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Economic losses due to insect pests on avocado fruit in the Nelspruit/Hazyview region of South Africa during 1991

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ABSTRACT

A survey of insect damage to 61 036 avocado fruits of five cultivars, was conducted at eight packhouses in the Nelspruit/Hazyview region. Stink bugs [incl Nezara viridula *(L)], coconut bug* [Pseudotheraptus wayi *Brown], fruitfly* [Pterandrus rosa *(Karsch) and* Ceratitis capitata *(Weidemann)], thrips* [Heliothrips haemorrhoidalis *Bouché and* Selenothrips rubrocinctus *(Giard)], and false codling moth* [Cryptophlebia leucotreta *(Meyrick)] were the most important pests responsible for 84,10% of the damage recorded. The South African avocado industry is losing up to R2,93 million per annum due to insect pests in the Nelspruit/Hazyview region. A comparison between this study and that of the 1990 avocado season, confirms the importance of the above five pests and the seasonal variation in pest attacks between cultivars. Hass showed the greatest overall incidence of insect pest attack. The insect pest-complex was increased with the addition of three new pests recorded as damaging, or present on, avocado fruit*

INTRODUCTION

Insect pests damaging avocado fruit increased in economic importance during the last four years. Until late in the 1980s, avocado orchards were relatively free from serious insect pests, as a result of good control by natural enemies (De Villiers & van den Berg, 1987). With the increased cultivation of avocados over the last decade, there has been a concomittant increase in the number and severity of insect pests and their impact on the avocado industry.

The insect-pest complex has increased from three lesion-causing pests in 1982 (Annecke & Moran, 1982) to nine insect pests in 1990 (Dennill & Erasmus, 1991). During 1989, outbreaks of thrips *[Heliothrips haemorrhoidalis* Bouché and *Selenothrips rubrocinctus* (Giard)] resulted in a loss of up to 80% of produce for some growers (Dennill & Erasmus, 1991).

Damage to avocado fruit, by the various insect pests, have been described and illustrated (Schwartz, 1978; Du Toit *et al*, 1979; Annecke & Moran, 1982; Viljoen, 1986; Viljoen & de Villiers, 1986; de Villiers & van den Berg, 1987; de Villiers 1990, a,b; du Toit & de Villiers, 1990; Robertson, 1990; Dennill & Erasmus, 1991). The damage previously attributed to stink bugs (pimply elevations on the fruit surface — see Dennill & Erasmus, 1991) has recently been questioned. The author observed leafhoppers (especially the citrus leafhopper, *Penthimiola bella* Stäl) attacking the Hass cultivar in particular, and considers the elevations a result of prolonged feeding activity by the insects. These insects may soon be a pest of considerable importance. Dennill & Dupont (this volume) find similarities between this damage and that attributed to coconut bug by various authors (Viljoen, 1986; Viljoen & de Villiers, 1986; de Villiers & van den Berg, 1987; du Toit & de Villiers, 1990).

The aim of the present study was to determine economic losses caused by insect pests on avocado fruit in the Nelspruit/Hazyview region during 1991, and to compare the results with those of the 1990 survey by Dennill & Erasmus (1991). The latter survey spanned the last half of the 1990 avocado packing season (June-August), while the present study was conducted throughout the 1991 packing season. Insect damage was assessed for the first time on two additional cultivars, Pinkerton and Ryan. The studies examined any changes in the insect pest-complex and the status of the various pests between the two seasons. The extent and spatial distribution of the damage or insects present on avocado fruit was determined. The efficacy of the sampling technique used in this study was established.

