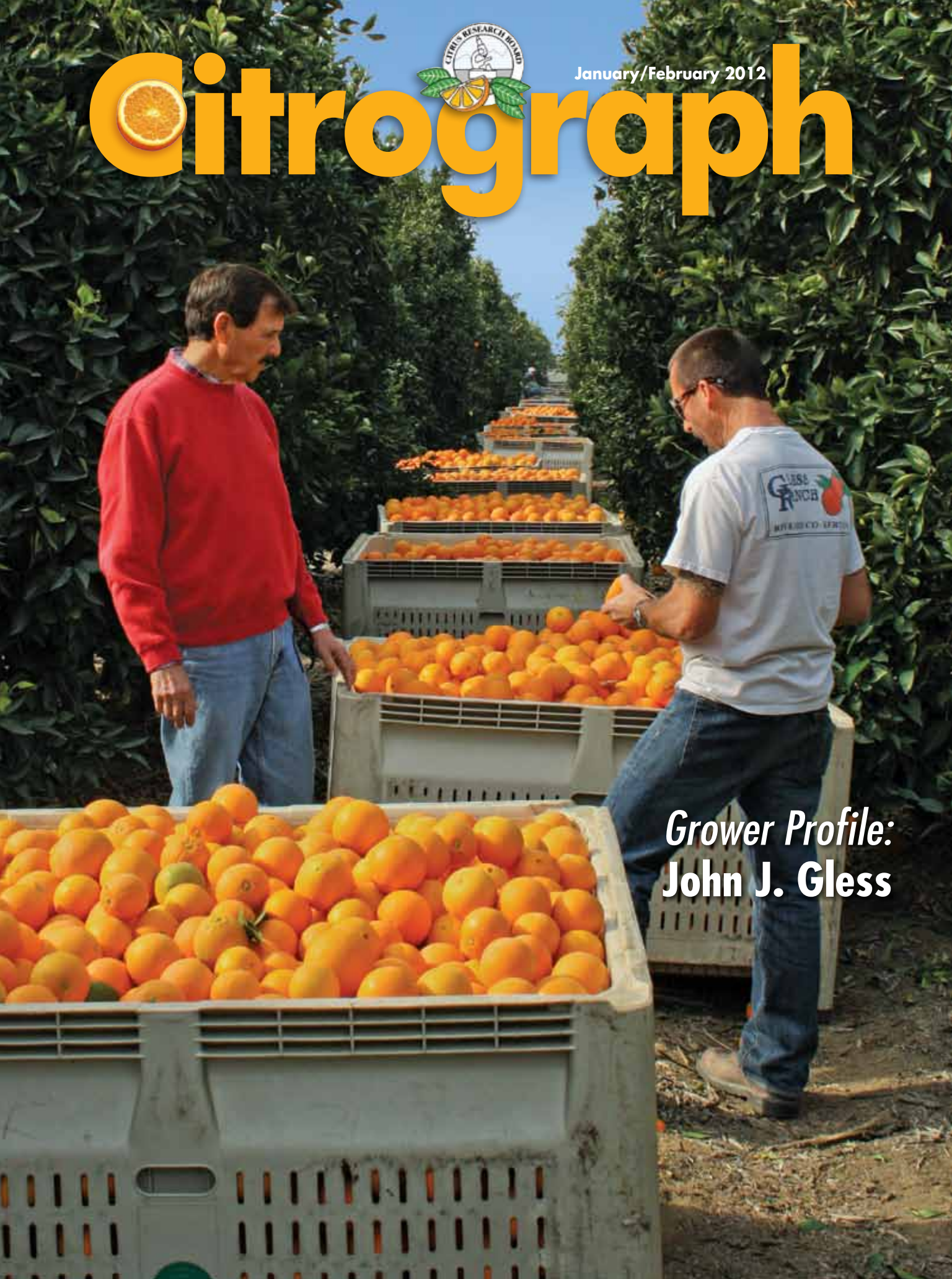
January/February 2012

Citrograph



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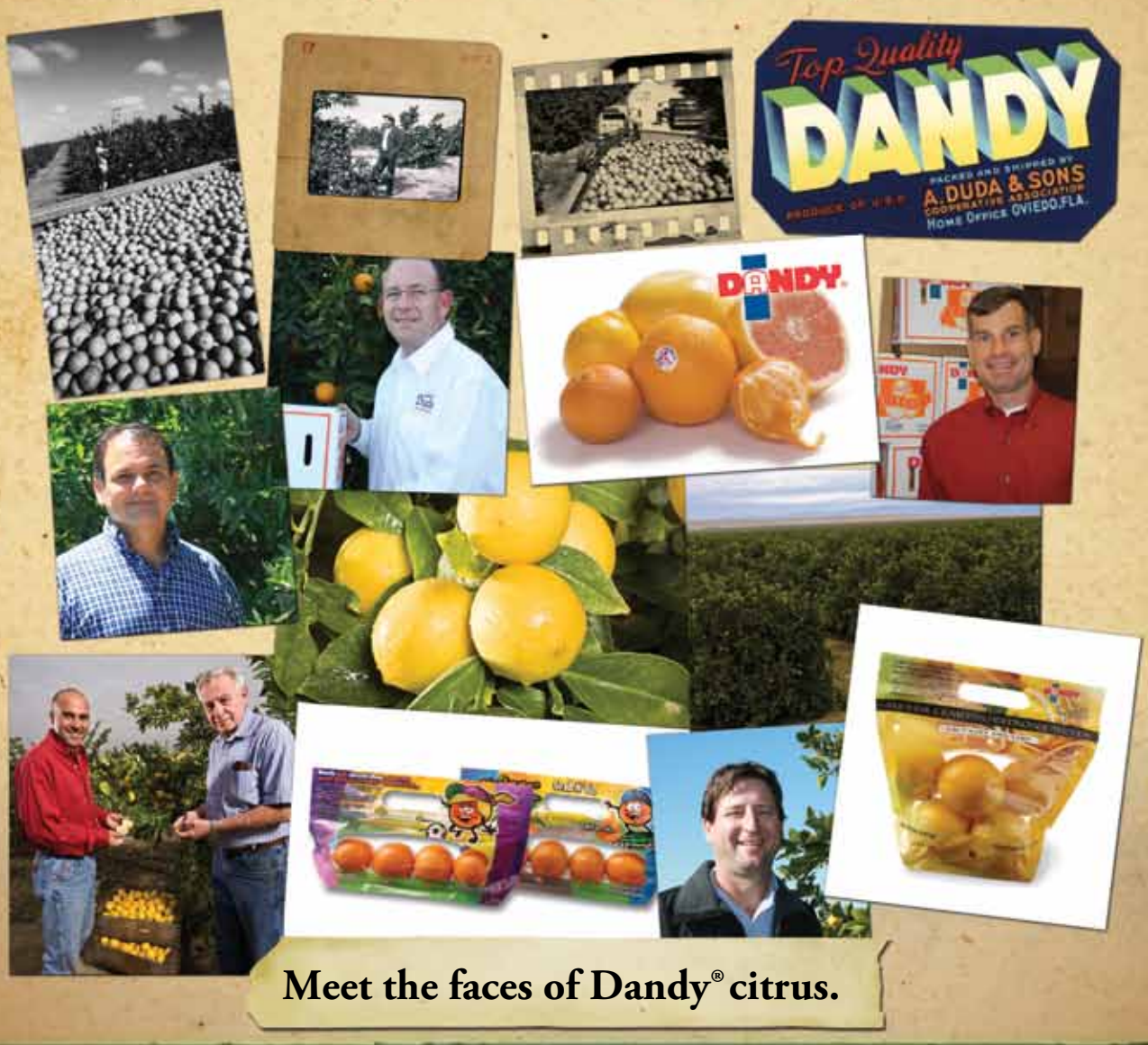

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Don't let the blind guy drive!

Now more than ever is the time for everyone to continue their support of the leadership of our industry in keeping the vision of a healthy and productive citrus industry in California.

As some of you may know, I have lost 90 percent of my sight in my left eye. This is a temporary situation while I wait for cornea surgery this March, so currently my wife takes me everywhere. While reflecting on this problem, we got into a conversation about the difference between sight and vision. It is very easy to lose one's sight, but you must never lose your vision—that ability to look forward and prepare for the next adventure in life.

Such is the case as the industry looks at the current state of affairs while analyzing threats to our future. By now, many of you have heard about the discovery of huanglongbing (HLB) citrus disease in Texas. Also, we have reported in previous issues the presence of HLB in both Sonora and Baja Sur, Mexico. The situation in Texas was fully predictable given the fact that the Texas Department of Agriculture and USDA-APHIS have picked up samples that tested positive but were not able to be confirmed using the complete protocol for HLB. We have seen a consistent pattern of detections throughout Mexico as they expand and improve their detection programs. These continued threats to California must constantly feed into the vision of the industry as we prepare for how we will respond to the presence of HLB.

Recently, the Citrus Pest and Disease Prevention Committee (CPDPC) approved a recommendation to the California Department of Food and Agriculture to shift emphasis of the urban treatment program from the core area of Los Angeles to the perimeter areas in an effort to increase the protection of the commercial groves in California. This was necessary to assure the limited resources were being used in the most efficient manner. Once again, this was the result of vision in planning the best strategy for protection of the California industry.

Also incorporated into this vision is the need for developing a sustainable biological control program that will help reduce the dependency on pesticide application. To this end, the University of California Riverside is starting the first phase of testing new biocontrol agents for their fitness and survivability in the California climates. This program will take several years to test and evaluate the best protocols for the use of biocontrol. This will be followed by a systematic development of rearing and deployment facilities to meet the demand of the program.

Now more than ever is the time for everyone to continue their support of the leadership of our industry in keeping the vision of a healthy and productive citrus industry in California. We are several years into a very aggressive trapping and detection system that is the best in the world. This was not present in Florida or in Texas. Our vision is to find and keep Asian citrus psyllid populations at very low levels to prevent the spread of HLB when it is eventually detected in California.

We may occasionally lose our sight, but we must NEVER lose our vision!

By the way, I drive a white Ford F-150 so if you see one on the road, please give it a wide berth because it may be me…

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Develop knowledge and build systems for grower vitality.
Focus on quality assurance, clonal protection, production research, variety development, and grower/public education.

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COMMENTARY BY JOEL NELSEN, PRESIDENT, CALIFORNIA CITRUS MUTUAL

Food safety mandates impossible to avoid

So does our industry need this examination and documentation? Yes and no.

The food safety incident that occurred regarding California citrus last….. hmm, I don't recall that ever happening nor does anybody in the industry. A juice bottler in California had a problem with product, and Florida inspectors once discovered frogs jumping around a juice plant. But fresh California citrus has never had a food safety incident.

Yet industry members at the grower and shipper levels are being asked, and eventually will be asked by government, to prepare a food safety plan thereby protecting the general public and the sellers of our product from sickness and liability therein. It is galling, but yet this plan and documentation by government just could be our way out of expensive, duplicative and unnecessary mandates.

We all know that our industry is the least likely fresh produce commodity to experience a food safety issue. We all know the reasons why. Unfortunately, other commodities and national produce industry leadership have made the issue a produce industry issue rather than a commodity or category-specific issue. Furthermore our retail and foodservice customers—in an effort to differentiate themselves in the marketplace—have chosen, among other things, to direct their attention to food safety as a marketing tool to enhance their brand before the consumer. Many of them have conjured up ludicrous plans demanding audits, none of which have seriously discovered a flaw in our existing programs.

Now, the Food and Drug Administration has been mandated to do likewise, and many of us believe that we must help FDA develop a legitimate commodity risk based plan that places greater burdens and inspections where necessary but not exempting any one commodity.

Food safety is everyone's business, and while our track record is the envy of all, we can't rest on our laurels. A food safety issue can strike suddenly and in a deadly fashion. Furthermore, should a citrus incident develop from another production area, we need to document our mitigation steps and somewhat prevent the PR fallout that will assuredly occur.

So does our industry need this examination and documentation? Yes and no. In a few weeks, producers will learn more about the industry's approach via a program developed by Sunkist, CCM and CCQC. The implementation of the program is akin to going to the dentist for the check-up or filling out the traffic school test online—neither one is pleasant, but both save you pain in the long run.

Our real problem appears to be a sudden shift by FDA from a commodity-specific risk assessment to one of cultural practices. Recently, CCM and colleagues from other tree and vine commodities met with FDA leadership to ascertain why the shift in thinking. The answers were not productive. This doesn't stop us from pushing back, however. We in the permanent crop business are developing safe commodities grown well above the ground where risk concerns are the greatest.

Congressmen Costa, Cardoza, Farr and Baca have weighed in on our behalf. Senator Boxer is poised to do so in a similar vein. By focusing on cultural practices such as using water for irrigation (well, duh!) and not having fences to protect against wild animal intrusion or harvesting product at ground level (forget the ladders as they are on the ground), we too are being characterized as a risk commodity.

Potatoes are not because you cook before consuming. Tomatoes are not because they have a food safety plan. (Allegedly.) Together the permanent crop commodities mentioned will enlist like-minded associations from other states to weigh in with their representatives because Congress was very specific. The spirit of the law is to target high-risk commodities and not waste resources in areas not warranted. (Hmm, this would be a first for government.)

