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Inside

History and Status of the Glassy-winged Sharpshooter in California

***by* Matt Daugherty**

Fifteen years ago Southern California grape growers were in the midst of a severe outbreak of Pierce's disease (PD), a fatal disease of grapevines caused by the bacterium *Xylella fastidiosa* (fig. 1). The disease itself wasn't new, having been known to occur in the region since the late 1880s (table 1). What was notable about this outbreak was its especially rapid pace and that it was attributable to a novel insect vector, the glassy-winged sharpshooter *Homalodisca vitripennis* (GWSS; fig. 2).

Although California is home to several native sharpshooter species that are also vectors of *X. fastidiosa*, GWSS is an exotic species here, native to the Southeastern United States. As with several other recent exotic invasive insects in the state, its initial establishment and spread was tied to urban and suburban areas. *H. vitripennis* was first reported in Ventura and Orange counties, perhaps following introduction via infested nursery plants prior to 1990. But by the late 1990s it had spread throughout

Editor's Note

In this issue, our feature articles and *Disease Focus* provide an update on the glassy-winged sharpshooter (GWSS) and the bacterial pathogen it vectors, *Xylella fastidiosa*. GWSS spread throughout Southern California in the 1990s, and was found on hundreds of plant species in agricultural crops, urban landscapes and natural habitats. High pest populations in citrus orchards migrated to nearby nurseries. In addition to a severe outbreak of Pierce's Disease in grapevines and an increase in "minor diseases," mutations of *Xylella fastidiosa*, combined with the broad host range of its vector, led to the spread of disease in new plant host species. In nurseries, quarantine restrictions on the movement of the many host plant species posed challenges. A 2012 survey documented that destroyed plants in infested nurseries represented an average loss of over $10 thousand per nursery. In this newsletter, we describe numerous implemented measures that have been successful in mitigating damage caused by the GWSS, including the new approved treatment program for nurseries.

♦ **Julie Newman and Steve Tjosvold**

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Southern California and into the southern Central Valley, including into vineyards in Riverside and Kern counties, promoting severe outbreaks of PD (i.e., > 90% prevalence at some sites) and other novel *Xylella* diseases (e.g., oleander leaf scorch).

Table 1. Timeline of notable *Xylella* disease events.

Time	Event and location	Notes
1880s	Southern California PD	"Anaheim vine disease"
1930s & 40s	Central Valley PD outbreaks	Alfalfa acting as a reservoir
Late 1980s	*Xylella* diseases in South America	Citrus and coffee trees
c. 1990	GWSS arrives in California	
Late 1990s	PD outbreak in Temecula	First outbreak linked to GWSS
Late 1990s	New diseases in ornamentals	Oleander, sweetgum
c. 2000	PD outbreak in Kern County	General Beale region
c. 2000	GWSS area-wide programs begin	
2012–	PD in General Beale	Failure of chemical control?
2013–	Olive leaf scorch in Italy	*Xylella* is the causal agent?

Xylella fastidiosa is a xylem-limited bacterium that is capable of infecting a broad range of host plants, though it causes severe disease in a minority of them. Notably, GWSS is not especially efficient at transmitting *X. fastidiosa* compared to some other sharpshooters. What is unique about GWSS compared to California native sharpshooters is its ability to achieve much higher population densities and a propensity to feed on a far broader range of host plants. This broad host range likely contributed to its role in the development of novel *Xylella* diseases and potential role in the resurgence of historically minor diseases (e.g., alfalfa dwarf, almond leaf scorch). It addition, it creates challenges for the nursery industry due to quarantine restrictions on the movement of the many plant species or varieties on which GWSS purportedly feeds or reproduces.

Fig. 1. Pierce's disease, like most other *Xylella* diseases, is characterized by progressive leaf scorch symptoms and defoliation. *Photo*: Matt Daugherty.