MATERIALS AND METHODS

Inspection of avocado fruit

Avocado fruit were inspected at eight packhouses in the Nelspruit/Hazyview region of the eastern Transvaal: Avalon, Haffenden Grove, H L Hall & Sons Pty (Ltd), Koeltehof, Pienaar Pakkers, Twycross, Vos, and Wayland Green Pty (Ltd). The packhouses were visited from Mondays to Fridays every alternate week, from 12 March to 11 September 1991. During each packhouse visit, five lugs (= crates) of freshly-picked, unsorted avocado fruit were randomly selected from growers' produce being packed at the time. A total of 61 036 avocados of five cultivars in 145 samples from 45 growers were selected (Table 1). Each fruit was examined for insect-induced damage and insect presence

TABLE 1 **Total number of avocado fruit examined for insect damage per cultivar**

Cultivar	Number of samples	Number of fruit
Fuerte	59	21 908
Hass	50	26 706
Edranol	16	6 112
Ryan	11	3 873
Pinkerton	9	2 437
TOTAL	145	61 036

The efficacy of the sampling technique was determined. Damage by the five most important insect pests was compared between two independent samples from 12 avocado orchards (4 Fuerte, 4 Hass, 2 Pinkerton, 1 Edranol and 1 Ryan) using pairwise Chi-square tests.

Lesion-causing insect pests

Damage caused by thrips, leafrollers *[Cacoecia occidentalis* (Wlsm) and *Tortrix capensana* (Walker)] loopers [possibly *Ascotis selenana reciprocaría* (Walker) (see de Villiers & van den Berg, 1987)], beetles (unidentified) and ants *[Myrmicaria natalensis (*Mayr)][1] feeding on the fruit surface was scored from one to 10, corresponding to the percentage fruit surface area damaged (1, 1-10% of the fruit surface area damaged; 2, 11-20% of the fruit surface area damaged; etc).

Insect pests that pierced the fruit surface were scored differently. The numbers of penetration sites per fruit were counted and their position on the fruit recorded. The fruit was divided into three regions: an upper area around the calyx, the side of the fruit, and the base as viewed from below. Coconut bugs *(Pseudotheraptus wayi* Brown) and stink bugs [including *Nezara viridula* (L)] pierce the fruit when feeding, fruitflies *[Pterandrus rosa* (Karsch) and *Ceratitis capitata* (Weidemann)] when ovipositing, and false codling moth larvae *[Cryptophlebia leucotreta* (Meyrick)] tunnel below the fruit surface.

Sedentary insect pests

The presence of armoured scales *[Hemiberlesia lataniae* (Signoret), *Chrysomphalus dictyospermi* (Morgan), *Aulacaspis tubercularis* Newstead, and *Fiörinia fioriniae* (Targioni)] was recorded, using scores similar to those for lesion-causing pests. The score represented the percentage of the fruit surface covered by the scale colony. Fifty fruits were randomly chosen from each avocado sample and the position of armoured scales (excluding mussel scale) on the fruit surface noted. The fruit was divided into the same regions as described earlier. Heart-shaped scale *[Protopulvinaria pyriformis* (Ckll)] was scored in a similar manner and its position on the fruit recorded. In the case of mealybug *[Pseudococcus longispinus* (TT)], the number of individuals on each fruit were counted.

Percentage of fruit total with insect damage

The total percentage of fruit with insect presence and damage was calculated. The pests were ranked in order of importance and the percentage damage by the top five pests determined.

Percentage fruit of each cultivar with insect damage

The five most important insect pests for each cultivar were determined. The pests were

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1 Damage previously attributed to ants (see Dennill & Erasmus, 1991) may be due to feeding by a species of slug or snail (G.J. Begemann, pers. comm.).

given a score of one to five for the lowest to highest ranked pest respectively. The scores were added to give a cumulative score for each pest. This was done to determine whether the overall ranking of the top five pests held true for the various cultivars.

The percentage fruit damaged by the top five pests was calculated for each cultivar, to compare relative insect damage and determine whether certain cultivars were more susceptible to insect pest attack than others. The data required a Log (x+1) transformation as determined by Taylor's Power Law (b = 1,575; p = 0,21). An analysis of variance (ANOVA) was carried out and minimum significant differences (MSDs) calculated using the GT2-method (Sokal & Rohlf, 1981).

