**South African Avocado Growers' Association Yearbook 1992. 15:57-61**

# An ecological study of the damage done to avocado fruit by Hemiptera in the Hazyview region, South Africa

**G B Dennill and F M A Dupont**
*Unit for Applied Insect Ecology, Department of Entomology, University of Pretoria, Pretoria 0002*

***ABSTRACT***

*Feeding by Hemiptera on avocado fruit in South Africa causes two kinds of symptoms: protrusions (attributed to stink bugs, including Rezara* viridula *(L) (Pentatomidae)) and indentations (caused by coconut bug* Pseudotheraptus wayi *(Brown) (Coreidae)). In the present study, conducted in the Hazyview region of the eastern Transvaal from December 1991 to March 1992, it was found that (1) the incidence of protrusions on Hass avocados (10%) was five times greater than on Fuerte (2%); (2) this damage is inflicted during early fruit development and did not increase during the study period; (3) damage was distributed throughout the study site with no edge effect; (4) feeding was density independent and random regarding height and aspect of avocado trees and (5) damaged fruit were not aborted.*

*A technique for monitoring the incidence of fruit bearing protrusions is described. Feeding by coconut bug was also density independent and random, but did enhance fruit drop, and the mass of indented fruit was 28% lower than that of healthy fruit and those bearing protrusions. There was no relationship between the incidence of fruit displaying protrusions and indentations, indicating that even though there are similarities in the internal damage to the fruit and patterns of feeding, the protrusions are not caused by coconut bug.*

## INTRODUCTION

The avocado was introduced into South Africa during the Dutch colonisation of the eighteenth century, but it only began to be cultivated as a crop between 1920 and 1930 (Durand, 1990). Until recently, there were few and relatively unimportant avocado pests (Annecke & Moran, 1982). However, during the last decade there has been a threefold increase in the number of insect pest taxa damaging avocado fruit, and this has been attributed to the recent expansion (>25% pa) in the avocado industry (Dennill & Erasmus, 1992).

During the last three years, avocado fruit have been increasingly attacked by hemiptera that induce protrusions on the fruit surface. The damage, described and illustrated by Dennill & Erasmus (1991), has been attributed to stink bugs, including *Nezara viridula* (L) (Pentatomidae), by various researches and consultants (see Dennill & Erasmus, 1991). In packhouse surveys (1990 & 1991) of insect damage to avocado fruit in the

Nelspruit/Hazyview district, the damage caused fruit losses of 1,8% and 3,1% respectively (Dennill & Erasmus, 1991; Erichsen, 1992).

During the 1991 and 1992 seasons, there was a sudden increase in the incidence of this damage in the Hazyview area (25°S;31°E), where some farmers claim to have lost up to 30% of their crop (W Vos, personal communication). The damage is also becoming more widespread, as reported from the Tzaneen and Natal avocado growing regions during 1991 and 1992 (C J Patridge, personal communication). Although researchers were previously unanimous that this damage was caused by stink bugs (Dennill & Erasmus, 1991), W J du Toit and C Erichsen (personal communication) claim, as yet without appropriate evidence, that the citrus leafhopper *Penthimiola bella,* (Stal) (Cicadellidae) is responsible.

The present study concerns two symptoms caused by hemipteran feeding on avocado fruit: protrusions and indentations. In the center of the protrusions, just below the fruit surface, the feeding hole where the insect inserted its piercing-sucking mouthparts is clearly demarkated by an elongated (1-3 mm) rod-like scar of dead, black tissue. This scar is surrounded by corky, orange-coloured tissue.

Indentations in the fruit surface are attributed to coconut bug, *Pseudotheraptus wayi* (Brown) (Coreidae), feeding on young fruit (Viljoen, 1986; De Villiers, 1990; Du Toit & De Villiers, 1990; Van der Meulen, personal communication). In the fruit flesh below these indentations are feeding marks and scar tissue, identical to those immediately below the protrusions.