Since the onset of the disease outbreaks in Temecula Valley 15 years ago, numerous measures have been put in place to mitigate the damage caused by *H. vitripennis*. A major element has been the area-wide control programs in Southern California and Central Valley grape-growing regions. These include GWSS monitoring, releases of biological control agents (i.e., the parasitoid *Gonatocerus ashmeadi*) and regular chemical control. Specifically, foliar insecticides and especially systemic imidacloprid applications target GWSS populations in citrus, to limit spread into nearby vineyards. Collectively, these measures have greatly reduced disease pressure in the region. A recent survey of Temecula vineyards found GWSS densities that were a fraction of the purported "hundreds" of sharpshooters per vine 15 years ago, and overall PD prevalence in the area of

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approximately 0.5%. The second major piece of sharpshooter management involves quarantine requirements for nursery stock shipping from GWSS-infested areas. A compliance agreement requires that nurseries monitor for sharpshooters, designate a controlled staging area for readying plant shipments, and inspect the source and potential receiving locations. More recently, an approved treatment program was established that relaxes the monitoring requirements in exchange for targeted insecticide applications (i.e., carbaryl or fenpropathrin) prior to shipping. Available data suggest that these measures greatly reduce the risk posed by nursery shipments.

Homalodisca vitripennis, though widely distributed in the southern part of the state, has not yet become prevalent in Northern California or much of the Central Valley. GWSS is endemic in most Southern California counties and portions of Kern, Tulare and Fresno counties. In addition, there have been localized infestations found in parts of Santa Clara, San Luis Obispo, Sacramento, Solano, Contra Costa, Butte and Imperial counties — most of which are believed to have been eradicated. The most recent was an apparently successful eradication of a residential infestation in San Luis Obispo. Yet, within the last couple of years there has also been cause for concern regarding GWSS control. Specifically, the General Beale region of Kern County has seen a resurgence in *H. vitripennis* and an accompanying localized outbreak of PD. One explanation may be poor management on the part of certain growers in the area (i.e., no removal of diseased vines or weedy hosts). Alternatively, the resurgence may be indicative of partial failure of area-wide chemical control due to poor uptake of systemic insecticides in some contexts, specifically some of the windbreak trees, or the development of insecticide resistance. The latter possibility has motivated UC Riverside researchers to initiate studies to determine whether there is evidence that the several years of insecticide applications in commercial citrus and nurseries have led to any resistance in *H. vitripennis*. Regardless of the explanation for this resurgence in GWSS, it illustrates the need to continue to remain vigilant about the threats posed by this invasive insect.

Fig. 2. Adult glassy-winged sharpshooter, *Homalodisca vitripennis. Photo*: Rodrigo Krugner.

Matt Daugherty is Assistant Cooperative Extension Specialist, Department of Entomology, UC Riverside.

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Glassy-winged Sharpshooter Nursery Subcommittee Update

***by* John Kabashima**

On September 17, 2014 the Glassy-winged Sharpshooter (GWSS) Nursery Subcommittee met at the UC ANR South Coast Research and Extension Center in Irvine, California. This subcommittee reports to the California Department of Food and Agriculture Pierce's Disease Control Program (PDCP), which is funded from federal funds and industry assessments totaling over $18.3 million.

In the opening remarks the committee was informed that several Pierce's Disease (PD) and GWSS research projects have made significant progress, including five GMO field trials and conventionally propagated grapevines that are providing resistance to PD. Reports were presented for the following programs.

Regulatory Nursery Program

There are 550 nurseries within the infested areas of the state under GWSS compliance agreements (fig. 1). There were 30,575 shipments through July 31, 2014. Shipments are down slightly in the regulatory program as compared to 2013. Eleven Notices of Rejection (NORs) have been issued year to date. Most areas are seeing an increase in pest pressure this season. Year to date, origin county inspectors have stopped more than 176 egg masses, 4 nymphs and 9 adults from moving in nursery stock shipments.

Approved Treatment Protocol (ATP). There are eight nurseries that are participating in the ATP with 28 associated shipping yards. This year, the total number of shipments through July 31, 2014 was 8,095, consisting of 1.46 million plants shipped to destination counties. No viable life stages have been found in any ATP shipments. Total number of shipments and plants shipped are up slightly from last year. Six egg masses from four ATP yards have been sleeved by destination counties, with no GWSS emergences. Ten out of 28 yards had holds due to

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trap finds with >10 GWSS adults. There has been an increase in the number of GWSS trapped this year compared to last year. ATP nursery holds tend to peak in July. This can be attributed to a variety of factors, including the GWSS lifecycle and activity in the citrus and avocado nearby. From July to August, there was a reduction in pest pressure. The PDCP conducts quality control at each ATP nursery by placing water sensitive paper on plants staged for treatment to monitor the coverage. Year to date, 205 papers have been placed and only 7 indicated the need for partial retreatment of the shipment. The Monterey County Agricultural Commissioner's Office continues to do residue sampling from ATP nurseries and the results have indicated good coverage this year. Napa County's residue samples have also been very good.