Thus, my view is to harmonize all the pressures under government's umbrella, thereby reducing to the extent possible unwarranted customer demands. Document what we have done and continue to keep at the ready this documentation recognizing that the pain is beneficial in the long run and short-lived. Through a number of workshops for producers, trainers and others we believe the implementation of a food safety plan can be done to protect all parties. This is scheduled to start in late January and conclude with CCM's Citrus Showcase in March.

Now, if we can just get FDA to cooperate, perhaps we can reduce the subjectivity of demands placed upon industry members. We can't walk away from the demands and the responsibility, but we can make the path relatively easy to traverse.

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Citrograph asks:

"Under the Produce Traceability Initiative (PTI), our citrus packers will now be required to provide complete electronic traceability for every box shipped in support of food safety. This will give the entire supply chain specific farm-source information at the *case* level. What's more, outside the scope of the PTI, some packers in other commodities such as berries are taking coding a step further by adding Quick Response symbols to their retail units (small boxes, bags, etc.), in some cases giving *consumers* the ability to get the i.d. of the originating farm. How do you view these developments? Might there be some benefits to citrus marketers and growers that aren't so readily apparent?"

Like many in the citrus industry, I admit to being a little apprehensive about the Produce Traceability Initiative (PTI). It always makes me a bit nervous when broad strokes are taken to requiring things of an industry as diverse as the produce industry, especially since we already do a great job tracking our products. But, I also agree that this PTI coding is what our customers want, and we need to provide it. That said, from a marketing standpoint, the additional idea of QR codes on consumer packaging, which is not a part of the PTI, does offer some real possibilities for us to better get to know our consumers and shine a light on our unique position in the produce industry. It could also present some challenges. Imagine yourself walking into the produce department of your local supermarket. Using your IPhone, you take a picture of the symbol on the side of a bag of Washington navels. Up pops a video about the individual marketer and/or grower. The video leads the shopper through a packinghouse or grove, the grower talks about growing techniques, fruit quality and variety information, and there are links to recipes. All good. The code might also provide information on when the fruit was picked, sugar-to-acid ratios and possibly other details. Hmmm. Various types of scan symbols and codes on packages are only part of an exciting new world we face in the produce industry. If we embrace it and use it to our advantage, it will help us stand together when we need to, and stand apart when we want to. ***—Lance Walheim, California Citrus Specialties***

To the second part of the question, I think the upside to QR codes on consumer packaging would be possible increased exposure in the marketplace for small business and their growers. It has the potential to be a positive experience for the consumers, giving them the opportunity to be active participants in discovering the origin and path of their food. It also would provide us with a way to communicate to the public our commitment to food safety in addition to the organic practices we've so diligently followed for years. However, I am concerned that if individually traceable units become the standard in consumer expectation, we will have to fight very hard to avoid it becoming expected policy. With regard to food safety and traceability programs in general, susceptibility to contamination (in every form) needs to be evaluated on a commodity-by-commodity basis. We have the chance to use traceability standards as a tool to educate the public about food safety -- that everything in the produce aisle does not carry equal risk. I believe these standards should be constantly scrutinized to assure that we are measuring the cost of the venture with the success of the targeted issue. As California growers, we are currently facing a lot of dynamic challenges, and I can't help but wonder: what might the financial consequences be of another layer of bureaucracy, and who ultimately will be paying that price? ***—Bill Hahlbolm IV, Sundance Natural Foods Company***

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Nick Hill, CPDPC Chairman

Update from the Citrus Pest and Disease Prevention Committee

Industry adopts strategic program to protect commercial citrus

At the December meeting of the California Citrus Pest and Disease Prevention Committee (CPDPC), members of the body adopted a plan that establishes an aggressive buffer detection and treatment program around the endemic Asian citrus psyllid (ACP) population in the greater Los Angeles Metropolitan area.

The goals of this plan are to (1) prevent natural HLB spread from northern Mexico via ACP, (2) prevent ACP spread eastward through Palm Springs to Coachella Valley, (3) prevent ACP spread westward from Los Angeles into Ventura, and (4) prevent ACP spread southward to Temecula/northern San Diego.

The newly adopted buffer program requires a more intensive survey effort and increased sampling for huanglongbing (HLB). Treatments will be targeted to the buffer zones as the ACP attempts to migrate into those areas. Simultaneously, the industry in partnership with the California Department of Food and Agriculture (CDFA) and the University of California, Riverside (UCR) has begun a research biocontrol program in Los Angeles with a promising strain of *Tamarixia radiata* discovered in the Punjab region of Pakistan. Within the endemic area of Los Angeles, CDFA will enhance the sampling program for HLB, and both CDFA and UCR will monitor the progress of the biocontrol research program.

There is no one-size-fits-all approach to battling the spread of ACP and preventing the introduction of HLB in our state. ACP treatment programs will continue in the counties of Imperial, Orange, San Bernardino, San Diego, Riverside, and Ventura. Furthermore, the western San Fernando Valley area will also be subject to treatment and eradication efforts as ACP are discovered.

Communication efforts within the Los Angeles area are being modified including expanding efforts at retail sales of consumer products. The collective message to homeowners in the Los Angeles area is that you too can help protect backyard citrus with proper utilization of chemicals available at your local garden center. Photos of ACP, print messages, and in-store promotional material will be used.

Quarantines remain in effect in all counties where ACP has been discovered; thus, mitigation steps are being employed continuously in these areas by producers and county officials in partnership with state and federal entities.

This is a massive battle on several fronts, with nothing less than our $2 billion industry future at stake and jobs for 12,000 employees hanging in the balance. It's a battle we can't afford to be cheap on and one we can't afford to lose.

Buffer zone boundaries and additional information regarding the entire effort can be found on several websites including: www.SaveOurCitrus.org (USDA); http://www.cdfa.ca.gov/plant/acp/ (CDFA); www.californiacitrusthreat.org (CPDPC); and www.citrusresearch.org (Citrus Research Board).

The Citrus Pest and Disease Prevention Committee (CPDPC) was formed in 2010 to assist the California Department of Food and Agriculture in combating diseases, vectors, and pests of California citrus. It is composed of 17 members who are appointed by the Secretary of CDFA. Fourteen members are citrus producers, one is a public member, and the two remaining members represent citrus nurseries. For more information on the CPDPC, contact Susan McCarthy at smccarthy@cdfa.ca.gov

Citrus Pest & Disease Prevention Program

Mark Hoddle, closest to the camera, briefs reporters prior to releasing vials of the parasitic wasp *Tamarixia radiata* in a biocontrol research block on the UC Riverside campus. *Photo by Ted Batkin, CRB.*

Researchers take a major step forward in investigating the potential for biological control against ACP in California

Ted Batkin

On Dec. 20, Dr. Mark Hoddle and his colleagues at the University of California Riverside released several vials of *Tamarixia radiata*, a small parasitic wasp that lays eggs under the nymphs of the Asian citrus psyllid. This event is significant in that it was the first release of this particular species of biocontrol agent in the western United States.

The release was done in a section of citrus on the UCR campus used for studies in biological control and separated from the remainder of the campus research plots. Assisting in the release was Dr. Dallas Rabenstein, Executive Vice Chancellor of UCR.

Hoddle and his wife, fellow entomologist Christina Hoddle, had brought several colonies of the parasitoid to California from the Punjab region of Pakistan under permit from USDA-APHIS. They had made four separate trips to the region over a period of 18 months to collect and bring back multiple genetic lines of *Tamarixia* from a region with a climate that is similar to California's. They held about 15 colonies in quarantine on the campus for over 14 months prior to receiving permission from state and federal officials to release the parasitoid in open fields.

The release at UCR was only the first step of a very long and arduous research program aimed at bringing additional tools to the fight against ACP in California. As Hoddle told reporters that morning, "*Tamarixia* will not be a silver-bullet solution but one of several tools that will be developed as part of an emerging and comprehensive strategy."

The initial phase of the project will be to evaluate the parasitoid's ability to establish, spread, and attack ACP in California. Once these small-scale field tests are complete, and if field evaluations indicate that the parasitoid appears to be working, a plan to expand the biological control program will be executed.

Since that initial release at UCR, the Hoddle team has released *Tamarixia* in several locations in Southern California where ACP is present. They are focusing on the urban areas of the Los Angeles Basin where the populations of ACP have grown to a point where chemical treatments have been discontinued.

CDFA and the Citrus Pest and Disease Prevention Program have shifted the deployment of treatment assets to areas outside the greater L.A. Basin. "The change will increase the protection of the commercial production areas and improve the impact of the limited resources of the program," reports Nick Hill, Chairman of the CPDPC. The UCR team will expand the areas of release as the numbers of *Tamarixia* in mass production increase.

The Citrus Research Board has established a Task Force to develop plans to provide the necessary sites for rearing and releasing larger numbers of the parasitoid. In addition, the Task Force will explore other options for biological control to include natural enemies already present in California that have potential to attack ACP as well. For the present, the group is focusing on *Tamarixia* as the primary natural enemy species for expansion of the mass production and release program.

The next steps for the Task Force will be to identify areas for production of *Tamarixia*. Currently, the team is focusing on the Insectary and Quarantine Facility on the UCR campus. That facility has several layers of protection to assure that populations of ACP are not escaping into the Riverside environment. As the program expands, additional facilities will be needed to rear the agent for release in urban areas.

The Task Force consists of participants from UCR, CDFA, and the citrus industry. It is chaired by the immediate past chairman of CRB, Jim Gorden.

Biogenic emissions from *Citrus* species in California measured via an enclosure system

John F. Karlik, Silvano Fares, Drew R. Gentner and Allen H. Goldstein

Introduction and background

Volatile organic compounds (VOC) are relatively small molecules containing carbon that evaporate easily. VOC originate from both human activity and from natural sources. Oxides of nitrogen (NOx) are produced mostly from internal combustion engines. VOC and NOx react in the presence of sunlight to form ozone and secondary compounds including aerosols.

Ozone is the most important air pollutant in California airsheds, and to reduce ozone levels the relative source strengths of VOC and NOx must be known.

A subset of VOC are those produced from green plants, known as biogenic VOC (BVOC), which enter into photochemical reactions to produce ozone but may also react with ozone to remove it from the atmosphere.

We were asked by California Citrus Mutual and the Citrus Research Board to investigate the role of citrus trees in production of BVOC as well as the destruction of ozone. This research will help the California citrus industry respond to air quality concerns, since we will better understand how citrus trees affect regional air quality.

This research will help the California citrus industry respond to air quality concerns, since we will better understand how citrus trees affect regional air quality.

To summarize our work, we plan to offer four articles in *Citrograph*. In a previous issue (July-August 2010, pp. 40-43), we reported results for ozone destruction studied in an enclosure system. In this article, we report our work with regard to BVOC emissions made in the enclosure system, and in the future we will discuss measurements made in a field setting.

Leaves are the main sources of BVOC from plants, and there are several BVOC of particular importance. Emission rates of some BVOC compounds vary according to both light and temperature (L+T), while emission rates of other BVOC are almost completely dependent on temperature only (T), so two different mathematical expressions are used to describe the variation of emissions with environmental conditions.

Isoprene, a five-carbon compound, is the dominant BVOC emitted to the atmosphere. Its formation pathway is related to photosynthesis, so its emission responds to light and temperature, and isoprene is released immediately after production.

Monoterpenes are 10-carbon compounds composed of two isoprene units with emissions dependent on temperature because emission is mainly the result of volatilization from storage pools. However, in a few cases, emission depends on light as well.

Sesquiterpenes are 15-carbon compounds whose emissions depend primarily on temperature, and they are formed by a different biosynthetic pathway than isoprene and monoterpenes. Sesquiterpenes have previously been considered to account for a small percentage of global BVOC emissions, but recent results suggest their total emissions are similar to monoterpenes. Sesquiterpenes are of great interest since they are highly reactive and important for the chemistry of both ozone and secondary organic aerosol.

There are also several BVOC containing oxygen produced by plants. Methanol (methyl alcohol) is emitted by plants to the atmosphere in large quantities from the demethylation of pectins in cell walls occurring during leaf expansion and senescence. Acetone is the most abundant ketone in the atmosphere, with primary emission from terrestrial ecosystems and oceans but with a large secondary source from oxidation via atmospheric reactions of hydrocarbons of both anthropogenic and biogenic origin. We know that acetone is released during senescence and oxidative stress on plants, although the biosynthetic pathway of acetone formation in leaves is not well known.

Acetaldehyde is another BVOC that is directly emitted from oceanic and terrestrial sources and is also a product of hydrocarbon oxidation in the atmosphere. Acetaldehyde is emitted from plants mainly under low oxygen conditions in roots and in leaves but also during and after abiotic stresses or after light-to-dark transitions.

Methods

Experiments were carried out in 2008 in the Oxford Greenhouse at the University of California, Berkeley. Selected species and varieties were orange (*Citrus sinensis* 'Parent Navel' grafted on Volk rootstock), lemon (*Citrus limon* 'Meyer' on Volk rootstock), mandarins (*Citrus reticulata* 'W. Murcott' and 'Clemenules' clementine, both on C-35 rootstock).

We bought a set of 10 individuals of the same genotype from a commercial nursery (Willits & Newcomb) and placed them in the greenhouse in February to allow adaptation to the environmental conditions. For each measurement, we enclosed a single branch which contained 10 to 500 grams of leaf biomass, an amount large enough to ensure that BVOC

The enclosure apparatus used in the experiments carried out at UC Berkeley.

concentration inside the enclosure system was sufficient to achieve an adequate signal/noise ratio. Plant stems were gently wrapped with Teflon film to avoid mechanical damage as much as possible.

