Ring spot damage to Florida citrus fruit caused by thrips feeling injury

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Introduction

Four years ago, several citrus growers in Florida began noticing a rind blemish problem primarily on maturing grapefruit. One grower first observed ring spotting of maturing fruit in August 1992. A few orange groves (i.e., 'Valencia' and 'Hamlin') have been affected, but to a lesser extent.

The damage is characterized by a brown ring of rough or smooth russeting that occurs at touch points between clustered fruit. High frequencies (50 to 100 percent) of ring spot damage on clustered fruit were recorded in six grapefruit groves located in Hendry, Collier and Polk counties during 1993.

Some growers consider this ring spot to be their most serious economic problem on red grapefruit, while other growers have not experienced the problem at all. Growers have been told that the problem is caused by the citrus rust mite (Coleman 1993). Results of ongoing research since 1992 in several affected citrus groves are reported here to identify the actual cause.

Insect Pests Causing Ring Spotting on Fruit

Two species of thrips are responsible for causing the circular or irregular rind blemish problems on both clustered and single citrus fruit in Florida. The orchid thrips, *Chaetanaphothrips orchidii* (Moulton), is one species and the greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouche') (Thysanoptera: Thripidae), is the other species. Both species have been previously reported on Florida citrus as pests.

Other arthropods occasionally found in association with damaged fruit at touch points in the affected groves include a fungal feeding thrips, *Adraneothrips decorus* Hood, mealybugs, purple scale, tydeid mites and citrus rust mites. However, the frequency of occurrence and numbers of these arthropods were low, relative to orchid thrips numbers in replicated alcohol samples or clustered fruit examined in the field.

Orchid thrips

The adult female orchid thrips is 1.1 to 1.2 millimeters (about 1/25 of an inch) in length, yellowish in color, with distinctive, dark-brown coloration at the bases of the first pair of wings (Fig. 1A). Both larval stages are white, lacking wings, and range in size from 1/l0th millimeter to near adult size. First stage larvae are too small to be seen without a 10X handlens. Mature second stage larvae turn yellowish in color as they mature (Fig. 1A, C). Both larvae I and II and adult females are the feeding stages in the life cycle. As with most thrips species, the propupal and pupal stages do not feed. Males of the orchid thrips are not known.

Both adults and larvae were active from May 1993 through January 1994 in several citrus grove sites in south- west and central Florida. Orchid thrips occur throughout the year in citrus groves in Florida.

High humidity, moderate temperatures and low light intensity are environmental conditions required for both the orchid and greenhouse thrips. Thrips prefer to get into minute or restricted areas of plants (that is, between closed petals or leaflets on floral or leaf buds, between frond sheaths, between touch points of clustered fruit, or between a leaf or twig and a developing fruit). Such areas are consistent with their needs for high humidity and reduced light exposure

Their preference for these conditions is further reflected in their distribution within citrus trees. Throughout the 1993 season, damage to clustered grapefruit was more commonly found inside tree canopies compared with more exposed fruit clusters in the outer canopies (Fig. 2A, B). When disturbed, both adults and larvae rapidly move out of exposed contact points between clustered fruit and fly or jump off the fruit surface to escape.

Thompson (1939) reported the orchid thrips as a pest in some grape- fruit, orange and tangelo groves in Brevard, Indian River, St. Lucie, Hardee, Manatee, Polk and Orange counties. The orchid thrips—the most abundant of the two species collected during 1993—was responsible for causing ring spot blemishes on immature and mature citrus fruit, including several varieties of grape- fruit and oranges grown for fresh market. It is especially troublesome on red grapefruit varieties. As many as 44 orchid thrips larvae have been collected from one cluster of three red grape- fruit in southwest Florida.

During l993, the ring spot problem first appeared in June with rind blemish rapidly developing after clustered fruit began to touch (Fig. 3A,B). Feeding injury can occur throughout the year as long as fruit remain on the trees (Figs. 3C, 4A-D). Rind blemish also can occur where a leaf covers part of a fruit surface (Fig. 4C).

The banana rust thrips, Chaetanaphothrips signipennis (Bagnall) causes circular or oval, bronze, discolored areas on the sides of developing bunched bananas where colonies have been feeding (Fig. SC) (Williams et al. 1990). These damaged areas closely resemble the distinctive feeding areas of the orchid thrips on immature and mature citrus as shown here

Greenhouse thrips

The adult female greenhouse thrips is black in color, with distinctive body reticulation and 1.0 to 1.5 millimeters in length (Fig. 1B). The wings, legs and antennae are whitish in color (Beattie 1986). This species is sluggish in movement when exposed to sunlight.