The agricultural commissioners' workload is much better now with the protocol adjustments that have already been made. It was suggested that the Subcommittee look at eliminating the hold period as a result of trap finds with >10 GWSS adults. The hold would still apply until the hold treatment occurred. It was decided that the PDCP would draft up the proposed change and consult with the California Agricultural Commissioners and Sealers Association (CACASA) GWSS Advisory Group. The outcome of that discussion will be shared with the Subcommittee.

Applied Research

Two research projects have been funded by the PD/GWSS Board exploring insecticide resistance in GWSS populations in California. One study, headed by Dr. Thomas Perring, UC Riverside, is a two-year project that will focus on Central Valley GWSS populations and is 50% funded by the Consolidated Central Valley Table Grape Pest and Disease Control District. Dr. Perring's study began on July 1, 2014. The

Fig. 1. Nursery stock in areas of the state infested with GWSS must be inspected to ensure that this invasive pest isn't moved in plant shipments. *Photo*: Matt Daugherty.

second study — headed by UC Riverside's Dr. Rick Redak, Dr. Frank Byrne and Dr. Bradley White — will also explore the Central Valley resistance concerns and additionally has a broadened scope to include populations from agricultural, nursery and urban settings. This project is funded for a three-year period, and began July 1, 2104.

Rapid Response

Fresno County has continued suppression treatments in 2014 in and around the Fresno/Clovis and Kingsburg areas. Year to date, over 3,600 properties have been treated in urban and rural areas. In Santa Clara County, there is one remaining infested area in

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the county, the Capitol area of San Jose. In response to a late season find in 2013, about 76 properties were treated in March 2014. The first Capitol find of 2014 was in an apartment complex and the county, coordinating with the apartment management's pest control operator, scheduled treatments in and around the find site. In Tulare County, there have been GWSS finds in the Visalia area, which is outside of the existing infested area. The county is still de-limiting the area and treatments have just started in response to the finds. The exact size of the area is still to be determined. There have been a handful of nursery trap finds in the non-infested areas of the state that have not indicated any breeding GWSS populations and appear to be isolated finds.

Area-Wide Program

The area-wide suppression treatments mainly target citrus, a preferred over-wintering host of GWSS. In the Temecula Valley area of Riverside County there is no longer funding for treatments; however, a trapping program is in place to monitor the GWSS populations. Year to date, 617 GWSS have been trapped in Temecula. Three GWSS have been trapped year to date in the Coachella Valley of Riverside County. In Fresno County, there have been some area-wide finds further west than seen before, with a total of 36 GWSS trapped year to date. Madera County has not had any GWSS detections this year. In Tulare County, there have been 2,598 GWSS trapped year to date, although 80% of those finds come from one organic ranch. Organic groves continue to be a challenge as there are not highly efficacious organic chemicals available. Fall foliar treatments are being scheduled for Tulare County. In Kern County, there are several zones trapped for GWSS. Year to date, there have been significant treatments made, mainly in the General Beale area, to control GWSS. Windbreaks continue to present a challenge in Kern County due to the fact that they serve as a reservoir for GWSS and insecticide coverage is difficult due to their size.

***John Kabashima is Environmental Horticulture Advisor, UC Cooperative Extension Orange County*. *The information used in this article was provided by the CDFA*.**

SCIENCE TO THE GROWER: A Nobel idea for plant lighting

***by* Richard Evans**

Whew! I barely got this article done in time for the newsletter because I have been busy writing my acceptance speech for the Nobel Prize. As it turns out, I've been passed over once again and won't need that speech now, but I'm a glass-half-full type of guy. I'm optimistic about the chance that I'll win next year. I'm also optimistic about the chance that the tuxedo I bought for the awards ceremony will still fit next year.