The aims of the present study were to determine:

1. levels of damage on the two main cultivars (Hass and Fuerte);
2. whether there is an increase in the incidence of damage over time;
3. the distribution of the damage in trees regarding height and aspect [some insects, eg citrus thrips *Scirtothrips aurantii* Faure (Thripidae), are more damaging on the warmer northern aspects of their host plants at higher latitudes (Grout & Richards, 1990)];
4. the distribution of the damage within an orchard (some insects are more damaging on the periphery);
5. whether feeding is density dependent;
6. whether there is any relationship between the incidence of the two kinds of damage (since the internal scars are similar in both cases and since some researchers currently doubt the identity of the insect(s) causing the protrusions);
7. whether the two kinds of feeding enhance fruit drop, and
8. a practical technique for monitoring this damage.

## METHODS

The study was undertaken on the farm of Mr W Vos (25°5'S; 30°59'E), which appeared to be most severely affected in the Hazyview area. The orchard selected consists of 2

374 trees of cultivars Hass and Fuerte, planted in alternating sets of three rows of each. The study site in this orchard is narrow (41 rows, maximum 26 trees/ row), being bordered on the eastern side by a riverine habitat containing indigenous vegetation invaded by weeds, eg bugweed *(Solanum mauritianum* Scop) and on the western side by a dust road beyond which the orchard continues (Figure 1).

The study began on 9 December 1991, after the farmers in the Hazyview area had alerted the South African Avocado Growers' Association to the problem. At this stage the width of the healthy developing fruit was that of a golf ball (mean mass = 46 g). Examination of the study orchard revealed many fruit with indentations associated with coconut bug.

The only other insect damage observed could be ascribed to loopers (Geometridae) (De Villiers & Van den Berg, 1987), and was minimal (three fruit damaged). Since the identity of the insect causing the protrusions was in question, and since the only other insect-induced damage in the orchard was due to coconut bug, fruit with indentations caused by the latter were examined in a similar way to those bearing protrusions

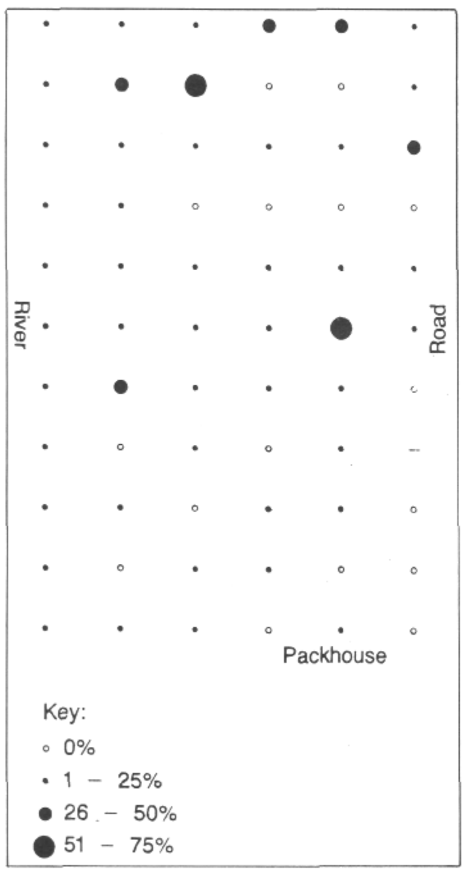


**Fig 1** The pattern of distribution of damage (protrusions) within the study orchard.

## Levels of damage (protrusions) on different cultivars

Between 9 and 13 December 1991, eleven pairs of contiguous rows of Hass and Fuerte trees (rows three and four, and thereafter every second and third row) were selected. In each set of rows every fifth pair of trees (one of each cultivar) was selected, and the damaged and undamaged fruit at head height were counted on each tree. Since the rows in the study area consist of about 30 trees each, six pairs of trees should have been sampled per row, yielding a total of 66 trees of each cultivar. However, since some trees had died or been removed, a total of 65 Hass and 59 Fuerte trees were sampled in order to determine whether there was a difference in the incidence of damage between these cultivars.