In all cases, measurements started 24 hours after plant enclosure to compensate for potential enclosure effects, and after negligible emission of leaf wounding marker compounds (3-Z-hexenol, 2-E-hexenal, 3-Z-hexenal, 2-E-hexenol) were observed. Measurements of photosynthetic parameters and BVOC were carried out by switching between the plant enclosure outflows every 15 minutes with a system of two- and three-way solenoid valves controlled by a datalogger that recorded data every minute. CO2 and water exchanges were measured with a closed-path infrared gas analyzer. Leaf area was measured after the experiment with a leaf area meter followed by drying and weighing. For more details about the enclosure setup, please refer to our previous article in *Citrograph*.

We used two analytical systems to measure BVOC emissions. Proton transfer reaction mass spectrometry (PTR-MS) was used for on-line measurements. In parallel with PTR-MS, hourly resolved VOC concentrations and emissions were measured using the second analytical system, an automated in-situ gas chromatograph equipped with both a mass-selective detector and a flame ionization detector.

Table 1. Total BVOC emitted under standard conditions with proportion of various compounds for the citrus studied. Units are nanograms carbon per gram dry leaf mass per hour.

Compound	Lemon	Clemenules Mandarin	W. Murcott Mandarin	Orange (no flowers)	Orange (+ flowers)
Methanol	140	300	190	480	880
Acetaldehyde	18	23	16	650	1700
Acetone	50	54	70	240	500
Isoprene	3.2	4.7	8.4	13	45
Monoterpenes	22	26	63	2500	7800
Oxy. Monoterp.	N.D.	N.D.	150	1300	4600
Sesquiterpenes	N.D.	N.D.	N.D.	1500	3200
Total	**233**	**408**	**497**	**6680**	**18700**

N.D. = not detected

Results

BVOC emission rates are often with units of micrograms (millionth of a gram) (μg) of BVOC compound emitted per gram dry leaf mass per hour measured under standard conditions of light and temperature. If the emission rate is very small, the emission rate may be given in nanograms (billionth of a gram) (ng). Because carbon comprises most of the mass of BVOC compounds, emission rates are sometimes expressed as amount of carbon, which makes it easier to compare amounts of different BVOC emitted. We show emission results for the citrus studied in Table 1.

Isoprene: Although isoprene (five carbon atoms) is the

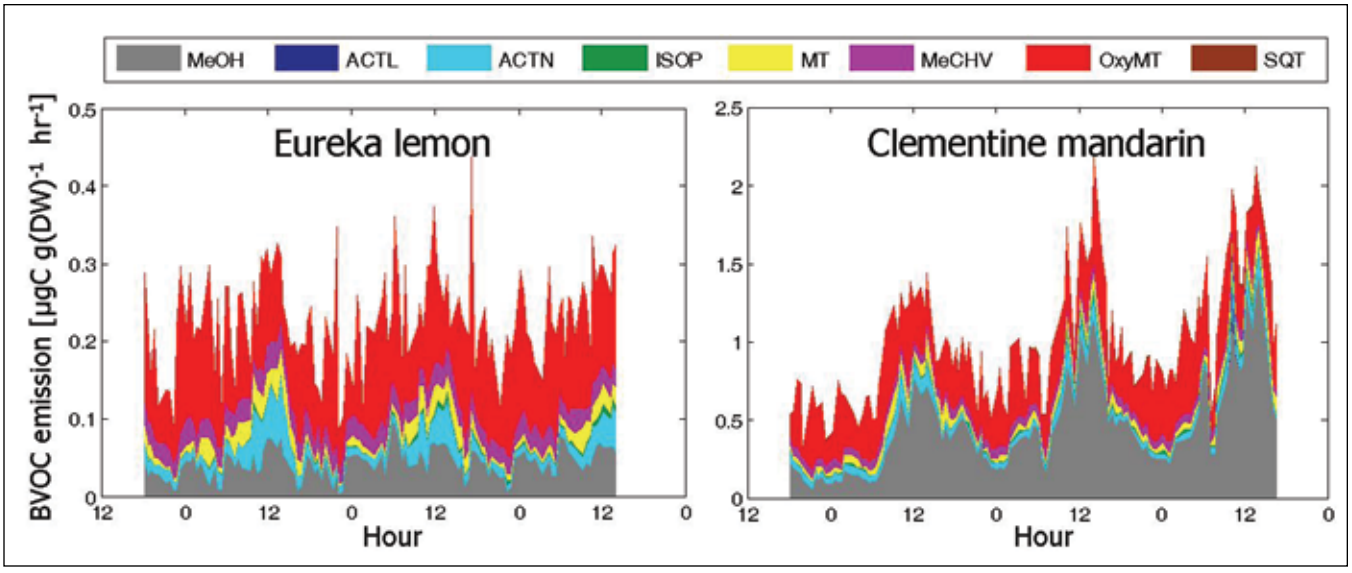


Figure 1. Daily variation in emissions corresponding to changes in light and temperature.

dominant BVOC emitted by green plants, in our study isoprene emissions were negligible, suggesting *Citrus* species are not significant isoprene emitters and that the methyl-erythritol-phosphate biosynthetic pathway in the leaves produces mainly monoterpenes rather than isoprene in *Citrus*, especially in navel orange.

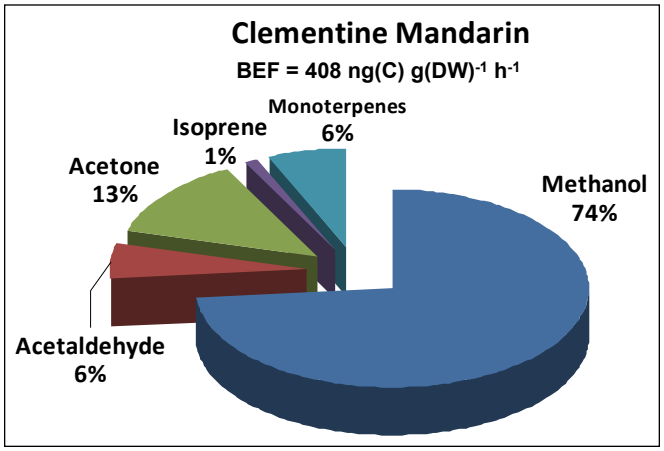
Monoterpenes: Orange had the highest levels of monoterpenes (10 carbon atoms) emissions but still only 2.5 µg(C) g^{-1} h^{-1}. Lemon and mandarins emitted a low, almost negligible, amount of total monoterpenes (22, 26, and 63 ng(C) g^{-1} h^{-1} for lemon, 'Clemenules' mandarin, and 'W. Murcott' mandarin, respectively). For mandarins, the most abundant monoterpenes were β-cis and β-trans isomers of ocimene with minor amounts of limonene, sabinene, and pinene. For all plants, the pattern of monoterpene emission (Figure 1) showed peaks during mid-day under the highest levels of light and temperature.

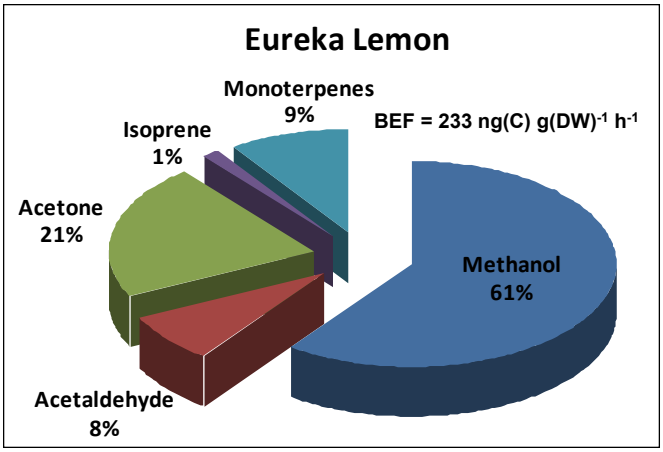
We compared measured emission rates to rates predicted by standard equations in which light or temperature, or both, varied. We did so because biogenic emission rates are influenced by light and temperature, and for an accurate estimate in atmospheric models we need to understand which type of equation best fit the relationship.

The correlations between measured and modeled BVOC emissions were highly significant ($p < 0.001$) for 'Parent Navel' orange, when emissions were modeled using both the L +T algorithm and the T algorithm. The possibility that some of the BVOC compounds (e.g. those stored in secretory structures) are more temperature dependent and others are more light dependent (e.g. those originated from *de novo* synthesis) seems the most likely explanation.

Sesquiterpenes: Sesquiterpenes (15 carbon atoms) were emitted by navel orange at a relatively high rate, 1.5 µg(C) g^{-1} h^{-1}, with β-caryophyllene the main sesquiterpene emitted. The T algorithm provided a better fit than with L+T algorithm, suggesting that temperature is more important than light in affecting the emission of sesquiterpenes in orange plants.

Oxygenated emissions — methanol, acetaldehyde and acetone: In lemon and mandarins, methanol was the BVOC compound with the highest emission rate, ranging from 140 to 300 ng(C) g^{-1} h^{-1} for 'Meyer' lemon and 'Clemenules' mandarin, respectively. We observed methanol fluxes at night from many plants that were up to half of the daytime maximum observed values even though nighttime temperatures were only ~17-19°C (63–66°F), consistent with emission during leaf expansion at night. The drivers of methanol emission do not strictly depend on light, so we did not find good correlation using either the L+T algorithm or the T algorithm. To accurately model methanol emissions, it seems





necessary to combine the current algorithms with more information on the life stage of the plant, which affects tissue expansion, and also consider increases of methanol emission in response to oxidative stress imposed by cutting or leaf wounding.

Our study demonstrates direct biogenic emission of acetaldehyde and acetone from citrus. Past field studies of citrus attributed emissions of acetaldehyde and acetone to atmospheric oxidation processes of other BVOC because no detectable emission was observed from branch enclosures. However, given the low retention time in our enclosures (~10 min) and the limited presence of reactive oxidants, we conclude acetone and acetaldehyde are direct plant emissions. Additional gas-phase chemistry may occur in the ambient atmosphere in field settings leading to production of both compounds.

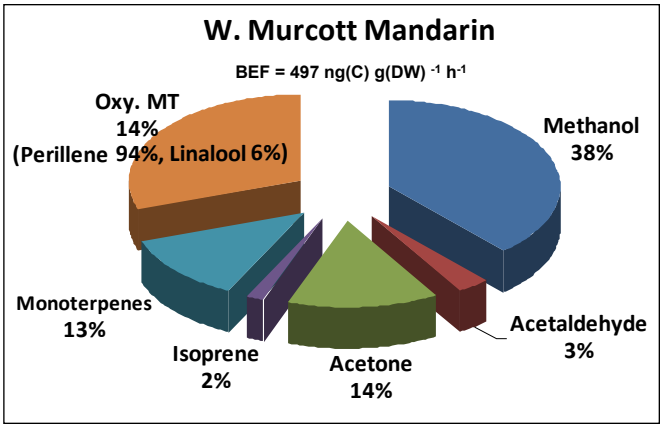
Acetaldehyde was emitted from navel orange at 650, but production jumped to 1700 ng(C) g^{-1} h^{-1} when flowering. Lemon and mandarins emitted at minimal rates (~ 20 ng(C) g^{-1} h^{-1}). Acetaldehyde emissions were better represented by the L+T algorithm in all *Citrus* species, with the exception of 'Clemenules' mandarin, where no significant correlation was found. This suggests that light is related to those catabolic processes responsible for acetaldehyde release, although we cannot provide a detailed explanation for the specific pathway which is triggered by light and leads to acetaldehyde emission.

Acetone was also emitted from leaves, with the highest emission observed from oranges, with 240 doubling to 500 ng(C) g^{-1} h^{-1} at flowering. There is still a lot of uncertainty about the biogenic sources of acetone. In our study, acetone emissions seemed to be better represented by the T algorithm for lemon and mandarins, while for oranges acetone emissions were correlated with both algorithms; thus, we cannot make a strong recommendation regarding which algorithm better represents acetone emissions to the atmosphere for all species studied.

Emissions during flowering events: Flowering is an important phenomenon that occurs once per year in most of the citrus in California's Central Valley. We observed that flowering increased emissions from orange trees by a factor of three with the bulk of BVOC emissions comprised of monoterpenes, sesquiterpenes, and oxygenated monoterpenes.

For example, flowering increased emissions of monoterpenes from 2500 to 7800 ng(C) g^{-1} h^{-1}, in agreement with previous studies. Monoterpene species emitted from flowering and non-flowering branches were substantially different. For non-flowering plants, β-myrcene was the main monoterpene emitted (67%), followed by β-E-ocimene. For flowering plants, 81% of the total monoterpene emissions were β-Z- and β-E- ocimene, a compound previously reported in emissions from flowering *Citrus* trees and known to attract pollinators. Linalool was the dominant oxygenated monoterpene observed from flowering orange plants (98%), also in agreement with past research.

We will have more to say in a future *Citrograph* article in which we discuss measurements made in the field during the flowering period.