RESULTS

Inspection of avocado fruit

The insect pests that damaged or were present and feeding on avocado fruit are listed in Table 2. Additions to the previously known avocado pests in South Africa are the noctuid moth *Eublemma brachygonia* Hampson and the armoured scales *Aulacaspis tubercularis* Newstead and *Fiorinia fioriniae* (Targioni).

Out of a possible 60 paired-sample comparisons in determining sampling efficacy, nine could not be done because the counts were zero. Only one comparison was significant (X^2 = 18; P < 0,001). Of the 51 comparisons, 72,55% were non-significant above the 90% probability level (0 ≤ X^2 ≤2,43; 0,10 ≤1,00). A further 9,8% of the paired sample comparisons were non-significant above the 95% probability level (0 ≤ X^2 ≤ 8,69; 0,05 ≤P ≤ 1,00). Thus 82,35% of the comparisons were reliable above the 95% probability level, indicating a high efficacy of sampling.

TABLE 2 Insect pests that damaged, or were present and feeding on, avocado fruit

Common name	Species
COREIDAE	
Coconut bug	*Pseudotheraptus wayi* Brown
PENTATOMIDAE	
Stink bug complex	incl *Nezara viridula* (L)
TEPHRITIDAE	
Natal fruitfly	*Pterandrus rosa* (Karsch)
Mediterranean fruitfly	*Ceratitis capitata* (Weidemann)
THRIPIDAE	
Greenhouse thrips	*Heliothrips haemorrhoidalis* (Bouché)
Red-banded thrips	*Selenothrips rubrocinctus* (Giard)
TORTRICIDAE	
False codling moth	*Cryptophlebia leucotretra* (Meyrick)
Citrus leafroller	*Cacoecia occidentalis* (Wlsm)
Apple leafroller	*Tortrix capensana* (Walker)
GEOMETRIDAE	
Looper	*Ascotis selenaria reciprocaria* (Walker) (possibly)
NOCTUIDAE	
Not known	**Eublemma brachygonia* Hampson
PSEUDOCOCCIDAE	
Long-tailed mealybug	*Pseudococcus longispinus* (TT)
COCCIDAE	
Heart-shaped scale	*Protopulvinaria pyriformis* (Ckll)
DIASPIDIDAE	
Palm scale	*Hemiberlesia lataniae* (Signoret)
Mango scale	**Aulacaspis tubercularis* Newstead
Spanish red scale	*Chrysomphalus dictyospermi* (Morgan)
Avocado scale	**Fiorinia fioriniae* (Targioni)
FORMICIDAE	
Ants	*Myrmicaria natalensis* (Mayr)[1]
COLEOPTERA	
Beetles	Unidentified

(* = new recordings)

1 Damage previously attributed to ants (see Dennill & Erasmus, 1991) may be due to feeding by a species of slug or snail (G.J. Begemann, pers. comm.).

TABLE 3 Percentage of the 61 036 avocado fruits from 145 samples on which insect damage was recorded

Pest	n	%	Rank
Stink bug	1 899	3,11	1
Coconut bug	1 718	2,81	2
Fruitfly	1 154	1,89	3
Thrips	923	1,51	4
False codling moth	806	1,32	5
Weevils	541	0,89	6
Mealybug	282	0,46	7
Leafroller	207	0,34	8
Ants	107	0,18	9
Looper	93	0,15	10
TOTAL	7 730	12,66	

(n = number of fruits)

Percentage totals of fruit with insect damage

Insect damage was recorded on 12,66% of the avocado fruit examined (Table 3). The five highest ranking pests were stink bugs (3,11%), coconut bug (2,81%), fruitfly (1,89%), thrips (1,51%), and false codling moth (1,32%), respectively (Table 3). These five pests accounted for 84,10% of the total damage; stink bugs and coconut bugs contributing 24,57% and 22,23% respectively. Leafrollers and loopers together, were responsible for 3,88% of the damage.