## Incidence of damage (protrusions) over time

In order to determine whether there was an increase in the incidence of damage over time, a random sample of Hass trees in the same orchard was selected each month from January to March. On each tree, the fruit at head height were examined for damage as described above. Only Hass trees were used, since the results indicated that Fuerte trees suffered only mild damage (2%), compared with Hass trees which were five times more severely affected (10%).

## Distribution of damage (protrusions) within the orchard

The 65 Hass trees sampled according to the method described above were scored from 1 to 5 according to the percentage of fruit that were damaged (0%, 1-25%, 26-50%, 51-75% and 76-100%, respectively). In this way the distribution of the damage in the orchard could be mapped.

## Distribution of damage (protrusions and indentations) within trees

Eleven Hass trees were randomly selected within the study area. Each tree was divided into horizontal 1-m strata and each stratum into four aspects (north, east, south and west). The fruit in each 1-m segment were picked and the damaged fruit (bearing protrusions or indentations) and undamaged fruit were counted. In this manner, the proportion of damaged fruit in each height class and aspect could be determined. Only Hass trees were used, since the results indicated that Fuerte trees suffered only mild damage (2%), whereas Hass trees were five times more severely affected (10%).

## Density dependence (protrusions and indentations)

Using the methods described in the preceding section, each tree was divided into a number of segments (each aspect of each 1-m height class). For each segment, the total number of fruit could be used as an index of fruit density, while the percentage of damaged fruit could be used to determine the incidence of damage for the density of fruit in that segment. These data could be used to determine the relationship between fruit density and incidence of damage for both kinds of damage.

### Relationship between the incidence of protrusions and indentations

Because the results indicated similarities in the pattern of distribution of both kinds of damage, it was thought that both symptoms may be caused by the same insect, namely coconut bug. The symptoms could therefore be different, either because the fruit were attacked at different stages of development, or because the fruit were attacked by different life stages of the insect. The relationship between the proportion of fruit bearing each symptom was examined for the eleven trees and for the segments

(1-m strata divided into aspects) into which the 11 trees had been divided. In addition, the mass of healthy fruit, fruit bearing protrusions and indented fruit, was determined for 100 randomly selected fruit of each kind.

### Enhancement of fruit drop (protrusions and indentations)

Damaged and undamaged fruit lying on the ground beneath each of the 11 Hass trees were counted. The relationship between the percentage of fruit dropped and percentage of damaged fruit, among the dropped fruit, could therefore be investigated to determine whether damaged fruit are shed.

### Development of a sampling technique

In order to devise a practical method for assessing losses due to fruit bearing protrusions, quick counts of damaged and undamaged fruit at head height were compared with the actual incidence of damage for 20 Hass trees. In addition, the percentage of damaged fruit in the 1-2 m stratum, which is easily accessible, was compared with the actual incidence of damage on the 11 Hass trees described above.

## RESULTS

### Levels of damage (protrusions) on different cultivars

The percentage of Hass avocados displaying protrusions (9,8%) was five times that of Fuerte avocados (2,1%) (Table 1).

### Incidence of damage (protrusions) over time

There was no increase in the incidence of damage to Hass fruit during the study period (Table 2).

### Distribution of damage (protrusions) within the orchard

The damage was evenly distributed throughout the study area; fruit on 75% of the trees were damaged and the median score for damage was 2 (ie 1-5%) (Figure 1). Trees displaying the highest levels of damage (25-75%) were scattered and did not occur on the borders of the study area (Figure 1).

### Distribution of damage (protrusions and indentations) within trees

The vertical distribution of fruit bearing protrusions was similar to that of the distribution of fruit on the trees (Figure 2). The vertical distribution of fruit with indentations followed a similar trend, except in the higher 3-4 m stratum, where there was a relatively greater incidence of damage (Figure 3).