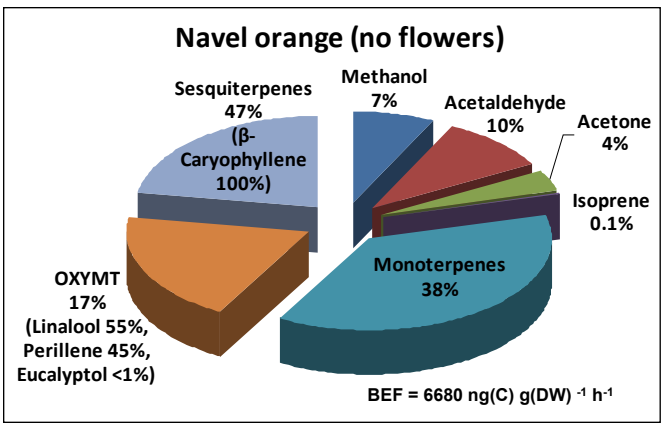
Conclusions

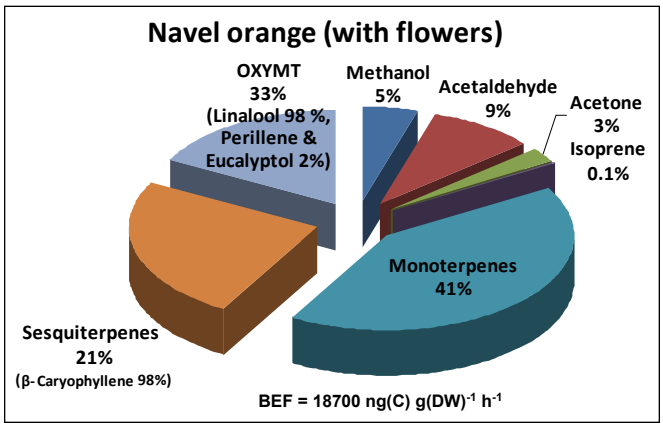
The aim of this part of our study was to provide new data on the quantity and identity of BVOC emissions and the daily BVOC emission dynamic for important *Citrus* species cultivated in California.

Our results will be useful to estimate whether BVOC emitted from these crop species play a significant role in regional air quality, especially when *Citrus* plantations are close to urban areas such as found in the Central Valley of California, where BVOC can combine with anthropogenic emissions to contribute to ozone and secondary aerosol production.

The data developed in this study provide the most current and robust set of measurements for citrus in California. The data will help describe the role citrus plays in the regional atmosphere and especially how much ozone is removed by an orange orchard.

We found that isoprene emission was very small for all the citrus studied. We found that oxygenated VOC (metha-





nol, followed by acetaldehyde, and acetone) represented the dominant fraction of the total BVOC emission for mandarins and lemon, while monoterpenes were most important for oranges. Ocimenes, β-caryophyllene, and linalool were important specific compounds.

Total BVOC emission rates measured were low compared to enclosure measurements for a number of other plants found in natural landscapes and urban environments. However, because of the amount of leaf mass represented by citrus orchards, the sum of emissions needs to be considered in air quality models.

The predictive capabilities of the model depend on use of the correct algorithm. L+T algorithms were better predictors of methanol, acetaldehyde, acetone, isoprene and monoterpene emissions for all the *Citrus* species, while T algorithms were better predictors for oxygenated monoterpene and sesquiterpene emissions.

In addition to utilizing our reported emission factors, we recommend future BVOC emission models consider flowering and harvest events, which may have a significant impact on regional atmospheric chemistry.

For a more complete discussion, please see our paper, Fares et al., 2011, "Biogenic emissions from *Citrus* species in California," *Atmospheric Environment* 45: 4557-4568.

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Earwigs: pests or beneficials?

Carla Romeu-Dalmau, Ping Gu, Sara Scott and Beth Grafton-Cardwell

Growers have noticed an increase in earwig abundance in California citrus orchards in recent years. This is probably due to a decline in the use of broad spectrum insecticides for pests such as California red scale and citrus thrips.

The two earwig species most commonly found in California citrus orchards are the European earwig, *Forficula auricularia* L., and the ring-legged earwig, *Euborellia annulipes* (Gené) (Photo 1). The ring-legged earwig is wingless, smaller in size, darker, and with shorter forceps (pincers) compared to the European earwig. Since the ring-legged species is rarely found on trees, it is not damaging to citrus and so it can be ignored.

The European earwig can be found both on the ground and in the tree, and has been observed to damage leaves and fruit, and so it is of most interest to citrus growers. Thus, the European earwig was the species targeted in our study of the role of earwigs in California citrus.

Earwigs have been proven to regulate pest populations in orchards. They can also be a springtime pest as growers have observed them feeding on citrus leaves and fruit.

General information about the European earwig

Earwigs are nocturnal insects; they forage at night, and during the daytime they seek dry and cool places to hide in such as rolled-up leaves, tree wraps, and trunk or soil crevices. Earwig females create nests in the soil in which they deposit their eggs. The females guard their eggs, and when the eggs hatch the females feed the early instars in their subterranean nests.

From the second nymphal stage onwards, European earwig nymphs gradually leave the nest and begin the free-foraging phase on the soil surface and in trees until they enter the soil again to reproduce as adults.

In the spring of 2011, European earwigs deposited many eggs in the soil and they readily hatched into nymphs. Based on the literature, we expected to see another period of egg laying in the fall. There was some fall egg laying, however, it was very small compared to the spring and few of the eggs hatched.

Earwigs are omnivorous; they feed on both plant and animal material. As an insectivore, the European earwig is considered a key biocontrol agent of important pests. It has been proven to regulate pest populations in orchards such as the woolly apple aphid *Eriosoma lanigerum* (Hausmann) in apple trees, the leafroller *Epiphyas postvittana* (Walker) in apple orchards and vineyards, and the pear psylla *Cacopsylla pyri* L. in pears.

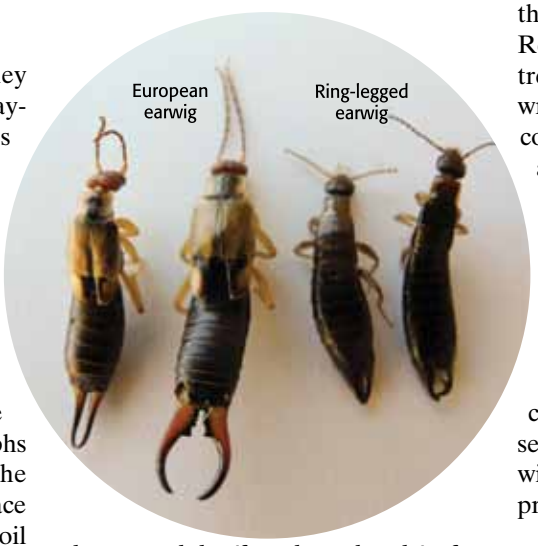


Photo 1. Adults (female and male) of the two earwig species most commonly found in California citrus orchards, the European earwig *Forficula auricularia* L. and the ring-legged *Euborellia annulipes* (Gené).

In fact, it is known that earwigs can consume higher amounts of aphids than other common predators such as ladybugs and green lacewings. Earwigs also feed on scale insects, mites, Collembola and fungi. As an herbivore, the European earwig can at times be a springtime pest as growers have observed them feeding on citrus leaves and fruit (Photo 2). Thus, it is not a simple matter to decide what role earwigs play in citrus orchards: are they pests or beneficials?

The impact of earwigs on citrus leaves flush

To begin to understand the role of European earwigs, we ran several experiments in the field and the greenhouse to determine how much leaf flush the earwigs might consume.

Field leaf feeding experiment: We utilized 'Tango' mandarin trees that were field planted one year earlier at the University of California Lindcove Research and Extension Center. Ten trees, called *earwig* trees, had foam wraps around the trunks. Earwigs could hide in these wraps and freely access the canopy. Ten trees, called *non-earwig* trees, had the tree foam wraps removed, and earwigs were excluded using a sticky barrier (Stikem Special) applied to plastic wrap (Saran) tightly wound over a cylinder of batting in contact with the trunk (Photo 3). This system excluded earwigs but not other flying insects. Only ants could also be excluded with this system, but they were barely present in this plot.

Ten flushes per tree were marked before earwig damage started and then sampled weekly. Damage was defined as chewed marks in the edge or middle of the leaf (Photo 4). We rated the percentage of leaf surface area lost (0%,

Photo 2. Earwig potential damage to fruit. Damage to fruit may occur just after petal fall when the fruit is small.

1-25%, 26-50%, 51%-75% or over 76%) per leaf. The treatment was applied on 13 April 2011, and weekly sampling continued until 27 June.

During the first flush (from April to the beginning of May), leaves in *earwig* trees lost an average of 6.9 ± 1.6 % of their leaf surface area (Photo 4), while leaves in *non-earwig* trees lost an average of 0.8 ± 0.2 % leaf surface area. The average number of earwigs found per sampled day per tree was 3 in the *earwig* trees (both nymphs and adults present) and zero in the *non-earwig* trees.

Thus, earwigs did feed on and cause significant damage to leaves during the first flush; however, we do not know if this level of damage affected the long-term growth of the trees. We plan to conduct additional studies with varying levels of earwig densities to determine the threshold of leaf damage that results in reduced growth and/or yield of young trees.

Significant leaf damage was not observed in the second flush (middle of May until June) in either the *earwig* or *non-earwig* trees (Photo 5). The average number of earwigs found during this second flush per sampled day per tree was one in the *earwig* trees (only adults) and again zero in the *non-earwig* trees. Thus, earwigs were still present during the second flush although in a much lower abundance.

Greenhouse leaf feeding experiments: We conducted a set of experiments during July under greenhouse conditions (heating below 60º F and cooling above 75º F, shade all the time), with 1-year-old Valencia or Rough Lemon seedlings. We placed ten field-collected adult earwigs (5 males and

Photo 3. One-year-old 'Tango' mandarin trees used in the field experiment. In *earwig* trees, earwigs had free access to the canopies; in *non-earwig* trees, earwigs were excluded using a sticky barrier applied to plastic wrap wound tightly over a batting cylinder in contact with the trunk.

Photo 4. Earwig damage to one-year-old 'Tango' mandarin leaves (May 6th).

Photo 5. Second flush of the two-year-old 'Tango' mandarin (June 27th), undamaged by earwigs.

5 females) inside each cage (Photo 6) with one or two food sources for two weeks.

The food source was (1) only a citrus seedling, to monitor leaf damage, or (2) a citrus seedling and a California red scale infested lemon (Photo 7), to study earwig preferences between animal and plant material. We completed eight replicates for each food source.

In the first treatment (1), there was 0.2 ± 0.1% of surface area lost per leaf. In the second treatment (2), there was 1.1 ± 0.2 % of surface area lost per leaf, and earwigs ate 47 ± 9 % of the scales. In both experiments, earwigs did almost no damage to leaves, a result that contrasts with the results found in the field for the first flush, when there was 6.9% of surface lost per leaf.

We need to conduct more tests, however, we believe that either the earwigs are changing their feeding habits as the season progresses or the nymphs and adults have different feeding preferences. During the first flush of the field trees, many fourth instar nymphs were present while the earwigs in second flush of the field trees and those used in the greenhouse experiments were only adults. Nymphs seem to attack leaves much more than adults, and adults seem to prefer to predate on California red scale. Since only adults are found in summer and they don't seem to feed on foliage very much at that time of year, our results suggest that control of European earwigs is not necessary in the summer.

Pesticide trials

During 2011, we began laboratory and field studies to determine what types of insecticides would effectively control earwigs and so reduce the damage they cause to leaves and fruit in field situations during spring. We screened a wide variety of insecticides using a petri dish method. We soaked filter paper in the petri dish with a field rate of insecticide mixed in 100 gpa water and added individual earwigs to the dishes (Photo 8) for a total of 10 dishes per insecticide.

We screened an array of registered insecticides (Table 1) including fairly broad spectrum insecticides such as organophosphate, carbamate, pyrethroid and neonicotinoid insecticides and also fairly selective insecticides such as Delegate, Success, Agri-Mek, Altacor and various insect growth regulators. We considered an earwig dead when it was not able to walk.

As expected, we did not see any negative effect of the insect growth regulators on adult earwigs because they are not molting. We found that a very limited number of insecticide groups were fully effective in killing adult female earwigs. Lorsban, Sevin, Seduce, Leverage and Baythroid were effective in causing 100% kill by day 14. We found that some pyrethroids would initially 'knock down' or temporarily paralyze the earwigs, but earwigs would sometimes recover and we would see lower mortality at 14 days compared to 2 days.

Several important points about the pesticide test results should be highlighted. First, only Lorsban Advanced was able to quickly kill the earwigs (full control within 2 days). Secondly, most of the highly effective insecticides are very broad spectrum and so are difficult to integrate with natural enemies needed for other pests.

Finally, Seduce was very effective in killing earwigs when it was provided as a bait that the earwigs fed on (rather than treated filter paper). Seduce is an organically approved product that is very soft on natural enemies; thus it has great potential for use by citrus growers. We plan to repeat testing of all of these insecticides using nymphs to see if that stage is more or less susceptible to the insecticides.

In the field, the grower applied treatments of Sevin XLR and Baythroid XL (Fig. 1) using a speed sprayer and 100 gpa on 15 April 2011 to the foliage of a 7-yr-old block of Rush navel oranges in Porterville, CA. The plots were

Photo 6. Greenhouse experiments. Twenty citrus trees were individually placed inside cages, each one with 10 earwigs (5 females and 5 males). Additionally, 10 of the cages also received a California red scale-infested lemon.

Photo 7. Earwigs fed on California red scale infesting the lemon, leaving behind white areas indicating where the scales were completely consumed.