TABLE 4 Ranking of the five most important insect pests of Pinkerton, Ryan, Edranol, Hass, and Fuerte cultivars (1 = least important; 5 = most important) and resultant cumulative scores

Pest Score	Pinkerton	Ryan	Edranol	Hass	Fuerte
5	Fruitfly	Stink bug	Coconut bug	Stink bug	Coconut bug
4	Leafroller	Mealybug	F-C moth	Coconut bug	Fruitfly
3	Coconut bug	F-C moth	Stink bug	Thrips	Weevils
2	Stink bug	Fruitfly	Fruitfly	F-C moth	Thrips
1	Thrips	Thrips	Thrips	Fruitfly	Stink bug

F-C = false codling

CUMULATIVE SCORES:

Coconut bug	17	Thrips	8
Stink bug	16	Mealybug	4
Fruitfly	14	Leafroller	4
F-C moth	9	Weevils	3

TABLE 5 The mean number of avocado fruit damaged by each of the top five insect pests per cultivar

	Stink bugs	Coconut bug	Fruitfly	Thrips	False codling moth
Pinkerton	2,130 ab	2,569 ab	7,865 ab	1,545 a	0,839 ab
Ryan	11,835 cd	0,385 a	2,852 ab	2,109 ab	2,707 ac
Edranol	3,853 bc	11,224 b	1,941 a	1,170 a	5,374 c
Hass	18,329 d	3,844 b	4,103 ab	6,475 b	3,649 c
Fuerte	0,566 a	6,091 b	5,694 b	1,220 a	0,555 b

(Similar letters denote no significant difference between means)

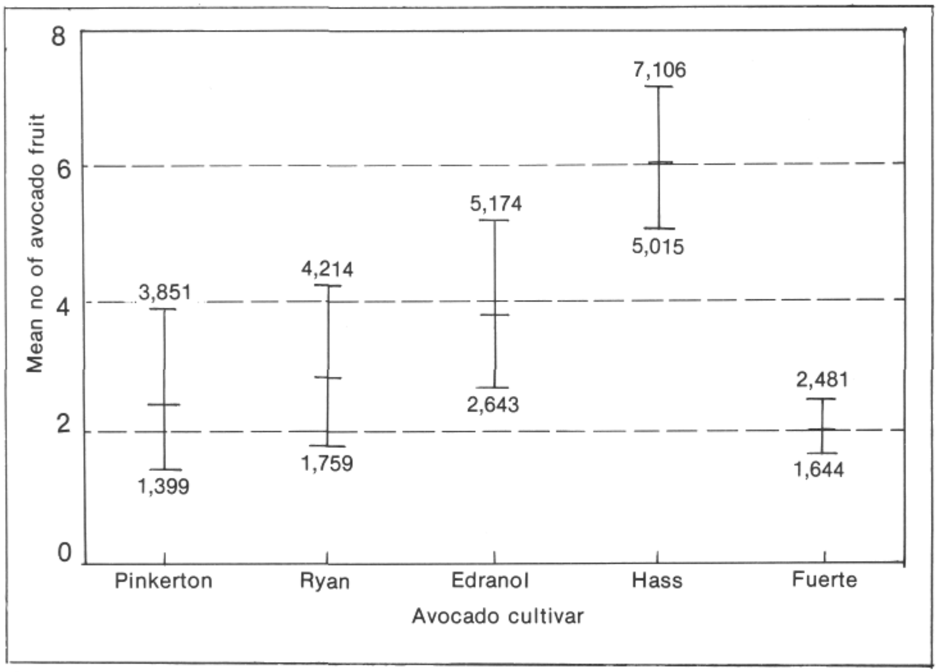

Fig 1 Mean number (and 95% comparison intervals) of avocado fruit attacked by the top five insect pests per cultivar. Means whose comparison intervals overlap are not significantly different.

Percentage fruit of each cultivar with insect damage

The five most important insect pests determined for each cultivar are shown in Table 4. The ranking shows coconut bug and stink bugs to be twice as important as either false codling moth or thrips. A comparison of the pest rankings in Tables 3 and 4 confirms that the top five pests are stink bugs, coconut bug, fruitfly, thrips and false codling moth.