One of this year's Nobel Prizes caught my eye because it's pertinent to greenhouse flower growers. The physics prize went to three Japanese scientists for their invention of the blue light-emitting diode (LED). Prior to that invention, we had to be content with red and green LEDs. Their energy-efficient light production probably saves money for big-box stores when they are all lit up for the Christmas season, but their incomplete light spectrum offered limited benefits to growers seeking efficient supplemental lighting for greenhouse crops. For example, Eskins (1992) showed that *Arabidopsis*, the guinea pig for plant scientists, takes nearly three times longer to flower when grown in red light than it does in blue light or a combination of blue and red.

Blue LED technology has many commercial applications, but its impact becomes evident when it is combined with red and green LEDs to make white light. All of you have felt that impact when you have watched cat videos on your smartphones while sitting in the audience enduring my extension talks. But you may eventually feel the greatest impact when you use white LED lamps for lighting your crops.

The obvious uses for white LEDs in ornamental horticulture are for increasing plant growth by supplementing natural light in winter months, and for controlling flowering by manipulating photoperiod with night interruptions. Growers have relied primarily on metal halide lamps for supplemental light and incandescent lamps for photoperiod control, but both light sources also emit large amounts of energy at wavelengths that plants can't use. That wasted energy is costly. LEDs have a low heat output, adjustable light intensity and color, and high efficiency of energy conversion to light. They also can be pulsed at high frequencies. Tennesen and others (1995) found that when all of the energy from continuous light was packed into 1.5 microsecond pulses from LED lamps every 150 microseconds, plants produced the same amount of photosynthesis as in continuous light. The rapid pulses of light saturate the plant's photosynthetic apparatus, and the pauses between pulses allow the plant to make use of the light energy they captured. That might not have a practical application right now, but it sure would annoy your neighbors.

Jao and Fang (2004) compared efficiency of fluorescent lamps and arrays of red and blue LED lamps in a tissue culture system. The highest growth rate was achieved with LED lamps that flashed on and off every 0.7 milliseconds. Growth was only slightly slower, and energy use was 80% lower, when the LED lamps flashed on and off every 2.8 milliseconds. That's a substantial energy savings, and I'm sure it still would annoy your neighbors.

Recently, Chang and others (2014) devised a scheme for greenhouse lighting that takes advantage of all of the variables afforded by LED lamps. Their system adjusts the spectrum and intensity of supplemental light as the spectrum and intensity of natural light changes during the day, and also makes adjustments according to the developmental stage of the plants (e.g., changing lighting to affect both vegetative growth and flowering).

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Right now, LED bulbs are expensive, and their high cost doesn't make them a viable option for most commercial horticulture applications. However, energy costs may rise again, and the price of LED bulbs is sure to come down. In the meantime, I'll gladly buy LED bulbs for everyone after I win the Nobel Prize next year.

Richard Evans is UC Cooperative Extension Environmental Horticulturist, Department of Plant Sciences, UC Davis.

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GET CULTURED: Reclaimed water use in nursery production

by **Don Merhaut**

Reclaimed water has become another water source for agricultural use. While the nursery industry has been using recycled nursery water for decades, the use of reclaimed water, which is treated municipal waste water, is relatively recent and is becoming more frequent. As infrastructure is established to deliver reclaimed water throughout the state, more companies and municipalities will be able to utilize this water source. In some areas, reclaimed water is the only water available.

The use of secondary water sources, such as reclaimed water, can present several chemical and physical problems to the agricultural industry; and, like other secondary water sources, modifications in irrigation and fertilizer management programs will alleviate most if not all of these problems. This article will provide an overview of the important chemical and physical properties used to evaluate secondary water sources for irrigation purposes and highlight some concerns, with emphasis on reclaimed water. In subsequent issues, information will be provided on how to properly treat and utilize reclaimed water.

Hydrogen ion activity (pH)

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Most ornamental and floriculture crops will grow in a pH range between 5.0 and 6.5, although there are exceptions. Many ericaceous plants such as *Vaccinium* and *Rhododendron* plants prefer a more acid media, while most other crops will perform better at pH 6.0. Secondary water sources, such as reclaimed water, may have a pH of 7.0 or greater; therefore, acid injection may be needed to reduce the pH to an ideal range.