Photo 8. Petri dish bioassay for testing the effects of insecticides on earwigs. The filter paper is soaked in insecticide, and the leaf disk is provided as food for the earwig.

Chemical group	Formulation	chemical	Rate per acre	% mortality at 2 days	% mortality at 14 days
Organophosphate	Lorsban Advanced	Chlorpyrifos	1 qt	100	100
Carbamate	Sevin XLR Plus	Carbaryl	5 qts	50	100
Pyrethroid	Baythroid XLR	Beta cyfluthrin	6.4 fl oz	60	100
Pyrethroid	Mustang	Zeta cypermethrin	4.3 fl oz	50	20
Pyrethroid	Danitol	Fenpropathrin	21 1/3 fl oz	80	60
Neonicotinoid	Assail 30 SG	Acetamiprid	6 oz	0	20
Neonicotinoid	Admire Pro	Imidacloprid	7 fl oz	0	10
Neonicotinoid	Actara	Thiamethoxam	5.5 oz	0	40
Mixture of pyrethroid and neonicotinoid	Leverage 2.7	Cyfluthrin and imidacloprid	11.6 fl oz	30	100
Spinosyns	Delegate WG	Spinetoram	6 oz	0	0
Spinosyns	Success Seduce bait*	Spinosad	10 fl oz .16 gm/dish	0 90	20 100
Avermectins	Agri-Mek 0.7 SC	Abamectin	3.5 fl oz	0	0
Insect growth regulator	Esteem 0.86 EC	Pyriproxyfen	16 fl oz	0	0
Insect growth regulator	Micromite 80 WGS	Diflubenzuron	6.25 oz	0	0
Insect growth regulator	Applaud 70 DF	Buprofezin	46 oz	0	0
Tetronic acid derivative	Movento 240 SC	Spirotetramat	10 fl oz	0	0
Diamides	Altacor WDG	Chlorantraniliprole	4 oz	0	10

Table 1. Effects of various broad spectrum (orange highlight) and soft (green highlight) insecticides on survival of adult female earwigs. Rates of insecticides mixed in 100 gpa water volume. *Seduce applied as bait and fed on by earwigs.

five rows by 16 trees and replicated 3 times. We sampled the center 5 trees in each plot by shaking the foliage onto a beating sheet on two sides of the trees. In addition, on 25 April Seduce bait was applied to the ground of three plots.

The foliar treatments successfully suppressed earwigs for about 3 weeks and then the adults were able to return to the trees. The Seduce treatment was ineffective in reducing earwigs. This was probably due to the fact that at the time of year the study was conducted (May), earwigs were predominantly in the trees and not foraging on the ground. This product may be more successful in the fall when earwigs are likely to be building nests in the ground. We plan to study Seduce treatment timing further. We surveyed the trees and did not find any fruit damage in either treated or untreated trees.

What we have learned so far by studying earwigs from April through August

• There are two species of earwigs in California citrus orchards. The European earwig is the one that growers should learn to identify, because it is the only one that climbs into the trees.

• Earwigs (and especially nymphs) may damage citrus first flush in spring. We did not observe fruit damage in our experiments, but others have observed fruit damage occurring at petal fall.

• Earwigs do not behave uniformly throughout the year. Even if they damage leaves during the first flush, they do not damage flush in the subsequent spring and summer flushes. This may be a seasonal change in diet or activity in the trees, or a difference between nymph and adult feeding habits.

• Earwigs are also predators of pests. In fact, in greenhouse conditions adults preferred feeding on California red scale rather than on leaves.

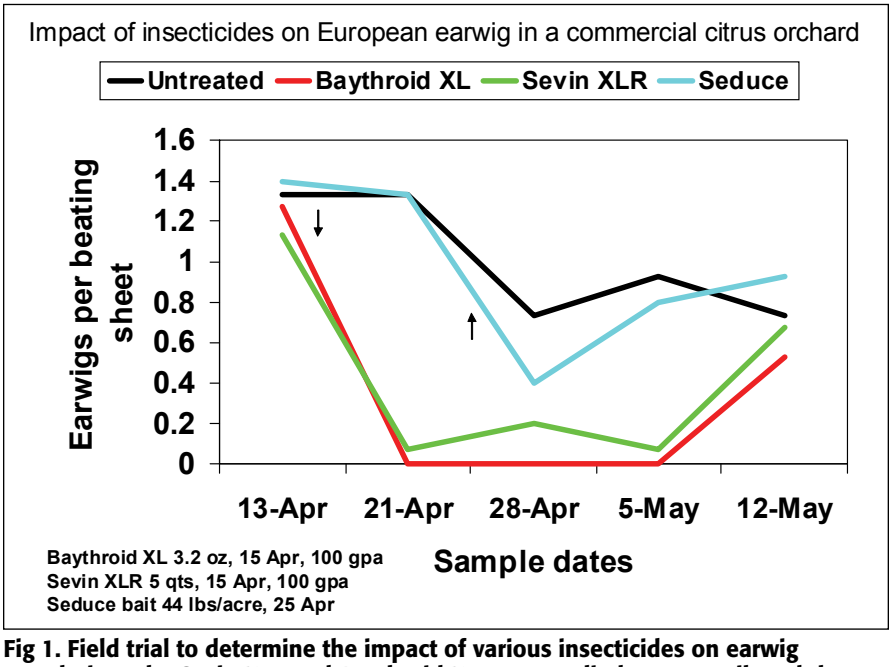


Fig 1. Field trial to determine the impact of various insecticides on earwig population. The Sevin XLR and Baythroid XL were applied on 15 April, and the Seduce was applied on 25 April.

• With one exception (Seduce bait), earwig adults are difficult to kill with anything but very broad spectrum insecticides such as organophosphate, carbamate and pyrethroid insecticides.

• Seduce bait is soft on natural enemies and very effective in the laboratory but did not work in a spring field trial, indicating that timing of application to attract ground feeding earwigs may be critical for successful control of earwigs.

Earwig management tactics

We have, in a very short period of time, learned some information about earwigs that will improve their management. In young nonbearing trees, protecting growth is most important. The best management tactic to protect spring flush from earwig damage is to either remove the tree wraps (to limit earwig refuges) or spray broad spectrum organophosphate, carbamate or pyrethroid pesticides into the wraps and/or on the foliage.

After the first spring flush, the earwigs become adults, they are found less frequently in the trees, and they don't seem to damage leaves. In summer, the wraps could be replaced to provide protection against sunburn and to reduce suckering.

In mature orchards, leaf flush damage is of little concern because the tree can tolerate heavy damage and maintain production. In mature trees, earwigs will only be a problem if they attack the fruit at petal fall. We did not observe earwig damage to the fruit in our field study, but we know that it occurs in some orchards as growers and PCAs have observed it.

We did observe feeding by adult earwigs on California red scales, indicating the adults can be significant beneficial predators. Therefore, the role of the European earwig in mature trees is not easy to define: pest or beneficial? When earwigs are found to be attacking fruit, a management tactic would be to apply a full rate of pyrethroid or organophosphate with the petal fall citrus thrips-katydid treatment to protect the new fruit. We will continue our studies of Seduce earwig bait and other soft insecticides to develop a softer, more integrated approach to earwig management for mature orchards with chronic earwig problems.

Take-home message

Are earwigs pests or beneficials? At this point, we would describe them as both – depending on the time of year and the situation. Earwigs can be pests of flush in young trees in the spring when they build up in wraps. They can also be pests of mature trees if they feed on new fruit at petal fall. However, they can also be natural enemies of citrus pests such as California red scale, and we did not find them damaging citrus flush or fruit in the summer.

We will continue our studies to determine thresholds for treatment and management methods to help tip the balance towards European earwig as a beneficial insect.

Dr. Beth Grafton-Cardwell is an Extension Specialist and Research Entomologist, Department of Entomology, University of California Riverside. When the work discussed in this article was conducted, Carla Romeu-Dalmau was a visiting Ph.D. student from the Autonomous University of Barcelona, Spain. Ping Gu and Sara Scott are Staff Research Associates with the UCR Department of Entomology stationed at the Kearney Agricultural Center and the Lindcove Research and Extension Center, respectively.

Update on the HLB situation in Mexico

Jim Cranney

Over the past several months, Mexican quarantine authorities (SENASICA) have released a steady stream of disappointing news about the spread of huanglongbing (HLB) throughout Mexico. In July, HLB was detected in central Mexico in the state of Hidalgo, and in August SENASICA announced detection of positive Asian citrus psyllids (ACP) in Michoacán, one of its major lime producing states, along with additional ACP detections in Veracruz, Mexico's largest citrus producing state.

HLB has been detected in Cabo San Lucas in Baja California Sur, and a positive psyllid was detected in a town near Ciudad Obregon in the state of Sonora. An HLB-positive psyllid has since been detected in the adjacent county north of Cabo San Lucas. On Sept. 18, a positive ACP was detected in General Teran in Nuevo Leon, just 130 miles from the heart of the Texas citrus industry.

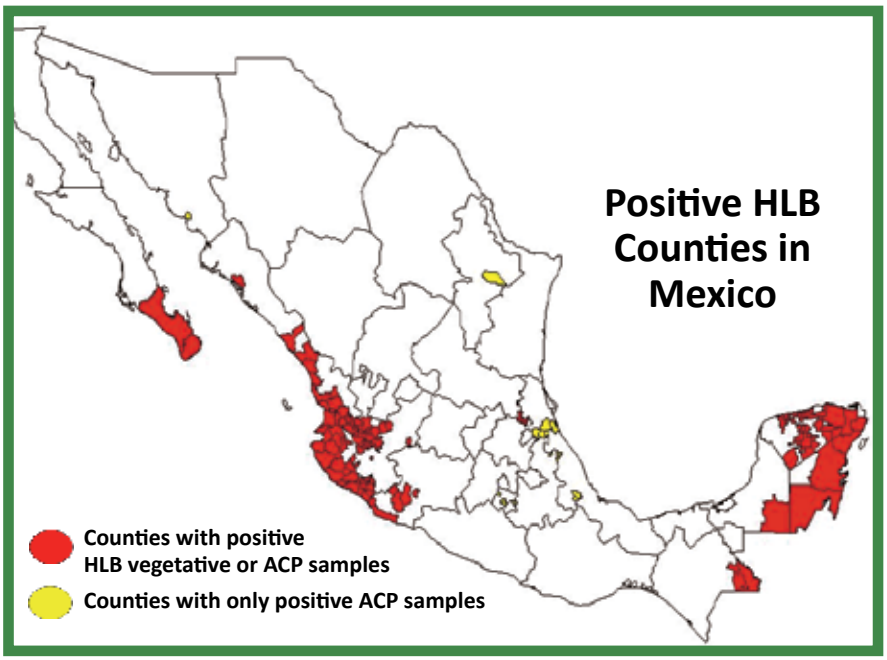
While Texas growers have made efforts to implement an area-wide ACP control program in coordination with Mexican growers, there is insufficient security to implement the border program in Mexico because of drug-related violence in the state of Nuevo Leon. Nevertheless, growers throughout Mexico are organizing on a local level to implement coordinated pesticide applications to try to reduce ACP populations.

Most recently, SENASICA announced on Oct. 21 that HLB had been detected in Tanquian, San Luis Potosí and Tempoal, Veracruz where over 6,000 trees tested positive for the disease. The state of Veracruz is the largest citrus producing state with over 550,000 acres of citrus accounting for 41 percent of Mexico's production. San Luis Potosí is the second leading citrus producing state representing 9 percent of Mexico's production.

Lack of resources hampers Mexican efforts

HLB has now been found in ACP or vegetative samples in 17 of Mexico's 23 citrus producing states. A scarcity of resources has impeded Mexico's ability to deal with the challenges of the disease. Many growers do not commonly use pesticides, so they do not have the equipment or infrastructure to implement a sustained program to combat ACP. Additionally, many citrus growers in Mexico are poor and manage only small acreage, so they cannot afford pesticides, and with so many small growers they are hard to organize. Only large growers have the capacity to use pesticides, but their efforts are hindered by increasing ACP populations in urban areas, small groves, and abandoned properties.

The situation in Mexico is serious. HLB is present, but little can practically be done to reduce ACP populations or reduce HLB infection. In some states where infections are high, such as Colima where 40 percent of the state's acreage is infected, government authorities are urging citrus growers to transition to alternate crops. This scenario is likely to play out in an enormous scale into the future as more acreage succumbs to infection.



Source: Map by Pedro Robles, SENASICA, Mexico

Sonora growers implementing area-wide ACP control

If there is an exception to the dire situation in Mexico, it is in Sonora. The Sonora citrus industry initiated an area-wide ACP control program last year with growers in southern Sonora making pesticide applications in approximately 80 percent of its southern citrus acreage, while the local pest control committee initiated pesticide applications in some urban areas over a year ago. The California Citrus Quality Council (CCQC) has been meeting with the committee periodically in Hermosillo, Sonora, to exchange information and discuss their area-wide plans.

The committee has reported that they are ramping up their capacity to treat in urban areas by purchasing more trucks and backpack sprayers. Commercial applications were made in October and November with the primary target planned for the period just before flush in February. The area-wide program has reduced ACP populations significantly in southern Sonora, but additional resources are needed to provide more coverage in urban sites.