The mean number of fruit damaged by the top five pests for each cultivar is tabulated (Table 5). The ANOVA on pest attack between cultivars was highly significant ($F = 17,16$, $df = 4$, $P < 0,001$). Damage by thrips was significantly greater on Hass and Ryan than on any other cultivar. Attack by false codling moth was significantly higher on Hass, Edranol and Ryan than on Fuerte and Pinkerton (Table 5). Hass and Ryan showed significantly higher degrees of stink bug attack than Fuerte and Pinkerton. Fuerte, Hass and Edranol showed significantly higher levels of damage by coconut bug than Ryan. All the cultivars were attacked by fruitfly to a similar extent (Table 5).

The comparison of insect damage between cultivars showed Hass to have the greatest overall incidence of pest attack (Figure 1). The mean number of Hass fruit attacked was 5,982. Pest attack on Hass and Edranol was significantly higher than on Pinkerton, Ryan and Fuerte (Figure 1).

Lesion-causing insect pests

Of the total number of fruits damaged by thrips (refer to Table 3), 41 were damaged over more than 30% of the fruit surface. Fruits with a score greater than three are culled. As a result, 4,43% of thrips damaged fruit for all the cultivars were culled. The median and range of thrips damage for all cultivars is tabulated (Table 6).

The median and range of the percentage fruit surface area damaged by leafrollers, loopers, beetles and ants is also tabulated (Table 6).

Coconut bug and stink bugs feed primarily on the side of the fruit (Table 7). The number of feeding sites per fruit is similar for both pests. Fruitflies oviposit mainly on the side and base of avocado fruit (Table 7). False codling moth larvae tunnel predominantly on the base of the fruit (Table 7).

Sedentary insect pests

The position where armoured scales were found on the fruit for all cultivars is tabulated (Table 8). Armoured scales were predominant in the calyx region on Edranol and Fuerte. Although also found on the base of Ryan fruit, armoured scales were mostly found in the region of the calyx on this cultivar. On Pinkerton, the scale insects were distributed mainly on the side and base of the fruit. On Hass, armoured scales were found primarily on the side of the fruit (Table 8). Heart-shaped scale, *Protopulvinaria pyriformis* (Ckll), was recorded on only the Ryan cultivar (17 fruits).

TABLE 6 **Median and range of the percentage fruit surface area damaged by thrips, leafroller, looper, beetle and ants per cultivar**

	Thrips		Leafroller		Looper	
	median	range (%)	median	range (%)	median	range (%)
Pinkerton	6,8	0–70	5,3	0–20	10,0	0–20
Ryan	8,9	0–40	5,0	0–10	5,0	0–10
Edranol	10,5	0–40	5,5	0–20	12,2	0–50
Hass	5,9	0–80	5,9	0–30	7,7	0–50
Fuerte	6,2	0–50	5,5	0–20	5,7	0–20

	Beetles		Ants	
	median	range (%)	median	range (%)
Pinkerton	5,8	0–30	5,5	0–20
Ryan	5,6	0–40	10,0	0–40
Edranol	6,9	0–70	5,0	0–10
Hass	5,7	0–50	9,6	0–40
Fuerte	6,1	0–70	6,3	0–40

TABLE 7 **The extent and spatial distribution of stink bug, coconut bug, fruitfly and false codling moth damage on avocado fruit over all cultivars (x = mean [± 1 SE] number of feeding [stink bug and coconut bug], oviposition [fruitfly] and tunnel [false codling moth] punctures per fruit region; y = mean [± 1 SE] percentage of fruit exhibiting damage in a particular fruit region)**