Alkalinity

Alkalinity is the measure of the water's ability to neutralize acid through the concentration of bicarbonates, carbonates and hydroxides. Reclaimed water and groundwater derived from limestone regions tend to be alkaline. If alkalinity is high, more acid will be required to lower water pH.

Electrical conductivity (EC)

Electrical conductivity is the measure of dissolved salts in water. This is a common way of estimating the amount of fertilizer dissolved in irrigation water. However, nonessential salts such as sodium will also increase EC. If a non-fertilizer-fortified water source has a relatively high EC (> 1.0 dS/cm), it may become difficult to use, since once fertilizer is added, the EC can easily approach 3.0 dS/cm, which may not be suitable for many crops. Accumulation of salts in containers (fig. 1) can be a major problem if lower quality water is not treated properly before being used. Management practices such as blending with fresh water of lower EC or filtration may be necessary.

Sodium and other non-essential elements

Of all the non-essential elements, sodium (Na) in reclaimed water is usually the biggest concern. However, other nonessential elements may be present. Nonessential elements are a problem because (1) they will increase the EC of the water, (2) they may accumulate to toxic concentrations in the plant, and (3) they may compete with essential nutrients for uptake into the plant.

Essential plant nutrients

Reclaimed water will usually contain essential plant nutrients such as chlorine (Cl), calcium (Ca), nitrogen (N), etc. Though beneficial, the concentration and the ratio of essential nutrients to one another should be known so that fertilizer inputs can be adjusted appropriately. Too high of one nutrient will result in toxicity of that nutrient or deficiency of other nutrients. Chloride concentrations are often high since chlorine is used to sanitize waste water. Other

Fig. 1. Accumulation of salts on media surface due to irrigation with secondary water sources containing high concentrations of dissolved salts.

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essential nutrients which may be in excess include sulfur (S) and boron (B). Correcting water quality is easy if a nutrient concentration is not sufficient. However, if a nutrient concentration is too high, it may mean that dilution or some sort of water purification process may be necessary.

Sodium Adsorption Ratio (SAR)

The Sodium Adsorption Ratio (SAR) of water is the relative ratio of sodium (Na) to calcium (Ca) and magnesium (Mg) in water. As the amount of sodium increases in water, the amount of sodium adsorbed onto clay surfaces increases, which causes clay particles to disperse or "run together." This, in turn, reduces water infiltration into soil. This chemical-physical problem ***only*** occurs on field soils. Even if a nursery utilizes clay-containing soils in the media, the clay amount is not sufficient to raise concern for an SAR problem. ***SAR problems do not occur in organic soils or containerized media.***

Physical impurities

Any algae or other type of particulate matter may be present in reclaimed water. If this is the case, the water must be filtered prior to use. Otherwise, emitters will become clogged, especially if microirrigation is being used. Particulate matter may also leave unsightly marks on foliage if irrigation water is applied by overhead irrigation.

Uniformity of availability and quantity

As with other water sources, the consistent availability of water needed for operations should be known. If sufficient water cannot be provided on a regular basis, then alternative water sources or necessary water storage should be arranged.

In future issues, we will address each of these conditions, presenting the problems in more detail and the correctional protocols.

Don Merhaut is a UC Cooperative Extension Specialist for Nursery and Floriculture Crops, Department of Botany and Plant Sciences, UC Riverside.

DISEASE FOCUS: Scorch diseases caused by *Xylella fastidiosa*

***by* Jim Downer**

For many years plant pathologists and horticulturists have struggled with scorch diseases. Specific strains of the bacterium *Xylella fastidiosa* caused disease in various hosts. For instance the almond leaf scorch strain causes disease in almond while the Pierce's disease strain causes disease in grape. Unfortunately the host range of a given strain is not unique to its host and can be quite large depending on the strain. Until several years ago strain-host specificity was kept narrow by a limited number of sharpshooter insect vectors with narrow host ranges. When the glassy-winged sharpshooter (GWSS) was introduced to California, it changed everything because this insect has a wide host range, can acquire numerous strains of *X. fastidiosa* and spread them to hosts that have never before experienced these strains. To make matters more complex, some strains may reside in one host without causing dis-

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ease but when moved to a susceptible host may be pathogenic. As a result, the ornamental tree industry has been widely affected in both nurseries (Huang 2007) and landscapes (Hernandez-Martinez et al. 2009) with new disease showing in olive, sweet gum, oleander (fig. 1), purple leaf plum, gingko, mulberry, silk trees and jacaranda. Scorch may also be occurring in other ornamental trees that have not yet been diagnosed as hosts.