The primary obstacle to a more robust area-wide program is funding. The pest management committee in Sonora asked the federal government

The California Citrus Quality Council (CCQC) has been meeting with the committee periodically in Hermosillo, Sonora, to exchange information and discuss their area-wide plans.

for 19 million pesos ($US1.4 million) but received only $8 million pesos ($US593,000) last year. The committee needs a similar sum this season to implement their plan. While no commitments have been made for funding, the committee expects a similar budget to last year's. That would leave the committee with less than half of the budget needed to implement their operational plan.

APHIS succeeds in reducing ACP populations in northern Sonora

USDA's Animal and Plant Health Inspection Service (APHIS) has been conducting a psyllid suppression program in northern Sonora along the California and Arizona borders for nearly three years with great effect. ACP is routinely detected along the border, but populations have been greatly reduced. Three years ago, it was common to find hundreds of ACP in each trap in Tijuana, but when ACP are detected now APHIS finds only two or three per trap.

APHIS has extended its program farther south to the region around Caborca, Sonora, which is approximately 60 miles south of the Arizona border, where properties are treated when ACP are detected. ACP populations have been low is this area and in Hermosillo, which is located in central Sonora where the vast majority of citrus is produced organically. However, these growers have recently made the difficult decision to forgo their organic status by making pesticide applications to reduce ACP populations.

APHIS is also contributing insecticides, yellow traps, and backpack sprayers to the Sonora pest management committee for urban pesticide treatments and recently transferred five surplus APHIS pickup trucks from Arizona to the committee. However, even with these contributions, the program has serious deficiencies.

Danger for California

Now that HLB has been detected in two municipalities (counties) in Baja California Sur, there is significant danger that HLB could be spread in psyllid populations in Baja California Sur where citrus acreage is present, but sparse. Approximately, 5,000 acres of citrus are cultivated in the region near Ciudad Constitucion in Baja California Sur. This production is marketed directly from groves to local markets in Tijuana and Mexicali. Without a cleaning step after harvest, potentially infected ACP could be transported to Tijuana in leaf debris or field containers.

APHIS is conducting a survey of Baja California Sur to evaluate the situation and outline risk reduction measures. Efforts are underway to extend the area-wide program to Baja California Sur, but the industry is much smaller that Sonora's, so resources are scarce. However, at least one area-wide treatment has been made to control ACP.

Meanwhile, area-wide management in Sonora holds promise in reducing ACP populations and slowing the spread of HLB, but a shortfall in resources threatens the viability of the program.

For now, everything that can be done is being done by APHIS, SENASICA and the Sonora pest management committee. CCQC will continue to engage with the Mexican industry to monitor the situation in Mexico and provide reports as the situation develops.

Jim Cranney is President of the California Citrus Quality Council (CCQC).

The "Trinational" fight against huanglongbing

Jim Cranney

Background

In the fall of 2008, the first Asian citrus psyllid (ACP) was detected in a backyard tree in San Diego County. With the expansion of ACP in Mexico, it was only a matter of time that ACP would cross the border and continue its northward expansion. Wrapped in this reality was the realization that huanglongbing (HLB) could be close behind. But, where was it, and how would we know when it was getting close?

In October 2008, the California Citrus Quality Council (CCQC) led a delegation of California citrus industry leaders to Mexico City to start a dialogue with the Mexican citrus industry to find out more about HLB in Mexico and to establish a working relationship in the fight against HLB and ACP.

A critical accomplishment in the early phase of this meeting and others to follow was the establishment of an ACP suppression program along the California and Arizona border in Mexico conducted by USDA's Animal and Plant Health Protection Service (APHIS). This program significantly reduced ACP populations in Tijuana and other border towns while California's Department of Food and Agriculture (CDFA) ramped up its efforts to control the psyllid in Southern California. This program continues to provide protection to the California and Arizona citrus industries along the Mexican border.

It didn't take long to understand that the Mexican citrus industry was just as concerned as any California grower about the threat of

HLB, so there was ready agreement that our industries should actively search for common interests and work jointly to address common problems.

The Trinational Citrus Industry Partnership

Before long, numerous proposals emerged on ACP and HLB detection, response plans, and control measures. However, since most of these options required the involvement of regulatory authorities, the effort soon evolved into a coordinated international regulatory program among Mexico, Belize and the United States and is now know as the Trinational Citrus Industry Partnership.

In the early stages of the partnership, the participants drafted a memorandum of understanding outlining the intentions of the parties to adhere to scientific principles for stopping or slowing the spread of HLB, with the understanding that each country would manage the disease with its own regulatory response.

Belize became a partner when HLB was detected in its citrus producing region in 2008. Their participation would be essential if Mexico were to check the spread of HLB into southern Mexico. More recently, the Central American Organization of Agricultural Health (OIRSA) has joined the effort to help coordinate the management of HLB in Central America.

The Trinational Partnership meets once or twice a year, usually in conjunction with North American Plant Protection Organization (NAPPO) meetings or other international conferences. The meetings have been an excellent venue for information exchange and relationship building among the partner countries.

The partnership is now managed and organized by APHIS and Mexico's plant health regulatory body, SENASICA. While APHIS' Osama El-Lssy has steadily managed the partnership on behalf of APHIS, his counterpart in Mexico City, Nick Gutierrez, handles coordination with SENASICA and regional pest management committees. Gutierrez' contacts in Mexico and sound advice have contributed greatly to the success of the partnership.

In the first three years of the partnership, most of the activity was focused on information exchange and relationship building. However, now that HLB threatens many of Mexico's most productive citrus producing states, the emphasis has changed to implementation of area-wide programs to control ACP.

Hector Manuel Sanchez Anguiano (left), SENASICA Director of Phytosanitary Protection, and Pedro Robles, National HLB Coordinator for SENASICA.

CCQC is working with Mexican growers in the Mexican state of Sonora to implement an area-wide ACP control program. By reducing ACP populations, Mexican growers hope to slow the spread of HLB into Sonora, which borders Arizona and is only miles from California. These activities are supported by APHIS' contributions of pesticides, backpack sprayers, and pickup trucks for urban pesticide applications.

While the Mexican industry is well aware of what needs to be done to implement the area-wide program, they have been handicapped by a shortage of resources. A positive psyllid was detected in southern Sonora near Guaymas last June. Growers are treating in groves near the detection site, but funds for urban applications have been depleted. Nevertheless, CCQC continues to work with growers in Mexico and our colleagues at APHIS to look for alternative funding sources.

The Trinational Partnership will continue to be a critical venue for collaboration with the Mexican citrus industry on HLB and other areas of common interest and CCQC will continue its participation in the partnership as the process continues and relationships mature.

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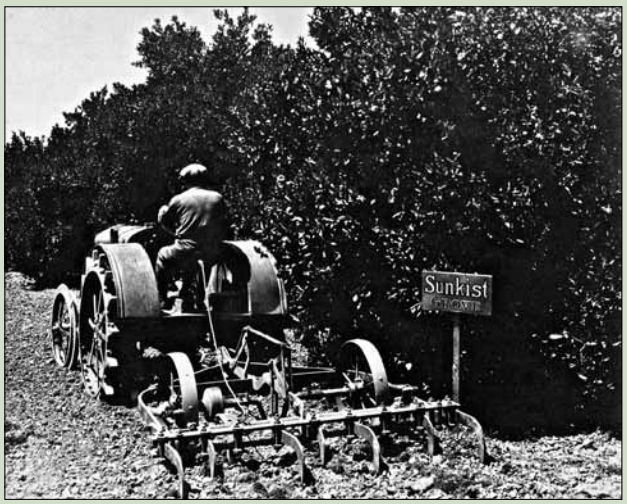

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California citrus spurred colonization

The Quest Continues ...

The Building Boom of 1887 induced the Citrus Gold Rush

Richard H. Barker

The "building cycle" is a wavelike movement which has a range of 16 to 22 years. It is fairly regular and reveals six "building cycles" during a period from 1830 to 1934. The aforementioned is different from the business cycle, for it is driven by production and economic activities. As an example, the business cycles from 1882 to 1909 are shown in the graph below. You will note that they are much shorter in duration. The variance is distorted when a business cycle coincides with the building cycle.

Imagine your own thoughts during a bitter winter storm in January while you were living on the plains in Iowa. Your hypothetical, conjectural mind would flash to what you had read and heard regarding the early stories of Billie (William) Wolfskill or Don Benito (Benjamin) Wilson. Their orange trees produced $100 to $125 per tree from their salubrious climate.

Your thoughts then shift to the banners on the passing trains carrying citrus which read an "Orange for Health ... California for Wealth." Suddenly, the image of the bright "California Cornucopia" of Southern Pacific appears in focus: "... a climate for Health and Wealth with no cyclones or blizzards."

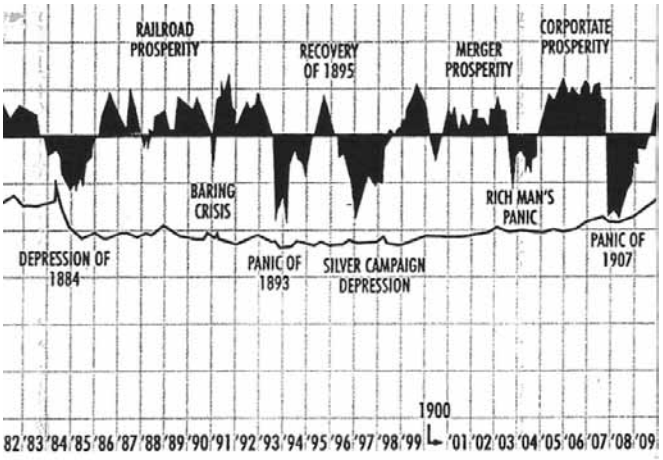
Then, in reverie, before you is the Southern California Citrus Fair, which in 1886 you attended while in Chicago. You were so moved that you saved the supplement which appeared in The Daily Inter Ocean *newspaper. An unforgettable spectacular exhibit of Southern California's subtropical climate with its fertile soil which would grow anything!*

All of these points have been echoing in a continual robust pulse to see firsthand this paradise! But you were not alone, for in the minds of thousands in search of a healthier lifestyle, this drumbeat never receded.

Southern Pacific Railroad had no real competition within California until the late 1880s. What they did have was a period of stagnation after the Gold Rush played itself out. The population had contracted, for it was considered to be a society of miners. This continued for over 30 years until the Boom of 1887.

California was one of the slowest-growing states, and hence the traffic income was very low. The main goal of the many elaborate exhibits was to change the impression of California to one of a fertile subtropical wonderland where almost any seed would grow, and every description was in the superlative.

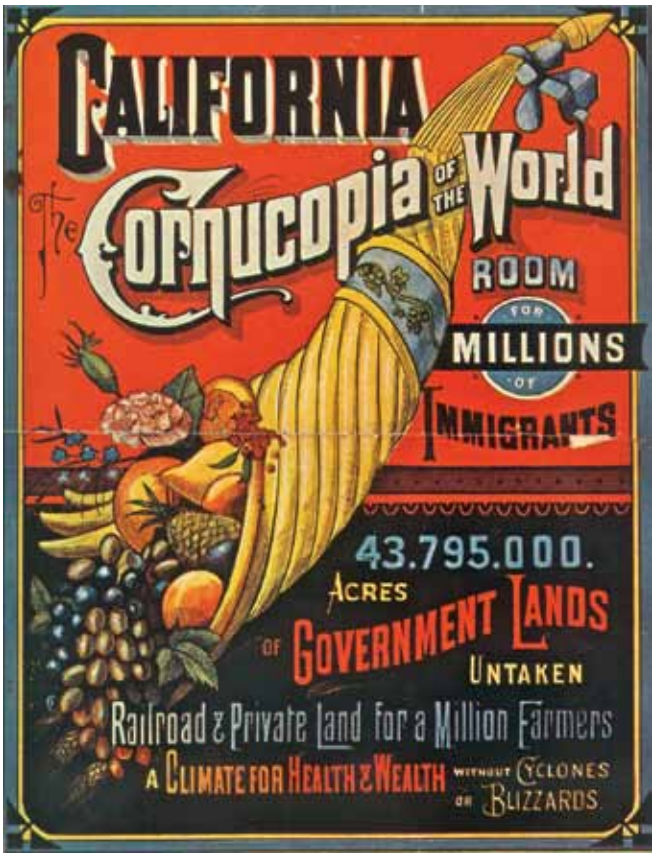
In 1873, in an attempt to thwart the slowness, Southern Pacific Company hired a well- known writer, Charles Nordhoff, to write a promotional book "California for Health, Pleasure and Residence". Later this book provided many opportunities as promotional material, and the paraphrase an "ORANGE FOR HEALTH - CALIFORNIA FOR WEALTH" was also drawn from the text. The drumbeat grew louder and never lost its pulsating beat.



Business cycles 1882 to 1909. (The wavy line is the wholesale price index.) *Courtesy of M. Boyd and R. H. Barker, "Our Legacy: Baldy View Entrepreneurs".*

The Atchison, Topeka and Santa Fe built south-southwest, and their wood-burning locomotives were sent over their bridge spanning the Colorado River. They entered Los Angeles in 1885, and now Los Angeles was served by two transcontinental lines.

Santa Fe was a very aggressive company, for it built, bought and negotiated its way through California, and ran tracks from San Bernardino to San Francisco. They came through the El Cajon Pass and began to do for the southern half of the state what Central Pacific did for the region around San Francisco.



Blockbuster ad by Southern Pacific touting California as having "a climate for health and wealth, without cyclones or blizzards".