Regarding both protrusions and indentations, there was no difference in incidence of damage (=proportion of damaged fruit out of the total number of fruit) within each aspect of the 11 trees (Tables 3 & 4). However, a comparison of the distribution of damaged fruit on the trees showed that there were significantly lower proportions of damaged fruit on the southern aspects of the trees (Table 3). The distribution of fruit (both damaged and undamaged) on the trees followed the same trend, with significantly lower proportions of fruit on the southern aspects of the trees (Table 3).

**TABLE 1** A comparison of the incidence (%) of damage (protrusions) on Hass and Fuerte avocados

| Cultivar | % fruit damaged | Sample size | |
|---|---|---|---|
| | | No fruit | No trees |
| Hass | 9,8 | 3 526 | 65 |
| Fuerte | 2,1 | 2 566 | 59 |

**TABLE 2** The incidence (%) of damage (protrusions) on Hass avocados from December 1991 until March 1992

| Cultivar | % fruit damaged | Sample size | |
|---|---|---|---|
| | | No fruit | No trees |
| 09–13/12/91 | 9,8 | 3 526 | 65 |
| 16–20/12/91 | 11,1 | 1 000 | 20 |
| 27–31/01/92 | 8,6 | 1 000 | 20 |
| 17–21/02/92 | 8,0 | 1 000 | 20 |
| 23–27/03/92 | 9,6 | 2 400 | 50 |

**TABLE 3** A comparison of the incidence ($x^a$) and distribution ($x^b$) of damaged fruit (protrusions only), and the distribution of fruit (damaged and undamaged) ($x^c$) in each of the four aspects of 11 Hass avocado trees

| Aspect | % damaged fruit | | % fruit in each aspect |
|---|---|---|---|
| | $x^a$ (se) | $x^b$ (se) | $x^c$ (se) |
| W | 28,17 (2,761) | 11,86 (1,911) | 28,50 (1,755) |
| N | 27,47 (2,761) | 13,36 (2,058) | 24,64 (1,755) |
| E | 26,88 (2,761) | 12,09 (1,979) | 26,59 (1,755) |
| S | 17,38 (2,761) | 10,26 (2,267) | 20,26 (1,755) |
| LSD* | 10,46 | – | 6,650 |
| P | 0,027 | 0,794 | 0,013 |

* Tukey's multiple comparison LSD at P = 0,05; (se: standard error of the mean).

Weighted analyses of variance were performed on the data that were tested for normality (transformations were not required).

**TABLE 4** A comparison of the incidence ($x^a$) and distribution ($x^b$) of damaged fruit (indentations only) in each of the four aspects of 11 Hass avocado trees

| Aspect | % damaged fruit | |
|---|---|---|
| | $x^a$(se) | $x^b$(se) |
| W | 10,29 (1,588) | 30,86 (3,294) |
| N | 7,37 (1,708) | 19,11 (3,294) |
| E | 9,10 (1,644) | 25,46 (3,294) |
| S | 11,78 (1,884) | 24,58 (3,294) |
| P | 0,357 | 0,111 |

(se: standard error of mean).

## Density dependence (protrusions and indentations)

The relationship between the total number of fruit and the percentage of fruit bearing protrusions in each stratum was strongly linear, with a positive slope of approximately one (Figure 4). The implied lack of density dependence was confirmed by the absence of a relationship between the number and percentage of damaged fruit in each segment ($R^2$ = 0,01%; n =185). In contrast, the relationship between the total number of fruit and the percentage of fruit with indentations in each stratum was exponential (Figure 5), although a straight line also fitted the data (y = -602 +1,36 x; $R^2$ = 80%; n = 6). The suggested density dependence was, however, not confirmed by testing the relationship between the number and percentage of damaged fruit for each segment ($R^2$ = 0,80%; n =185).