	Fruit region					
	calyx		side		base	
	x	y	x	y	x	y
S	1,3 ± 0,08	11,2 ± 2,32	1,5 ± 0,06	82,2 ± 14,69	1,6 ± 0,18	6,7 ± 6,717
C	1,3 ± 0,12	14,2 ± 3,22	1,8 ± 0,16	72,7 ± 3,23	1,6 ± 0,46	13,0 ± 5,05
F	0,9 ± 0,22	1,7 ± 0,80	1,9 ± 0,33	54,7 ± 3,74	1,8 ± 0,37	43,6 ± 3,20
FCM	0,6 ± 0,25	0,7 ± 0,20	1,2 ± 0,07	22,12 ± 5,05	1,4 ± 0,08	77,2 ± 5,06

(S – stink bugs; C – coconut bug; F – fruitfly; FCM – false codling moth)

TABLE 8 **The spatial distribution of armoured scales per cultivar (x = mean number of armoured scales found in a particular fruit region; y = percentage of fruit with armoured scales in a particular fruit region)**

	Calyx		Side		Base	
	x	y	x	y	x	y
Pinkerton	2,32	14,72	3,78	34,60	4,32	50,68
Ryan	2,82	47,08	2,75	13,26	3,45	39,66
Edranol	2,25	74,74	1,95	9,69	1,76	15,56
Hass	2,23	14,22	3,28	52,40	2,18	33,38
Fuerte	2,52	73,75	2,00	9,87	2,18	16,38

TABLE 9 Comparison between percentage insect damage and insect pest ranks of the 1990 and 1991 avocado seasons (pest ranks in brackets)

Insect pest	Percentage damage (pest rank)	
	1991	1990
Stink bugs	24,57 (1)	14,25 (4)
Coconut bug	22,23 (2)	36,29 (1)
Fruitfly	14,93 (3)	14,35 (3)
Thrips	11,94 (4)	16,25 (2)
False codling moth	10,43 (5)	5,04 (6)
TOTAL	84,10	86,18

DISCUSSION

Although relatively young and small in comparison to other South African fruit industries (Durand, 1990; Garbers, 1987), the avocado industry is rapidly expanding. Kotzé (1990) reported an annual increment in exports of over 25% per annum for the last decade. With the increasing cultivation of avocados (approximately 9 000 ha at present) there has been a concomittant increase in the insect-pest complex. Since 1982, the number of insect pests damaging avocado fruit in South Africa has trebled (see Dennill & Erasmus, 1991). In the present study, three additional pests have been recorded (Table 2). The noctuid moth, *E bmchygonia* Hampson, was reared from avocados thought to contain false codling moth larvae. Certain species of *Eublemma* larvae are known to feed on soft scale insects (Coccidae) and aphids (Aphididae) (Pinhey, 1975; Bedford, 1978). Whether *E brachygonia* Hampson larvae are pests of avocado fruit *per se* or were an opportunistic find, requires further investigation.

The five most important insect pests attacking avocado fruit during the 1991 picking season were stink bugs, coconut bug, fruitfly, thrips and false codling moth respectively (Table 3). The five pests were responsible for 84,10% of the damage recorded on avocado fruit, which compares well with 86,18% found by Dennill & Erasmus (1991) (Table 9). Exported fruit generates approximately R120 million per annum. Fruit cull as a result of insect pests, therefore, is costing the avocado industry up to R13 million per annum.

Compared with that found by Dennill & Erasmus (1991) in the 1990 season, the four top pests have remained the same, although the rank of each differs (Table 9). The fifth pest in 1990, weevils, is replaced by false codling moth in this study (Table 9).

Stink bugs were shown to be considerably more important in the 1991 season than in 1990 (Table 9). This may be a result of misinterpretation of the damage incurred by this insect by Dennill and Erasmus (1991). The ranking of fruitfly did not change (Table 9). This may be a direct result of regular baiting procedures conducted by growers. Baiting significantly reduced the rejection of fruit as a result of fruitfly damage for most avocado cultivars in the first half of the 1980s (Partridge & Smith, 1984; Pieterse, 1986).

Thrips were not as important a pest as in the 1990 season. The total cull of 4,43% is lower than the cull of 5,72% calculated by Dennill and Erasmus (1991). The primary feeding site for thrips on Guatemalan varieties is the fruit (Bekey, 1986). This may account for the high incidence of thrips on Hass (Table 5). The percentage of the fruit surface area damaged, however, is lower on Hass than the large fruit of other cultivars (Table 6).