In the spring of 1886, Santa Fe withdrew from the Transcontinental Traffic Association, and a major price war commenced. The normal fare from St. Louis to Los Angeles was $125. The "war" caused fares to plunge. By March 1887 the rate had fallen to $12, and for a few days a ticket could have been purchased for $1.00. (The panic of 1893 led to AT&SF declaring bankruptcy, and later they reorganized.)

To set the stage for this high drama, take another look at the graph "Business Cycles 1882-1909 (see left column this page), and note that the economy was in a positive mode. Consumer confidence was high, and employment was the same. People had money.

In 1885, the Santa Fe entered Los Angeles from the south, and a brass band was there to herald the arrival.

William Wolfskill making a fortune from his "citrus gold".

Newspaper supplement promoting the Southern California Citrus Fair in Chicago, 1886.

Most who were physically able wanted to see California, and with the deep discounted fares they could now afford the trip. This pent-up demand to visit, and the echo of the "roll of the drums" motivated hordes of visitors. Excursion trains from Los Angeles brought the multitudes to various areas. To further understand the mania or rage, just look at the number of buggies driven by salespeople. The mania was all over Southern California, though the greatest concentration was within the overall Los Angeles area.

"Social group dynamics" drove the situation to unheard-of feverish prices. A $5,000 sale was quickly followed by an offer of $10,000, and in three months this same property was $50,000.

The excitement became lunacy. The "group dynamics" of the crowd was heightened by the synchronization of the excursion train schedules. The recurrence came as waves and caused a feverish atmosphere which compelled one to make a decision at once in acquiring land. The graph is better than a thousand words regarding the flurry from May to the pinnacle in July!

Now addressing the sales force, most came from the other side of the Rockies, and as J. M. Guinn wrote in an article, "The Great Real Estate Boom of 1887", the salesmen were "very adept in the tricks of real estate boomings." They came to sell, and they had success due to the fervor.

Landowners became developers, viewing this as a fortunate opportunity. Between the eastern limits of the City of Los Angeles and the San Bernardino County line, a distance of 36 miles along the newly laid Santa Fe tracks, they platted in delirious haste 25 new towns -- an average of one town for each mile-and-a-half of track. A high percentage of these new towns ended as "ghost towns" after the bust. The aforementioned was along the Santa Fe right-of-way. Along the Southern Pacific Railroad, further new towns were platted, though to a lesser number for this line was more established.

In "The Boom of the Eighties", Glenn S. Dumke wrote that "during June through September of 1887, a buying frenzy took place ... over $38 million changed hands in real estate transactions in Los Angeles County, and the figure for the year was nearly $100 million."

In 1888, interest rates started to rise on the "red hot" deals of raw land, and to the recent investor young groves suddenly looked to be a "money pit" without a return. The impulse was to sell, and sell at any price was a chain reaction. With this mania, the bust gained speed.

After the "Boom", many lots and parcels previously sold went back to the original owners, and it took time to correct. The collapse was more orderly than one would expect, for the banks had been very conservative in their participation. In the late 1880s and 1890s, owners came to the realization that their property needed to earn a return, and they built structures taking advantage of the glut related to building materials or they planted citrus (as can be documented through the table shown below). The tightening of money also stimulated the holders to develop their land to the best usage.

Schedule of Orange and Lemon Trees and Acreage by County (As of September 17, 1891)

	Bearing Trees		Non Bearing (young)		Total Acres	
	Orange	Lemon	Orange	Lemon	Orange	Lemon
Los Angeles	475,726	47,408	511,376	29,564	9,871	769
Orange	89,260	5,097	51,769	19,959	1,410	250
Riverside *founded in 1893*						
San Bernardino	391,656	24,066	1,895,544	155,934	22,872	1,800
San Diego	26,715	7,006	177,311	58,916	2,048	639

[Please view www.citrusroots.com for additional statistics.]

The Building Boom of 1887 brought people to California in large numbers as another rush, the citrus gold rush. Many of those who travelled via the AT&SF were "lusting to convert the golden fruit nuggets to real gold" as a second career. They also poured into Southern California for a chance, if possible, to get well from various ailments.

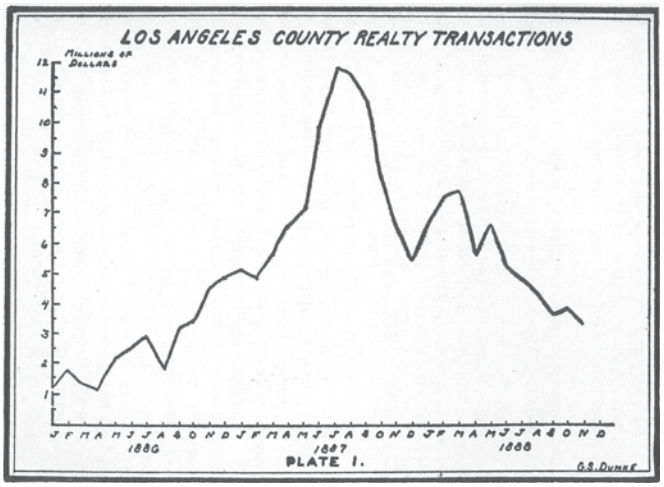
An excursion trip from Los Angeles to Ontario and Upland on the Southern Pacific Railroad Company.

Monrovia 1887. An excursion trip. Note the "ocean view" sign.

An excursion trip to Santa Ana on the Southern Pacific. Each buggy of a salesman is ready to take the next wave of prospects out on a buying tour upon the arrival of the next excursion train.

So, money they had, and this movement had a powerful influence on the development of Southern California and the state. Where once the cattle had silently grazed, now American citizens built communities, churches, schools, and trolley lines, and founded banks, citrus packinghouses, plus citrus-linked businesses including water companies to bring water to their thirsty citrus trees, etc.

In closing, I will borrow the thoughts from Glenn S. Dumke's "The Boom of the Eighties" (excerpts), p.276, "The boom was significant… It wiped out forever the last traces of the Spanish-Mexican pastoral economy which had characterized California history since 1769... The boom was the final step in the process of making California truly American."



From "The Boom of the Eighties in Southern California" by the late Dr. Glenn S. Dumke, best known for his service as chancellor of the California State University system.

"All's Well That Ends Well" (borrowing Shakespeare's title), and it was this "Boom of 1887" which induced the Citrus Gold Rush. This rush generated a far-ranging, extensive planting of citrus as you have observed. The young California citrus industry was emerging! The "story" will continue, spurring colonization…

Richard H. Barker is the founder and president of the Citrus Roots-Preserving Citrus Heritage Foundation. For a number of years, he has been leading a drive to bring about a higher awareness of the role citrus played in developing California. Dick is a retired investment banker and was a third generation Sunkist grower. He has published four volumes on citrus heritage.

The author wishes to credit the following: Huntington Library, San Marino; Gordon McClelland; Pasadena Museum of History; Santa Ana Public Library; Upland Public Library.

Note: The artwork from the Chicago newspaper supplement is a copy of a treasured piece in the Jay T. Last Collection of Lithographic and Social History, which is recognized as the largest private collection of color lithography in the U.S. In assembling his collection, which he is now gifting to the Huntington Library, Last collaborated with Gorden McClelland who made the arrangements for the Foundation to receive the copy.

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	 Early Vegetative	 Growth/ Flush	 Flowering	 Fruit set	 Fruit fill	 Post harvest
YaraMila® 15 - 15 - 15	20% of total N / 10% of total K_2O					30% of total N / 15% of total K_2O
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SQM 0 - 0 - 51		20% of total K_2O		30% of total K_2O		25% of total K_2O

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YARA

Knowledge grows

Relax and unwind at a citrus country bed-and-breakfast

You will be transported to Tara of "Gone-with-the-Wind" fame (but with a touch of the tropics!) when you visit the Plantation Bed and Breakfast in Lemon Cove, just a few miles east of Visalia. Surrounded by citrus trees, this peaceful oasis is nestled against the foothills near our own UC Lindcove Research & Extension Center. While this romantic getaway spot is elegantly appointed, proprietors Scott and Marie Munger strive for a relaxed atmosphere and are most likely to greet you with broad smiles and bare feet!

Photo by Diana Glass.

Marie and Scott lived very different lives – different from each other as well as from this lifestyle -- before they met, married, and pursued Marie's dream of owning a B&B. (Theirs is a wonderful love story, told on their website at www.theplantation.net.) They bring complementary skills to this venture (which they started in 1996), not the least of which are Scott's flair for the business side and Marie's culinary talents.

Freshly squeezed orange juice from locally grown oranges is served every morning along with Chef Marie's lavish gourmet breakfasts. Her recipes have delighted over 40,000 guests from all over the world (109 countries at last count!), and she received so many requests for her original recipes that she published a book,"Plantation Brunch", with 73 of her most-requested including these favorites.

Blueberry Lemon Scones

Ingredients

3 cups Flour
1/3 cup Sugar plus more for tops
2 ½ tsp Baking powder
½ tsp Baking soda
1 tsp Salt
1 tbsp Lemon zest (grated lemon rind, yellow-colored part only)
1 cup Cold butter cut into patties
2/3 cup Lemonade, approximately
3 cups Blueberries
Heavy cream
Preheat oven to 400° F.

Whisk together the first five ingredients. Stir in the zest. Add the butter and work it in with your fingers until it resemble crumbs. Stir in the blueberries. Mix in the lemonade gradually tossing and mixing with a fork. Drop heaping tablespoons full of dough on an ungreased baking sheet. Brush them with cream and sprinkle them with sugar. Bake at 400° until golden brown, about 25 minutes.

Yields 18 scones.

Citrus Croissant French Toast

Ingredients

4 Large croissants
6 Eggs
½ cup Orange juice
1 tbsp Lemon juice
2 tbsp Orange liqueur
1 cup Strawberries – fresh or frozen, thawed
Powdered sugar
Mint leaves
Butter or margarine for frying


Photo by Scott Munger.

Slice the croissants in half lengthwise. Whisk together the eggs, juices and liqueur.

Dip the croissant slices one at a time, soaking them well. Place the slices on a rimmed pan or tray. Pour any excess egg mixture over the top. Refrigerate until ready to use (cover with plastic wrap if you are not using them right away).

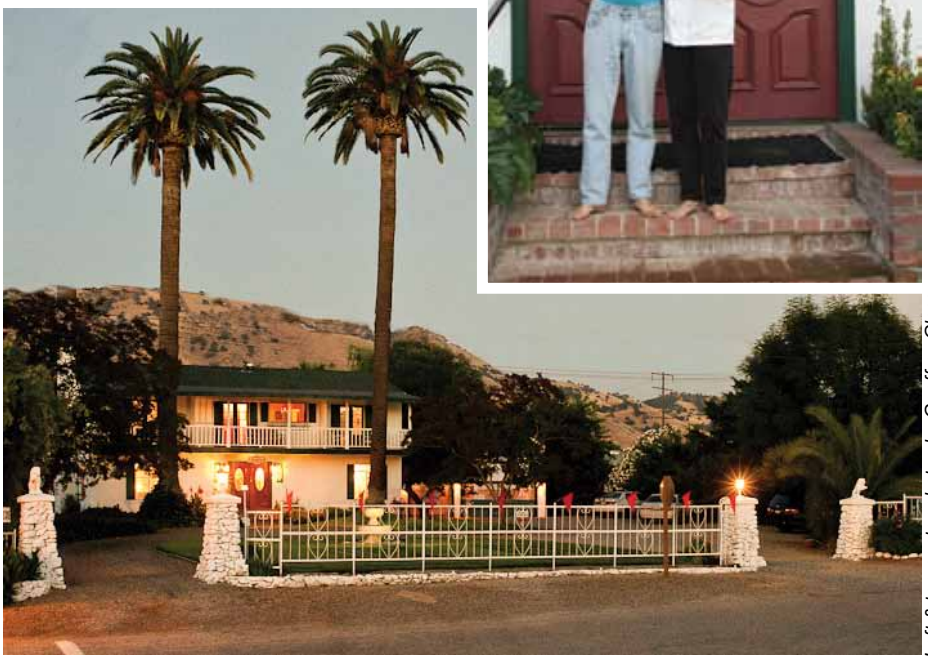
Puree the strawberries in a blender. Fry the croissants on a hot griddle in plenty of butter or margarine. Serve on warm plates with strawberry puree. Garnish with mint and sprinkle with powdered sugar over all.

Makes 8 pieces.

Photo by Louise Fisher.

Photo by Louise Fisher.

Photo by Scott Munger.



Left & top center photos by Geoffrey Glass.

Mandarin Tart

Crust:*

2 ¼ cups Flour

½ cup Sugar

1 tbsp Orange zest (grated rind, orange-colored part only)

1 cup Cold butter sliced into patties

Filling:

1 Egg

1 Egg yolk

1/3 cup Sugar

2 tbsp Orange juice

2 tbsp Lemon juice

2 tbsp Cream

2 – 11 oz cans Mandarin orange segments

Mint for garnish, optional

Preheat oven to 325° F.

Crust: Wisk together the flour, sugar and zest. Add butter and rub it with your fingers. Press the dough on the bottom and sides of an 11" tart pan with a removable rim. Bake at 325° until the crust is lightly brown, about 30-40 minutes.

Photo by Scott Munger.

Filling: Whisk together the egg, yolk and sugar. Whisk in the juices and cream. Place the mandarin orange segments in the crust in a pretty circular pattern. Gently pour the mixture over the segments. Return the tart to the oven and bake until the filling no longer jiggles when gently shaken, 30-40 minutes.