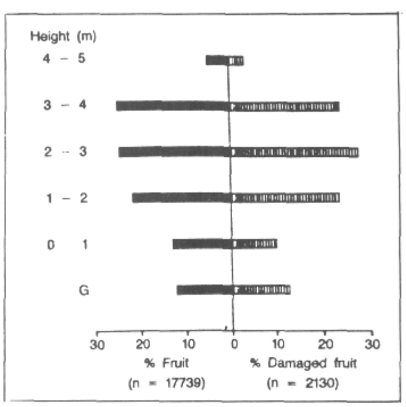


**Fig 2** Diagrammatic comparison of the vertical distribution of damaged fruit (protrusions) with the general vertical distribution of fruit on Hass avocado trees.

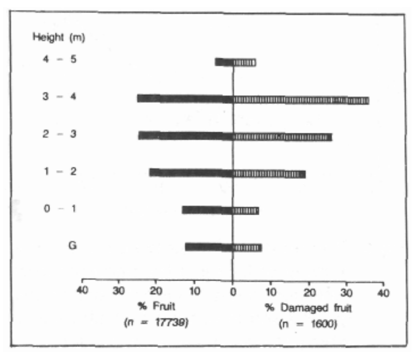


**Fig 3** Diagrammatic comparison of the vertical distribution of damaged fruit (indentations) with the general vertical distribution of fruit on Hass avocado trees.

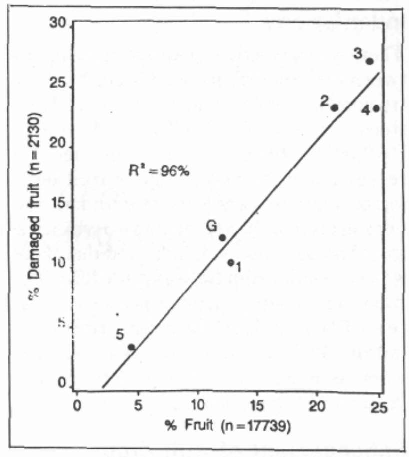


**Fig 4** The relationship between the total number of fruit and the percentage of damaged fruit bearing protrusions on the ground and in vertical 1–m strata, into which 11 Hass trees were divided ($y = -2{,}23 + 1{,}13x$). (G = fruit lying on ground, 1 = 0–1 m stratum, 2 = 1–2 m stratum, etc).

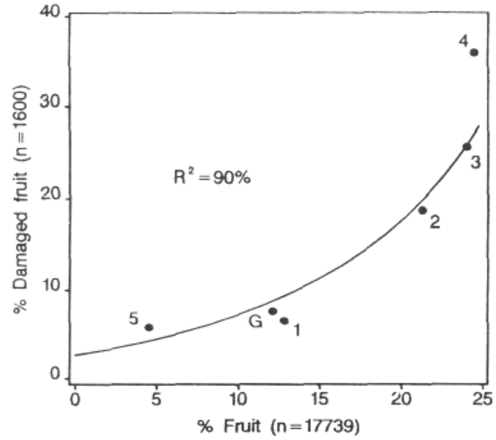


**Fig 5** The relationship between the total number of fruit and the percentage of damaged fruit with indentations on the ground and in vertical 1–m strata into which 11 Hass trees were divided ($y = e^{(1{,}03\ +\ 0{,}92\times)}$). (G = fruit lying on ground, 1 = 0–1 m stratum, 2 = 1–2 m stratum, etc).

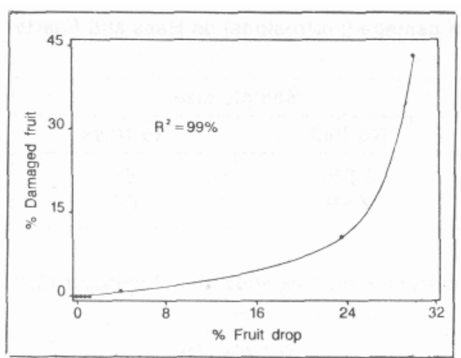


**Fig 6** The relationship between the percentage of fruit dropped and the percentage of fruit with indentations among the dropped fruit ($y = -2{,}76 + 3{,}78/1\text{–}0{,}0319x$).