The greenhouse thrips occurs in the United States outdoors in central and southern Florida and in southern California (Denmark 1985). A green- house pest in much of Europe and North America, this species was not as common on Florida citrus as the orchid thrips (Thompson 1939).

Reproduction by the greenhouse thrips is parthenogenetic. Virgin females lay eggs that produce female offspring. Males are rare. The females lay between 10 and 25 eggs over several days. Under optimum conditions of moderate temperature and high relative humidity, development from egg to adult occurs in less

than 3 weeks (Zondag 1977). Only the adult female and the two larval stages of the greenhouse thrips feed. Like the orchid thrips, the propupal and pupal stages do not feed.

The greenhouse thrips is a pest on citrus in Puerto Rico (Gaud 1959) and in Australia (Gellatley 1976, Beattie 1986). Beattie and Jiang (1990) reported this species feeding on immature and mature citrus fruit and leaves. Feeding occurs at touch points on both leaves and fruit with economic dam- age related to the number and proportion of clustered fruit.

According to Beattie and Jiang (1990), susceptibility of fruit is related to the length of time they remain on trees. Infestation of immature fruit increases by the presence of infested mature fruit.

All stages of the greenhouse thrips including adult females, larvae, propupae and pupae are found together between grapefruit at touch points. Feeding injury on red grapefruit and 'Valencia' orange (Fig. 5A, B) by the greenhouse thrips in Florida was identical to damage shown on 'Valencia' orange fruit in Australia by Beattie and Jiang (1990). Characterization of internal feeding injury to red grape- fruit will be reported later.

Greenhouse thrips is also a serious pest problem on avocado in Israel, California and South Africa (Swirski et al. lam, McMurtry et al. 1991 Dennill and Erasmus 1992) and radiata pine, Pinus radiata, and young Douglas fir, Pseudotsuga menziesii, in New Zealand (Zondag 1977).

Feeding populations cause a silvering of the rind where cellular contents have been removed. The affected areas on citrus fruit are circular or irregular in shape. Chlorophyll is extracted by the greenhouse thrips when feeding on the pericarp of avocado (Dennill and Erasmus 1992). This causes bronzing of the surfaces of developing avocado fruits while the skin of severely damaged fruits may crack. Thrips excreta are visible on the discolored parts of the pericarp. This had also been observed on Florida citrus.

Infested or damaged avocado fruit that were clustered were consistently damaged at higher levels compared with fruit that did not touch (Fig. SD) (Dennill and Erasmus 1992).

Management practices

Two experiments were conducted during the fall of 1993 to evaluate differences in insecticidal control of the orchid thrips on citrus.

Treatments were established in a randomized complete block design and replicated four times at two grove locations. Treatments were applied with airblast sprayers in 250 gallons per acre (gpa) at Alico on Sept. 10 and 11 and 500 gpa at Silver Strand on Sept. 10, 1993.

Fifty clustered fruit were picked at random from each treatment replicate and immediately washed in a bucket containing a solution of 70 percent ethanol. A maximum of four clustered fruit from one tree, with a minimum of 13 trees per replicate, were sampled on each collecting date. The liquid from each replicate was poured back into a separate pint jar after the last fruit from each sample was washed in solution. The bucket was then rinsed and poured back into the same jar.

Results from the two field experiments showed that Lorsban, Supracide, Carzol (at one location) and Ethion + petroleum oil, at the rates tested, provided the best control of the orchid thrips (Tables 1 and 2). Sulfur, Carzol (at one location), and Agri-mek + petroleum oil were ineffective.

All of the insecticides were evaluated under the worst conditions in that treated fruit were nearly mature. Penetration of insecticidal spray between clustered mature fruit would likely be less effective than earlier applications when fruit were smaller.

Additional research is needed to identify optimal rates of selected insecticides and to determine the optimal timing of one or more spray applications for control of the orchid thrips. Excessive spraying of insecticides at inappropriate times will only result in increased costs and flaring of secondary arthropod pests.

Beattie and Jiang (1989) recommend that clustered 'Valencia' orange fruit be harvested as early as possible to minimize risk of damage. Similar recommendations are made on 'Hess' avocados in California to reduce the effects of feeding damage caused by the greenhouse thrips (Phillips in press).

Selective harvesting of clustered citrus fruit in Florida may reduce late season damage. Where heavy thrips infestation of clustered fruit occur prior to harvest, selective early picking of single fruit may reduce the volume of damage at the packing- house.

