Seasonal Abundance and Insecticidal Control of Citrus Leafminer in a Citrus Orchard

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Abstract. Population density of citrus leafminer, Phyllocnistis citrella Stainton (Lepidoptera: Gracillariidae), was monitored in a Florida citrus grove for 5 years by scouting weekly for larval-induced mines (leafminer-created tunnels in the leaves) in a replicated citrus plot treated with seven insect control regimes: Admire (imidacloprid) applied at 12, 6, 3, or 2-month intervals; Temik (aldicarb) applied annually; Metasystox-R (oxydemeton-methyl) applied annually; or no insect control. Leafminer populations were highest during the warmer months (April to September) and lowest during the cooler months (November to March). Populations peaked during June in all 5 years monitored. Trees treated with Temik or Metasystox-R had the same number of mines as the untreated controls. A biannual treatment with Admire reduced leafminer damage (number of mines) all 5 years compared with the controls. Additional Admire applications further reduced damage during some, but not all, years. A single application of Admire significantly reduced mines in 3 of the 5 years.

The citrus leafminer (CLM), Phyllocnistis citrella Stainton (Lepidoptera: Gracillariidae), was first described in Calcutta, India, in 1856 (Stainton, 1856). It has been a widely distributed pest in citrus-growing regions of Asia for many years (Clausen, 1931, 1933), including China (Sasscer, 1915), the Philippines (Sasscer, 1915), and Japan (Clausen, 1927). The pest has since moved into Eastern Africa (Badawy, 1967) and Australia (Beattie, 1989). In the last 15 years, leafminers have invaded most of the citrus-producing regions of the world, including the Mediterranean Basin (Garcia-María et al., 1997) and North, Central, and South America (Ware, 1994). It is widespread in the citrus-producing regions of Florida (Heppner, 1993).

Adult leafminers oviposit on young, tender leaves (new flush). The eggs mature within 1 d. The young larvae enter the leaf and burrow between the upper and lower cuticle. As the larvae move and feed on the epidermis, they leave a twisted, irregular tunnel (mine) (Achor et al., 1997; Sohi and Verma, 1965). The leaves frequently become distorted and curled with early abscission (Pandey and Pandey, 1964). The adult leafminer can deposit 50 eggs during her life. There are three larval stages plus a prepupal and pupal stage, which occur within the mine. The prepupa produces silk to form a pupal chamber, usually located along the rolled edge of a leaf, where metamorphosis to the adult stage occurs. Adults emerge after 3 d or longer, depending on temperature. There can be 15 generations per year depending on the weather (Badawy, 1967; Beattie, 1989). In Florida, the life cycle is completed in 3 weeks.

CLM affects all citrus varieties (Pandey and Pandey, 1964) and a few closely related Rutaceae (Heppner, 1993), including Aegle marmelos (L.) Corr. Srv. (Fletcher, 1920), Poncirus trifoliata (L.) Raf. (Clausen, 1915), Atalantia sp. (Sasscer, 1915), Murraya paniculata (L.) Jack. (Pruthi and Mani, 1945), Jasmínium sambac (L.) Aiton (Fletcher, 1920), Pongamia pinnata Pierre (Margobandhu, 1923), and Alseodaphne semecarpifolia Nees (Latif and Yunus, 1951). Damage to host plants, and particularly citrus, is incurred by direct feeding and by providing an infection site for Xanthomonas axonopodis pv. citri, a bacterium that causes citrus canker. Feeding damage is related to availability of young leaves and flushing pattern.

Several studies have been conducted to correlate CLM damage with economic loss. Knapp et al. (1995) reported that a 10% leaf area loss did not affect citrus yield. In Florida, control of CLM increased yield of 3- to 5-year-old grapefruit or orange trees by 13.1% to 16.9% (Stansly et al., 1996). In another Florida study, a 16% to 23% leaf area loss caused significant yield reduction of 15-year-old Tahiti lime trees, and 18% to 85% leaf area loss caused significant yield reduction of 5-year-old lime trees (Peña et al., 2000).