Xylella fastidiosa is a fastidious mollicute, that is, a gram negative bacterium that must inhabit the xylem of a living host in order to reproduce. The bacterium causes disease when it multiplies and clogs xylem vessels in sapwood. This reduces the water supply to foliage which then wilts or yellows leaves and defoliates branches and ultimately kills its host. The symptoms somewhat mimic Verticilium wilt but without the staining of the xylem that is observed in that disease. Symptom development is quite variable depending on the strain found in the host. Krugner et al. (2014) suggest that in olive, infections may be self-limiting, and that chronic infection may not be common. It was certainly difficult for Krugner and others to infect and redetect the bacterium in healthy olive plants. I have also observed landscape olives with symptoms of infection that recovered. Krugner et al. further suggest that olive is often infected by canker-forming fungi that could account for scorch symptoms and so suggest that *X. fastidiosa* may not be the cause of symptoms seen in landscape olives. This logic may also be applied to other *Xylella* hosts such as *Liquidambar* (sweet gum) which are similarly affected by numerous fungal pathogens such as *Botryosphaeria*. However, Hernandez-Martinez et al. (2009) verify that the strain of *Xylella* causing disease in sweet gum can reproduce disease in healthy trees, thus suggesting it is the likely source of scorch symptoms in *X. fastidiosa* positive trees. These two examples underpin the need for continued careful research on each strain and host interaction in order to understand these diseases.

Fig. 1. Yellow, brown, dying leaf margins are symptoms of bacterial leaf scorch caused by *Xylella fastidiosa. Photo*: Jack Kelly Clark.

Jim Downer is Environmental Horticulture Farm Advisor, UC Cooperative Extension, Ventura County.

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INSECT HOT TOPICS: Daylily leafminers

***by* James A. Bethke**

The Society of American Florists' Pest and Production Management Conference began as the Leafminer Conference back in 1980. The Leafminer Conference was all about one agromyzid leafmining fly, *Liriomyza trifolii* (Diptera: Agromyzidae), which was causing havoc on a wide variety of vegetables and ornamental plants nationwide. The seriousness of the issue caused a decade of frantic research on the biology and control of this species, and it also caused many growers to go out of business or change what they were growing.

There is a new looming threat, the daylily leafminer, *Ophiomyia kwansonis* Sasakawa (Diptera: Agromyzidae), that is plaguing *Hemerocallis* species in landscapes and ornamental production across the country. Fortunately, if there is one saving grace, it is that it is host specific. It originates from Japan and Taiwan, and it was first noticed on daylilies in the United States in 2006 in Maine (see bugguide.net link below). Soon afterward, it was observed widespread as people took note. As of January, 2014, it has been officially detected in Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Mississippi, Missouri, New Hampshire, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Virginia and West Virginia. The likelihood of detection in California is high, so be on the lookout.

Fig. 1. Daylily leafminer mines. *Photo*: Linda Sue Barnes.

The damage caused by the daylily leafminer closely resembles the damage caused by the serpentine leafminer except that it is more linear rather than serpentine (fig. 1). Pupation occurs in the larval tunnel, often near the leaf base (fig. 2). This is very different than the serpentine leafminer, which pupates in the soil below the plants. This is also problematic because eggs, larvae and pupae (that remain within the leaves) could be shipped to new areas where daylilies are marketed. In colder climates there will be two to three generations per year, but in California, they are likely to reproduce year-round.

As with the serpentine leafminer, control of the daylily leafminer is difficult, and colleagues across the country are seeking answers. It is obviously more difficult to manage in the landscape than in production due to the greater number of chemical control options in production. Due to the fact that they pupate in the leaves, removal of older infested leaves will likely reduce populations. As with other *Liriomyza* species, native parasitoids may attack the daylily leafminer, but none have been recorded so far.

Gaye Williams, an entomologist from the Maryland Department of Agriculture, is conducting a national