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Fig 1 (A) Orchid thrips adult fernales and larvae. Note white first instars and two yellow second instate (larvae) along upper margin. (B) Scanning Electron Micrograph (SEM) of an adult green- house thrips. (C) SEM of an orchid thrips larva

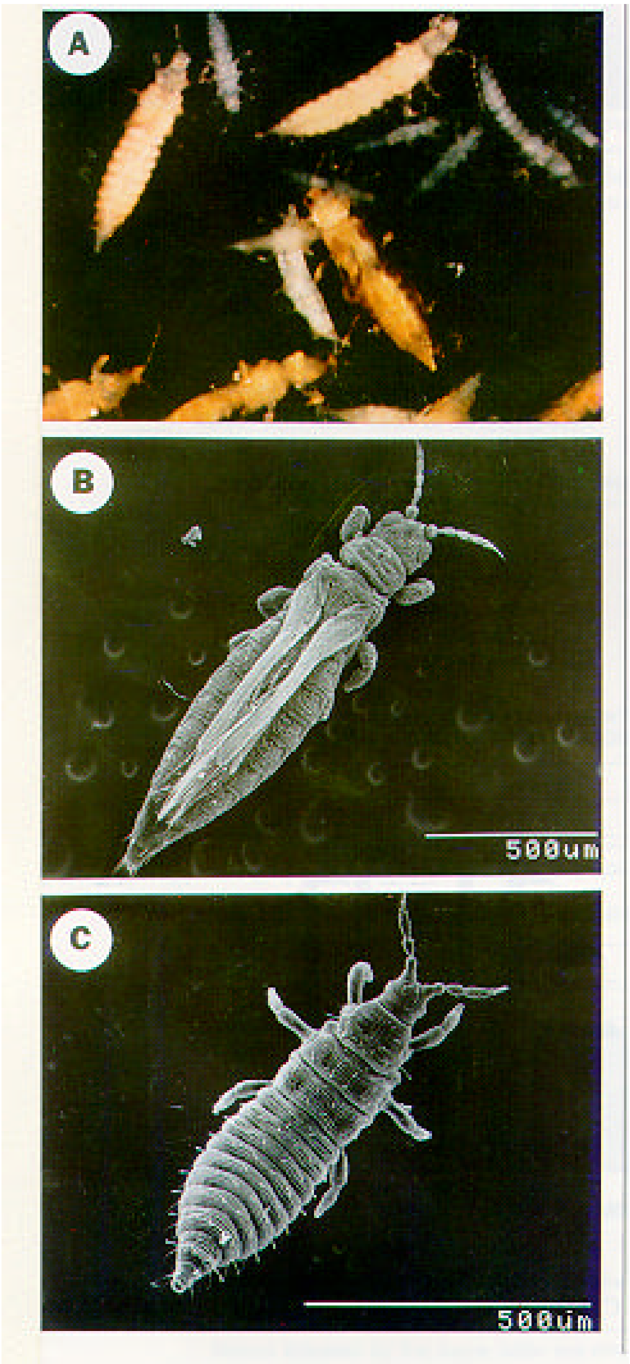

Fig. 2 Orchid thrips damaged red grapefruit from clustered interior fruit compared with clustered fruit collected from the outer tree canopies of the same trees at (A) Silver Strand and (B) at Alico-Collier in Collier County, Florida

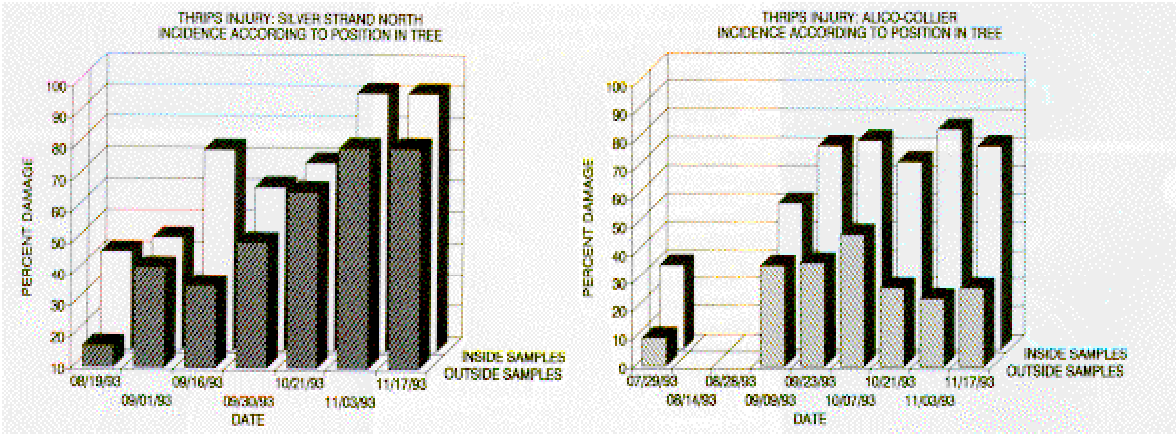

Fig. 3 Immature fruit (A) and (B) with rind blemish damage caused by orchid thrips feeding injury. Note size comparison of coin and blemished areas where clustered fruit had touched. (C) Damaged fruit that have gone through a packinghouse.