There was little change in the top five insect pests between the 1990 and 1991 avocado seasons (Table 9). The change in the ranking of the pests, however, may be explained through differences in insect pest attack on the individual cultivars.

Hass exhibited the highest overall incidence of pest attack (Figure 1). Stink bugs on Hass were more important than coconut bug in the 1991 avocado season than the 1990 season (see Dennill & Erasmus, 1991, Table 4). Similarly, there was a greater incidence of coconut bug damage on Edranol in the 1991 season than on Fuerte the previous season. In contrast, fruitfly attack on Edranol was lower in 1991 than in the 1990 season. The high incidence of fruitfly attack recorded on Pinkerton, however, may be a result of a cultivar shift similar to that of coconut bug. Whether environmental conditions or baiting practices influenced the shift could not be determined.

This suggests that although there is little change in the top five pests, insect pest attack on individual cultivars may vary from season to season. Avocado pests have been shown to be highly mobile, polyphagous insects (Dennill & Moran, 1990; Dennill & Erasmus, 1991) which may explain seasonal variation of pest attack between cultivars.

The Natal fruitfly, *P rosa* (Karsch), is a considerably more important pest than the Mediterranean fruitfly, *C capitata* (Weidemann), on avocados in South Africa. The former is able to sting firm fruit although eggs are not necessarily oviposited. The latter will oviposit only in avocados that have softened on the tree or lay in oviposition holes of other females (Rivnay, 1941; Ebeling, 1959; Christenson & Foote, 1960; Armstrong *et al,* 1983). Krainacker *et al* (1987) have shown medfly pre-adult survival on ripened avocados to be second only to plum out of 24 host fruits tested. Medfly cannot oviposit on firm fruit. Callus formation in unripened avocados forms a barrier between the avocado flesh and enclosing larvae. As a result, larvae are crushed within the fruit or die whilst searching for food and moisture on the fruit surface (Armstrong *et al,* 1983). Since avocados are mainly picked while still firm, medfly is not an important threat.

The position of long-tailed mealybug on the fruit at the time of recording cannot be seen as relevant, as the insect may have moved from its original position during fruit handling. All stages of the mealybug are found on avocado fruit and fruit petioles where they extract sap. The insect secretes honeydew, which facilitates the growth of sooty mould (Wysoki *et al,* 1977; de Villiers & van den Berg, 1987). Ants, such as aphidicolous *Crematogaster* species, are also attracted to the surplus honeydew and in return afford the mealybug protection from predators and parasitoids (personal observation).

The low occurrence of heart-shaped scale on avocado fruits, as opposed to leaves, shows that this scale species is not primarily a fruit-dwelling species. Like mealybug, the scale species secretes large amounts of honeydew, facilitating the growth of sooty mould. As a result, photosynthesis on the leaf surface is inhibited (de Villiers, 1989).

The high incidence of armoured scales on Fuerte, Ryan and Edranol is a result of these cultivars possessing a persistant calyx which provides scale cover and protection from environmental conditions and predator/parasitoid attack respectively (Table 8). Scale crawlers would easily move in under the calyx and obtain more protection under the firm and tight-fitting fruit region than on the exposed fruit surface. The large, rugose, basal region of Pinkerton and Ryan also lends itself to colonization by armoured scales (Table 8). Hass, albeit with a rugose surface, is a small fruit in comparison to Pinkerton and Ryan, which is why armoured scales are found predominantly on the side of the fruit (Table 8). The irregular fruit surfaces of these cultivars provide protection for the armoured scale species.

Over 300 pests have been recorded on avocados worldwide (Milne, 1973). Of these, 76 occur in southern Africa and although some are already avocado pests, many may still be recruited onto avocados in the future. Whether the South African avocado industry can afford the growth of the avocado insect-pest complex remains to be seen.

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