocados was supported by the findings of this study. Distribution of these insects in a production region appears to be heterogeneous and it was speculated that the compliment of cultivated and wild host plants play a major role in this regard. Towards the end of the season, prominent infestation gradients were observed. Typically trees in the perimeter of the orchard were more severely damaged, which suggests that the insects migrate into avocado orchards when the fruit have reached the desired level of maturity. Additionally, "hot spots" were also observed within orchards. These hot spots were usually limited to a single tree and in some cases damage was even confined to a specific sector in a tree.

Acephate is currently the only registered product available later in the season, but usage of this chemical especially during the late season could be problematic due to chemical residues on the fruit at export destinations. This problem is further compounded because monitoring techniques for the coconut bug are currently very rudimentary. Yellow obstruction traps were not effective and although trap crops show some promise, an effective alternative host plant suitable as a trap crop has not been located thus far.

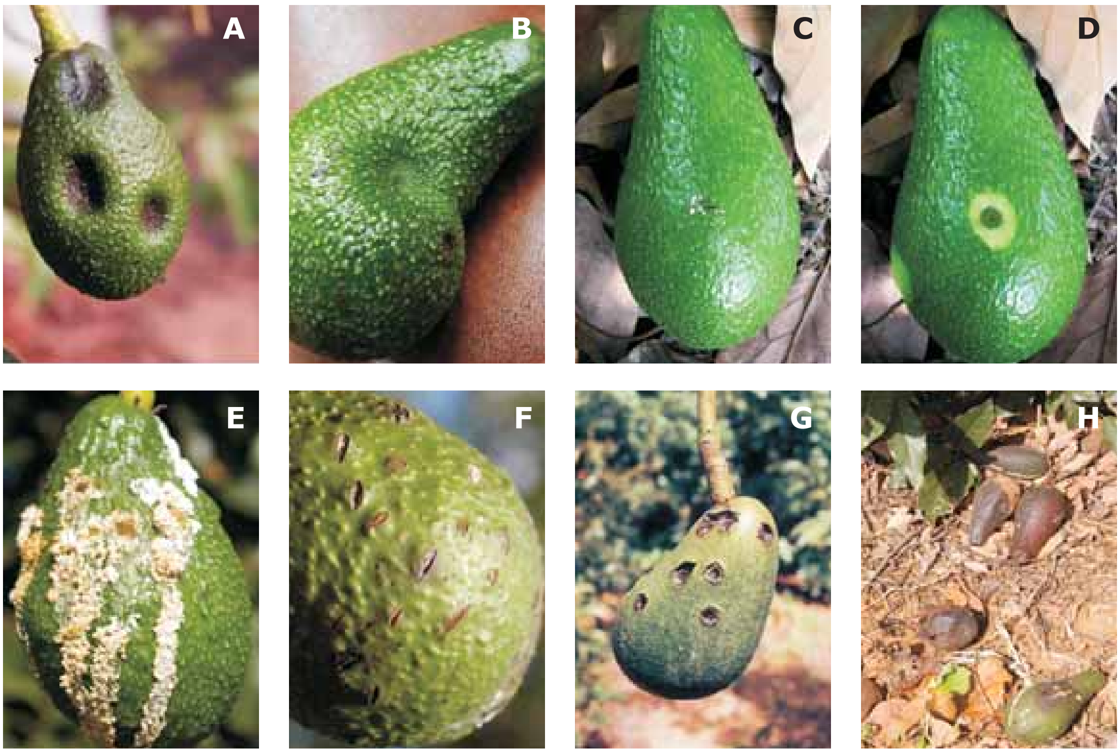

Figure 2. Damage symptoms of the coconut bugs: A – Early season damage prior to fruit abortion. B – Asymmetrical fruit which was probably damaged during an early stage. C – Horizontal cracks at the coconut bug feeding site with epidermis intact. D – With the epidermis removed. E – White sugary exudates originating from coconut bug lesions on a severely infested fruit. F – External symptoms with the exudates removed. G – Old lesions resembling hail damage. H – Mature 'Pinkerton' fruit aborted due to excessive damage.

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