## Relationship between the incidence of protrusions and indentations

There was a positive linear relationship between the proportions of fruit bearing protrusions and indentations on the 11 Hass trees ($y= -0{,}79 + 1{,}322\ x$; $R^2 = 66\%$; $P = 0{,}002$). However, the more detailed regression of the percentage of fruit bearing protrusions versus those with indentations in each of the segments into which the trees had been divided, indicated that there was no relationship ($R^2 = 4\%$; $n = 185$). The mass of healthy fruit (mean = 46,3 g; se = 1,61) and fruit bearing protrusions (mean = 46,5 g; se = 1,34) was similar, whereas indented fruit were 28% lighter (mean = 33,6 g; se = 0,92).

**Enhancement of fruit drop (protrusions and indentations)**

There was no relationship between the percentage of fruit dropped and the percentage of fruit bearing protrusions among those that had dropped ($R^2$= 17,15%; n = 11). However, there was a strong rectangular hyperbolic relationship ($R^2$ = 99%) between the percentage of fruit dropped and the percentage of fruit with indentations among those that had been dropped (Figure 6). This indicates that trees with a higher percentage fruit drop shed a higher proportion of damaged fruit. The proportion of damaged fruit dropped increases dramatically when the percentage fruit drop exceeds about 24%.

**Development of a sampling technique**

Head-height counts of damaged fruit were an unreliable index of the actual levels of damage on the trees (y = 6,808 + 0,730x; $R^2$ = 24%; P = 0,029; n = 20). However, the percentage of damaged fruit in the 1-2 m stratum is a reliable index of the actual fruit loss (y = 3,255 + 0,791x; $R^2$ = 88%; P = 0,00002; n = 11).

## DISCUSSION

Although sampling the incidence of protrusions at head-height was not an accurate assessment of actual fruit loss, the large number of fruit sampled in this manner to compare damage on Hass and Fuerte cultivars, clearly indicated that losses were significantly greater (five times) on Hass. The low variation (8-11%) in the percentage of Hass fruit with protrusions, over five sampling dates (December 1991 to March 1992) since the initiation of the study, indicates that:

(a) the incidence of damage remained fairly constant, and that 10% is probably a reliable estimate of fruit loss; and

(b) that this damage was done during the earlier stages of fruit development (September October).

The incidence of fruit with protrusions was not greater along the borders of the orchard, but was distributed throughout the study site. Trees with the highest levels of damage occurred in the center of the study site, indicating that the insect is highly mobile.

A less mobile, slower disperser would produce a typical edge effect, or a wave of damage advancing from a particular point of infestation within the orchard.

The pests currently causing lesions on avocado fruit in South Africa are all sporadic, because they are polyphages whose mobility enables them to exploit a range of crops (Dennill & Erasmus, 1992). The pentatomids (and possibly cicadellids) causing the protrusions conform to this suite.

The distribution within the trees of fruit bearing protrusions, indicates clearly that the pest's feeding is not density dependent; irrespective of height or aspect, a constant percentage of fruit was damaged. The proportion of damaged fruit was significantly lower on the southern sides of the trees, but this occurred only because there were less fruit on the southern aspects (it is commonly known that the shadier sides of trees bear less fruit (Jackson, 1986; Hartmann *et al,* 1988). Comparison of the incidence of damage in the four aspects of the trees, however, confirmed random feeding.

There was no increase in fruit drop as a result of the feeding by the insects which caused protrusions. This is unfortunate, since it means that the trees expend energy to mature fruit that are useless to the grower.

In contrast, fruit feeding by the coconut bug does enhance fruit drop. The indentations are attributed to the coconut bug feeding at an early stage of fruit development (Viljoen, 1906; De Villiers, 1990; Du Toit & De Villiers, 1990; Van der Meulen, personal communication).

The damaged part of the developing fruit does not grow normally, while the healthy surrounding tissue does, resulting in an indentation where the damage was done. The first phase of fruit abortion occurs during the early stages of fruit development (September-October), and this explains why trees can shed a high proportion of developing fruit with this kind of damage.