The CLM may also help spread Xanthomonas axonopodis pv. citri and the citrus canker disease it causes (Ando et al., 1985; Hill, 1918). This bacterium causes one of the most severe diseases of citrus worldwide and its attempted eradication has been a major source of tree loss in Florida. The bacterium is dispersed in windblown water, and leaf wounding increases the likelihood of establishment. Leafminer activity may provide leaf wounds by which the bacteria can gain access.

Control of CLM has focused on biological control using a variety of parasitic wasps (parasitoids); 39 parasitoid species have been identified (Heppner, 1993). In Florida, Ageniaspis citricola Lopatinovskaya and Cirrospilus ingenuus Gahan have been released (Hoy and Nguyen, 1994, 1997; Hoy et al., 1995, 1997; Pomerinke and Stansly, 1998; Smith and Hoy, 1995). Control with specific parasitoids has been complicated by low leafminer populations during the winter months. Chemical control strategies for CLM have been used in Australia (Beattie, 1989) and Florida (Browning et al., 2007; Stansly and Knapp, 1994), but extensive insecticide evaluation in Florida is not yet complete.

Materials and Methods

The experimental area consisted of 294 ‘Valencia’ sweet orange (Citrus sinensis L. Osbeck) trees grafted onto sour orange rootstock (C. aurantium L.) The trees were in single beds (rows) with 9.15 m between rows. The in-row spacing was 4.5 m.

The experiment was a randomized complete block design with each of six rows serving as a replication. There were seven treatments in each of the six replications with seven trees per experimental unit (plot). The treatments were an annual application of aldicarb (Temik; Bayer Cropscience, Research Triangle Park, NC) (8.5 g/tree a.i. incorporated into the soil); an annual application of oxydemeton-methyl (Metasystox-R; Gowan Co. Yuma, AZ) (trunk drenched, 0.62 mL L–1); soil drenches with imidacloprid (1-[6-chloro-3-pyridinyl]-N-nitro-2-imidazolidinimine) (Admire; Bayer Cropscience) at 1920 mg a.i./plant applied at 12-, 6-, 3-, or 2-month intervals; and no insecticide application. Temik was applied the last week of April, and the trunk drenches were applied in the spring between 19 Apr. and 22 May. Insecticide rates were based on manufacturers’ recommendations.

The experimental area was scouted for leafminers every week over a 5-year period. Each tree was examined and the total number of mines (integumental tunnels that are easily visible and incited by burrowing of single leafminer larvae) was recorded. Weekly data were combined into monthly totals recorded within each replication for each treatment.

Mine numbers (square root transformed to normalize the variance) were subjected to an analysis of variance using the SAS software program (SAS Institute, Cary, NC). Main treatment effects means that had a significant
F test were separated by Fisher’s protected least significant difference test at the 5% level of significance. When yearly data were totaled, each year was a block.

**Results**

*Seasonal abundance.* Because there was no difference among trees tested with Metasystox-R, Temik, or no insecticide treatment, these data were combined to analyze seasonal abundance. The mean numbers of mines per tree per month (averaged over 21 trees from non-Admire-treated trees in each of six replicates) were very low during the cooler months (November through March) all 5 years (Table 1). Leafminer activity began in April or May (depending on the year) and subsided in October. Fewer than one mine per tree was detected over the 5-year period in January, February, March, and December. Large numbers of mines were detected in May through July, resulting in considerable damage to the young leaves in which the mines occurred. The numbers of mines were significantly higher in June than any other month in all 5 years. Leafminer activity also varied from year to year. The lower counts observed in 2004 were likely influenced by three hurricanes that impacted the area that year.