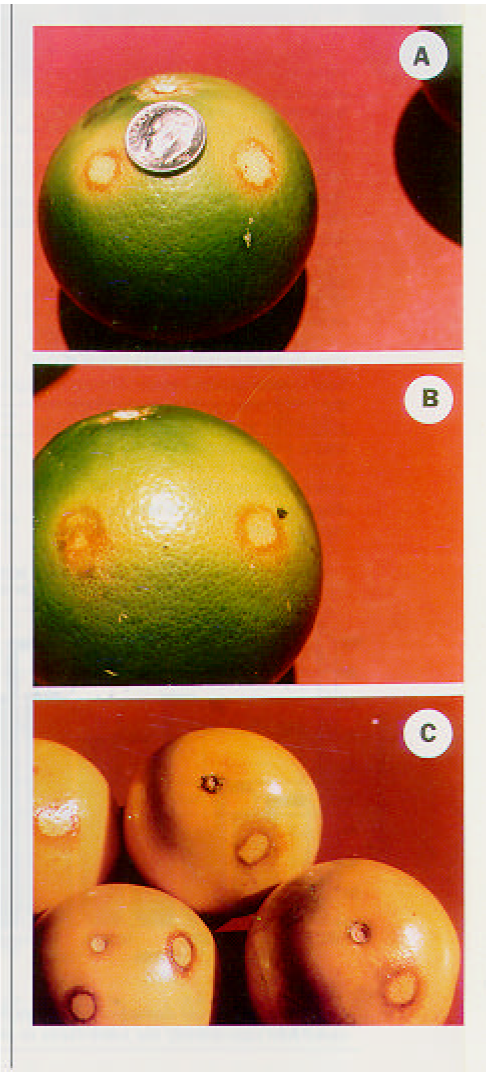

Fig. 4 Damaged areas on two mature fruit at the touch point caused by orchid thrips (A) and (B). (C) Rind blemish where a leaf had pressed against the fruit surface. (D) Rind blemish caused by orchid thrips. Note changes in the touch point locations with growth of the fruit and corresponding thrips damage.

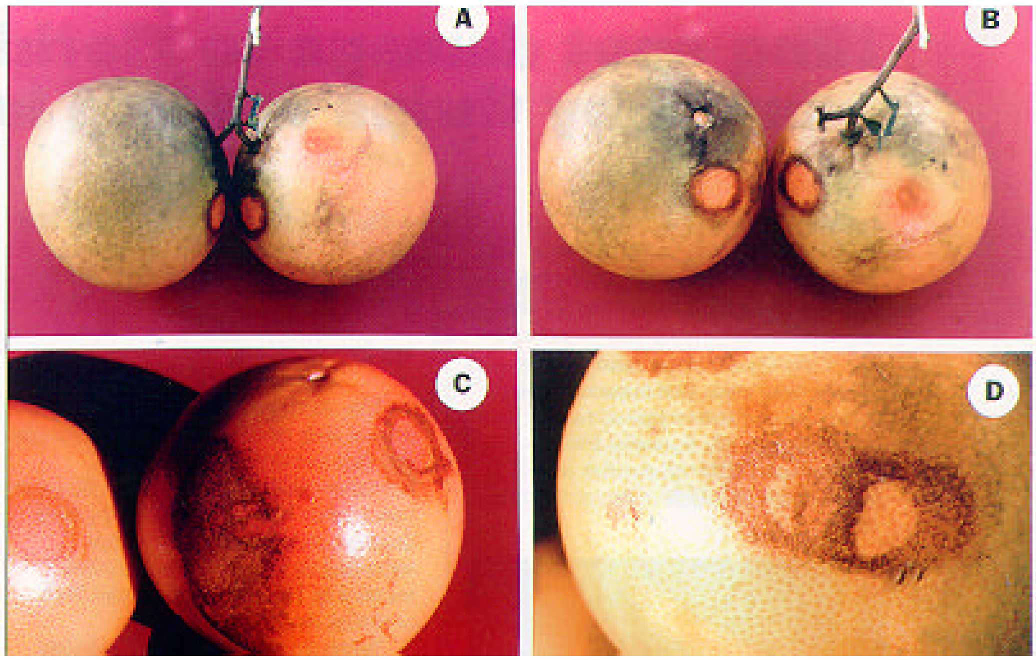

Fig. 5. Rind blemish damage (A) and (B) caused by the greenhouse thrips on red grape- fruit. Note the whitish circular areas where cellular contents have been removed by thrips feeding. (C) Rind blemish damage caused by the banana rust thrips. Oval undamaged center area is marked with an asterisk (photograph from Williams et al. 1990 with permission of the Annals of Botany). (D) Greenhouse thrips feeding damage to avocado fruit. Note characteristic circular damage from thrips feeding where clustered fruit had touched (photograph from Dr. M. Wysoki, Inst. Plant Protection. The Volcani Center. Bet DaPan.