It is equally unfortunate that the mass of fruit with protrusions is similar to that of healthy fruit. This implies that the damaged fruit are as energy expensive to the plant as healthy fruit. In contrast, the indented fruit were 28% lighter in mass and are therefore about 28% less energy consuming.

Although the feeding by coconut bug causes internal scars similar to those underneath the protrusions and is similarly density independent, with no preference for a particular aspect and only a possible tendency for the upper reaches of the trees, there was no correlation between the two kinds of damage. This, and the difference in fruit drop and mass between the two kinds of damaged fruit, suggests that the two symptoms are caused by different species (and specifically that it is probably not coconut bug at a younger stage of nymphal development or different stage of fruit development).

Sampling fruit with protrusions at head-height yielded samples that were too small to accurately estimate crop loss. Counts of the fruit in the 1-2 m stratum were, in contrast, accurate. This is to be expected since feeding by the insect is random and the proportion of fruit in the 1-2 m stratum is high (21%). These results indicate that only the 1-2 m stratum need to be counted to monitor the damage caused by this pest, and that further timesaving could be achieved by sampling a proportion of fruit (within the accessible 1-2 m stratum) of magnitude between the total number of fruit in this stratum and that at head-height.

## ACKNOWLEDGEMENTS

The authors thank Mr C J Partridge for alerting them to this problem; the South African Avocado Growers' Association for financially supporting this research; Prof J M Kotzé for inspiration and encouragement; Mrs M F Smith and Dr S L Chown for assistance with statistics; Ms L Croukamp for providing horticultural information and Mr W Vos for being willing to sacrifice so much of his produce in pursuit of knowledge.

## REFERENCES


ANNECKE, D P & MORAN, V C, 1982. Insect and mite pests of cultivated plants in South Africa. Durban: Butterworth, 383pp.

DENNILL, G B & ERASMUS, M J, 1991. A packhouse survey of insect damage to avocados in the Nelspruit/Hazyview area during 1990. *S A Avocado Growers' Assoc Yrb,* **14,** 79 - 82.

DENNILL, G B & ERASMUS, M J, 1992. The insect pests of avocado fruits increasing pest complex and changing pest status. *J ent Soc sth Afr,* **55,** in press.

DE VILLIERS, E A, 1990. Thrips in avocados. *Farming in South Africa,* Avocados H.3/1990, 2pp.

DE VILLIERS, E A & VAN DEN BERG, M A, 1987. Avocado insects of South Africa. S *A Avocado Growers' Asoc Yrb,* **10,** 75 - 79.

DURAND, B J, 1990. Inleiding tot die kweek van avokado's in Suid-Afrika. *Boerdery in Suid-Afrika,* Avokado's A.l/1990, 1p.

DU TOIT, W J & DE VILLIERS, E A, 1990. Identifisering van avokadovrugletsels wat deur insekte veroorsaak word. *S A Avocado Growers' Assoc Yrb,* **13,** 56 - 60.

ERICHSEN, C, 1992. Economic losses due to insect pests of avocado fruits in the NelspruitHazyview region of South Africa during 1991.S *A Avocado Growers' Assoc Yrb* **15,** in press.

GROUT, T G & RICHARDS, G I, 1990. Monitoring citrus thrips, *Scirtothrips aurantii* Faure (Thysanoptera, Thripidae), with yellow card traps and the effect of latitude on treatment thresholds. *J Appl Ent,* **109,** 385 - 389.

HARTMANN, H T, KOFRANEK, A M, RUBATZKY, V E & FLOCKER, W J, 1988. Plant science-growth, development, and utilization of cultivated plants. Second Edition. London: Prentice-Hall, p 133.

JACKSON, D 1,1986. Temperate and subtropical fruit production. Wellington: Butterworth, p 39.

VILJOEN, H M, 1986. Kokosneutstinkhesie -'n potensiële plaag op avokado's. *S A Avocado Growers' Assoc Yrb,* **9**, 72 - 74.