*Insecticidal control.* Annual applications of Temik or Metasystox-R were ineffective in leafminer control (Table 2). An annual application of Admire reduced leafminers in 3 of 5 years, whereas biannual or more frequent applications of Admire significantly reduced mines all 5 years. Overall, the more frequent the Admire application, the better the control.

**Discussion**

The seasonal pattern of leafminer activity was fairly consistent over the 5-year study with populations peaking in the late spring and declining during the winter. The number of mines followed the flushing pattern of the trees to a great extent, as expected, because predominantly young leaves were mined.

The efficacy of the insecticides for leafminers was similar to that previously reported for aphids (Powell et al., 2006) and psyllids (Powell, unpubl. data), in that Admire, but not Temik nor Metasystox-R, reduced populations. The major difference was that one annual application of Admire performed better with aphids and psyllids than with leafminers. Leafminers may not normally cause sufficient feeding damage to warrant control with insecticides because of the cost and environmental concerns. However, reducing leafminers may reduce citrus canker. Admire will also reduce populations of aphids and psyllids and possibly the diseases they transmit, citrus tristeza and citrus greening, respectively. One annual application of Admire may be considered as part of an integrated strategy to control these three insects and their associated diseases.

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**Table 1. Seasonal variation of citrus leafminers in a Florida citrus grove.**

| Month   | 2000 | 2001 | 2002 | 2003 | 2004 |
|---------|------|------|------|------|------|
| January | 2 a  | 0 a  | 0 a  | 0 a  | 0 a  |
| February| 0 a  | 0 a  | 0 a  | 0 a  | 1 a  |
| March   | 0 a  | 0 a  | 0 a  | 0 a  | 0 a  |
| April   | 0 a  | 6 a  | 39 b | 5 a  | 7 b  |
| May     | 46 b | 65 c | 27 b | 277 d| 9 b  |
| June    | 147 c| 160 c| 123 c| 512 c| 15 c |
| July    | 32 b | 23 b | 111 b| 116 c| 6 b  |
| August  | 47 b | 0 a  | 10 b | 21 b | 8 b  |
| September| 15 b| 3 a  | 31 a | 19 b | 4 b  |
| October | 27 b | 5 a  | 3 a  | 19 b | 0 a  |
| November| 3 a  | 8 a  | 0 a  | 0 a  | 0 a  |
| December| 4 a  | 4 a  | 0 a  | 0 a  | 0 a  |
| Total   | 319  | 274  | 344  | 969  | 50   |

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**Table 2. Population densities of citrus leafminer in a Florida citrus grove under seven different control strategies.**

| Treatment* | 2000 | 2001 | 2002 | 2003 | 2004 | Total |
|------------|------|------|------|------|------|-------|
| Control    | 282 c| 290 d| 369 c| 960 d| 52 b | 1953 c|
| Meta-Systox-R| 312 c| 307 d| 309 c| 924 d| 48 b | 1900 c|
| Temik      | 360 c| 226 d| 351 c| 1024 d| 51 b | 2012 c|
| Admire 1x  | 94 b | 264 d| 11 b | 44 c | 63 b | 476 d |
| Admire 2x  | 68 b | 63 c | 3 a  | 15 b | 2 a  | 151 c |
| Admire 4x  | 4 a  | 28 b | 0 a  | 2 a  | 0 a  | 34 b  |
| Admire 6x  | 1 a  | 4 a  | 0 a  | 5 a  | 0 a  | 5 a   |

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*Numbers are the mean number of larval leafminers per tree (averaged from 21 trees in each of six replications). Data are from nonimidacloprid-treated trees. Numbers in a column followed by different letters are significantly different (5% level) by Fisher’s protected least significant difference.

*Admire 1x = imidacloprid applied annually; Admire 2x = imidacloprid applied every 6 months; Admire 4x = imidacloprid applied every 3 months; Admire 6x = imidacloprid applied every 2 months; Temik = applied annually; Metasystox-R applied annually; Control = no insecticide applied.
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