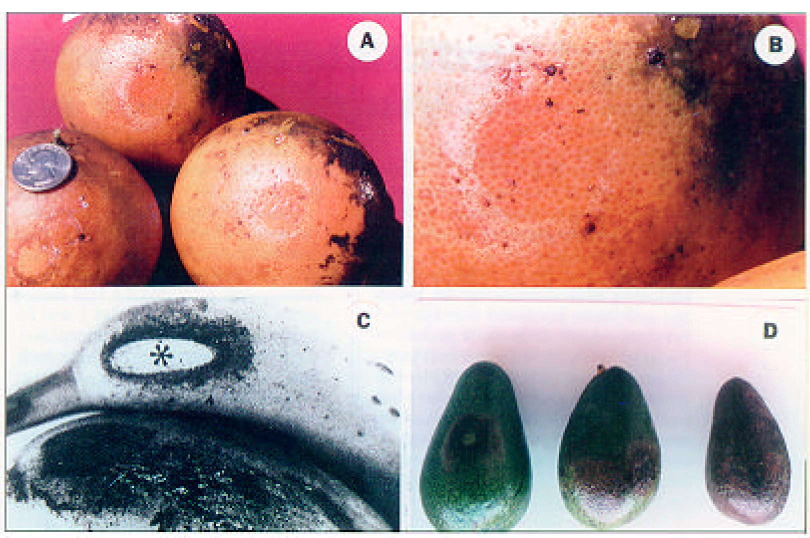

Table 1. Control of orchid thrips adults and larvae (combined) on 'Ruby Red' grapefruit at Alico in Collier County, Florida, 1994.

Treatment	Formulation	Rate/Acre	Sep 8	Sep 14	Sep 17	Sep 23	Sep 28	Oct 14
Carzol	92 SP	1.25 lbs	14.5 a	1.2 c	4.7 b	1.2 be	4.0 be	2.2 be
Lorsban	4 EC	5 pints	27.2 a	1.2 c	0.5 c	0.5 c	0.7 c	0.7 c
Sulfur	90 WP	25 Ibs	19.2 a	14.0 ab	33.7 a	19.7 a	17.5 ab	22.2 a
Ethion+ petroleum oil	4 EC FC 435-66	6 pints +5 gallons	33.2 a	4.7 be	3.7 b	4.0 b	1.5 c	7.2 b
Agri-mek + petroleum oil	0.15 EC + FC 435-66	10 oz + 5 gallons	27.7 a	18.2 a	25.2 a	34.5 a	21.5 a	24.5 a
Untreated			19.0 a	37.7 a	26.2 a	43.2 a	52.0 a	47.5 a

Means followed by the same letter are not significantly different (p = 0.05) DMRT.

Table 2. Control of orchid thrips adults and larvae (combined) on 'Ruby Red' grapefruit at Silver Strand in Collier County, Florida, 1994.

Treatment	Formulation	Rate/Acre	Sep 8	Sep 14	Sep 17	Sep 23	Sep 28	Oct 14
Carzol	92 SP	1.25 Ibs	36.3 a	9.5 be	14.5 b	15.3 ab	13.3 a	6.3 b
Lorsban	4 EC	5 pints	37.3 a	3.0 c	2.3 cd	0.3 c	0.5 b	1.0 bed
Supracide	2 EC	5 pints	47.5 a	10.0 c	0.5 d	1.8 c	2.0 b	0.3 cd
Ethion + petroleum oil	4 EC + FC 435-66	6 pints + 5 gallons	25.3 a	3.0 c	3.3 cd	2.0 c	3.3 b	0 d
Agri-mek + petroleum oil	-0.15 +ECFC 435-66	10 oz +5 gallons	57.3 a	15.0 b	6.3 be	3.3 be	3.8 b	1.8 be
Untreated			35.8 a	53.0 a	56.5 a	29.5 a	19.0 a	14.8 a

Means followed by the same letter are not significantly different (P = 0.05) DMRT.