When the tart is cool enough to handle, gently remove the pan rim. If you have another tart pan bottom, it is very helpful in dislodging the tart platter. If you sense that the tart may fall apart while trying to remove it from the pan bottom, you may exercise one of two options: 1) Simply put the tart with the pan bottom attached on the serving plate; or 2) Cut the tart into individual servings and remove them to individual plates or reassemble the slices on the serving platter.

Serve at any temperature. Fresh mint makes a nice garnish.

Serves 10-12.

*A traditional pie crust may also be used. Put aluminum foil around the outside bottom and sides of your removable rim tart pan since the traditional crust is more likely to leak. Allow the foil to extend a half-inch higher that the pan and it will protect your crust edge from over browning.

Huanglongbing and Asian citrus psyllid genomics-based research:

The Tesuque Experience

These presentations have been the basis for continuing assessment of what has been accomplished and have set the stage for formulating and adjusting the path forward.

Ed Civerolo

The **transcriptome** represents that small percentage of an organism's genome that is transcribed into RNA molecules (RNA transcripts). These include messenger RNA (mRNA), ribosomal RNA (rRNA), transfer RNA (tRNA), and non-coding RNA.

Effectors are proteins that are injected by bacterial and fungal plant pathogens into host cells (using a specialized secretion apparatus) to modulate host plant defense responses, enabling colonization of plant tissue. The primary function of effectors is to suppress host immunity or resistance.

Elastase is an enzyme that hydrolyzes certain proteins into smaller polypeptides and amino acids.

Metagenomics is the study of uncultured and non-culturable microorganisms .

Phages (bacteriophages) are viruses that infect bacteria.

Pathogenesis is the mechanism by which pathogens cause disease.

Introduction

During the past several years, there have been various forums to discuss and identify research needs, current knowledge and research gaps, and priorities for developing effective, sustainable and economic strategies to manage citrus huanglongbing (HLB) and the Asian citrus psyllid (ACP).

These meetings have included Citrus Health Research Forums in 2010 and 2011, International Huanglongbing Research Conferences in 2008 and 2011, a joint Citrus Huanglongbing-Potato Zebra Chip Research Conference in 2009, and the annual Citrus Research Board New Technologies Conferences.

These discussions have involved citrus industry representatives from California, Florida and Texas; and researchers from the University of California, University of Florida, Texas A&M Research and Extension Center, University of Arizona; and federal researchers from Los Alamos National Laboratory; USDA-APHIS, USDA-ARS in Frederick, MD, Ft. Pierce, FL, Ithaca, NY, and Parlier, CA.

Unique among these forums have been those that have focused on genomic-based solutions to mitigate the effects of HLB and ACP. These have included two workshops organized and co-sponsored by the California Citrus Research Board, the Los Alamos Center for Biosecurity Science, and the USDA-Agricultural Research Service. These "Tesuque Workshops" were held in Tesuque, New Mexico, in 2010 and 2011.

The main objectives of the Tesuque Workshops were to identify genomics-based short-term and long-term strategies for early, rapid, reliable HLB detection/diagnosis, including developing tools for surveillance and management of HLB by citrus growers.

The main focus of the targeted research identified has been on developing tools with genomics information from: pre-symptomatic, symptomatic and infected but asymptomatic trees; the known species of Liberibacter that are associated with HLB; the psyllid vector that transmits the HLB-associated bacteria to citrus; and the citrus host itself.

At each of the Workshops, scientists presented cutting-edge research progress on genomics-based approaches to managing HLB and the ACP. These presentations have been the basis for continuing assessment of what has been accomplished and have set the stage for formulating and adjusting the path forward. The Workshops have also been instrumental in the formation of collaborative research teams and plans to fill in knowledge gaps.

Highlights of Tesuque 2010

In 2010, the overall purpose of the meeting was to initiate the development of a nationally coordinated research genomics program to develop technology to manage or mitigate HLB and to identify barriers to genomic research and ways to overcome those barriers.

The focus was on reviewing the research progress made related to: the sequencing of HLB-associated Liberibacters ('*Candidatus* Liberibacter asiaticus', '*Ca*. Liberibacter americanus' '*Ca.* Liberibacter africanus'), the ACP, and citrus; new HLB detection technologies; and potential novel technology based on transgenic citrus to mitigate the impact of HLB.

Significant research progress included:

- The genome of a Florida strain of '*Ca*. Liberibacter asiaticus' has been completely sequenced and annotated. Sequencing the genomes of a second strain of '*Ca*. Liberibacter asiaticus' from China, a strain of '*Ca*. Liberibacter americanus' from Brazil, and a strain of '*Ca*. Liberibacter africanus' is underway.
- Partial ACP genome sequences are available.
- It is now known that Liberibacter phages in infected plants and inoculative insect vector are different. This may

have some potential for developing an HLB control strategy.

• Presumptive *in vitro* cultures of three HLB-associated Liberibacter strains are available, but these are not pure enough for genome sequencing. Fulfillment of Koch's postulates has been reported; however, this has not been confirmed.

• Two assemblies of citrus genomes (Clementine mandarin and Ridge Pineapple sweet orange) are ready to be released.

• New HLB detection platforms based on lateral flow microarray, Luminex flow cytometry, volatile organic compounds detector, and Liberibacter-specific antibody fragments are being developed.

• Transgenic citrus expressing synthetic anti-microbial peptides and chimeric anti-microbial proteins to protect citrus against Liberibacter infection and HLB are being developed.

The following research needs were also identified:

• Perform comparative genomics to identify potential targets for functional genomics, that is, need to know what the sequence data means – determine the phenotype.

• Sequence several strains including a strain/isolate that is nonpathogenic, and isolates from Pakistan and India; these need to be maintained as a stable form for reference.

• Determine whether there are bacterial population differences within individual host plants.

• Isolate '*Ca*. Liberibacter asiaticus' in pure culture, complete Koch's postulates, and sequence the genome from a pure culture.

• Sequence the genome of a bacterium that results from the successful completion of Koch's postulates.

• Ensure that genome assemblies are accurate before being made public.

• Develop a rapid, reliable multi-pathogen screen that can be field deployed.

Additional items included:

• Genome Centers with useful resources across the USA were identified.

• A working group was formed composed of six scientists that will coordinate HLB and ACP genomics research progress including research being conducted in Brazil, South Africa, and elsewhere.

• Future needs for HLB-associated Liberibacter genome sequence, assembly, annotation and bioinformatics should be prioritized.

• Genome sequence data should be posted in GeneBank as soon as possible

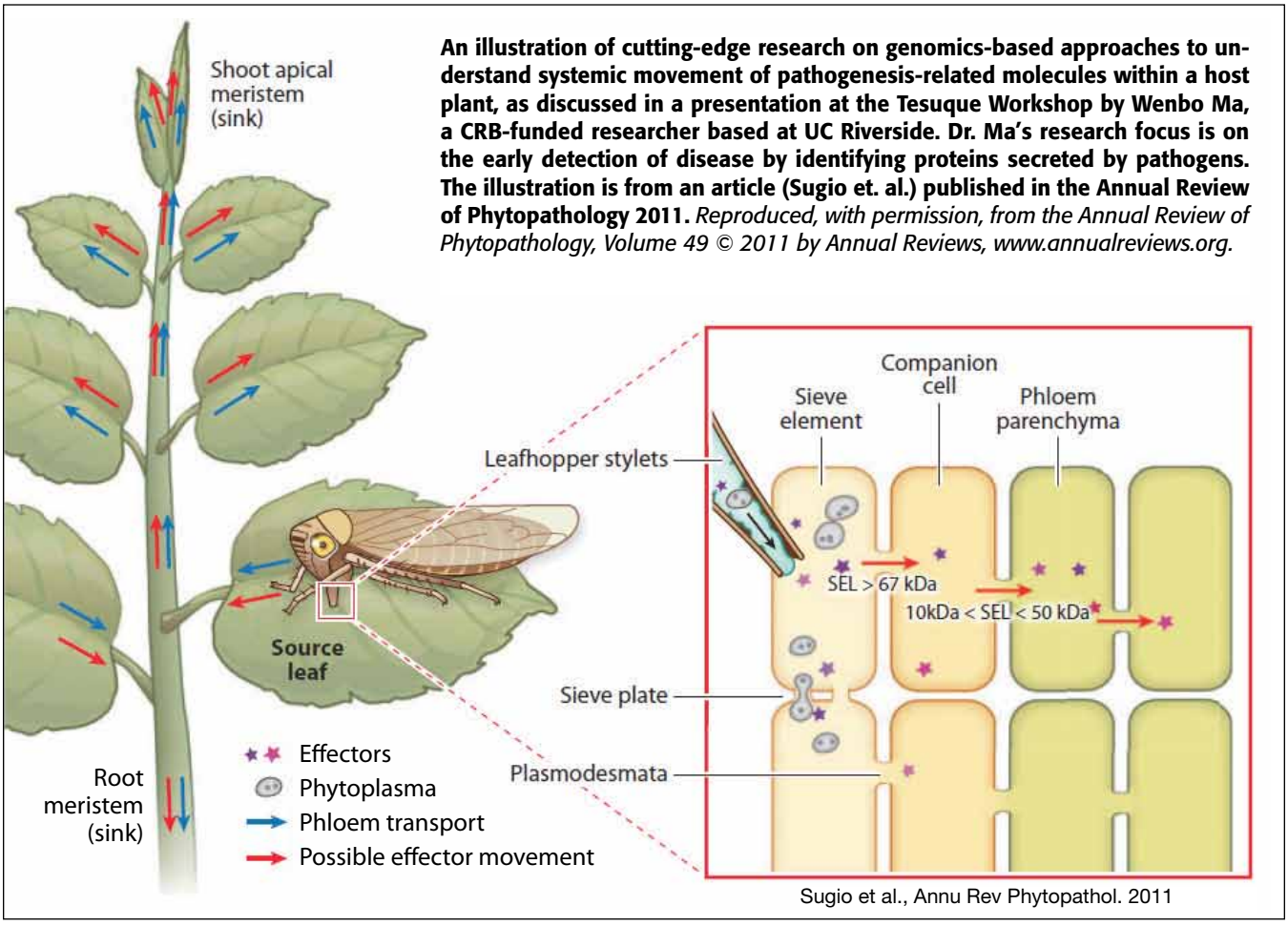
• Partial genome sequences should be made available so that detection platform technology can move forward and be implemented.

• Funding sources need to coordinate and pool their resources in order to fund HLB and ACP genome-related research projects.

• Research project leaders need to provide sponsors with an organized plan that includes evidence and/or reasons for success or the delivery of a useful product or solution.

Highlights of Tesuque 2011

In 2011, the discussion initiated during Tesuque 2010 on research program development to bridge knowledge and technology gaps was continued and extended. Accordingly, the research and technology needs were reviewed to bet-



An illustration of cutting-edge research on genomics-based approaches to understand systemic movement of pathogenesis-related molecules within a host plant, as discussed in a presentation at the Tesuque Workshop by Wenbo Ma, a CRB-funded researcher based at UC Riverside. Dr. Ma's research focus is on the early detection of disease by identifying proteins secreted by pathogens. The illustration is from an article (Sugio et. al.) published in the Annual Review of Phytopathology 2011. *Reproduced, with permission, from the Annual Review of Phytopathology, Volume 49 © 2011 by Annual Reviews, www.annualreviews.org.*

Sugio et al., Annu Rev Phytopathol. 2011

ter understand the biology and management of HLB. The progress made since the Tesuque 2010 meeting was assessed, and significant strides were noted.

Research progress since the Tesuque 2010 meeting included:

• Sequences of multiple Liberibacter genomes ('*Ca.* Liberibacter asiaticus Florida strain, '*Ca.* Liberibacter solanacearum') are now available. The sequence of a Chinese strain of '*Ca.* Liberibacter asiaticus' is nearly complete.

• Based on Multi-Locus Sequence Typing, 300 '*Ca.* Liberibacter asiaticus' isolates from Brazil, China, India, Philippines, Thailand and the United States (Florida) were separated into three groups. Isolates from India were the most genetically distant. Isolates from two counties in Florida were also distinct, suggesting multiple introductions of '*Ca.* Liberibacter asiaticus'. Finally, no Indian genotype was found among the Florida isolates analyzed.

• Three or four newly identified bacteria in the ACP may be associated with plant disease(s).

• Various citrus genotypes are been screened for HLB resistance in different locations. However, HLB-resistance/tolerance is affected by several factors, including (but not necessarily limited to) citrus species/cultivar, rootstock-scion combination, environmental conditions, nutritional status, other cultural practices.

• ACP genome sequencing will be completed within 11 months. However, researchers are already accessing and using the data hosted by the National Center for Biotechnology Information (NCBI), including metagenomic data to identify genes that may be active in some way to interrupt Liberibacter transmission.

• Genome-based discovery of genes related to HLB tolerance or resistance is underway. A wide range of biological processes are differentially modulated in HLB-affected trees.

• Unique VOCs have been detected from the peel of fruit with symptoms.

• Transgenic citrus expressing spinach defensin are being evaluated in the field in Florida.

Research needs that were identified included:

• Increased bioinformatics work is needed to take research progress to the next level.

• A DNA purification platform is needed to obtain high quality Liberibacter DNA for rapidly sequencing the genomes of many isolates from various locations.

• Finish the sequencing of the genome of HLB-associated Liberibacters from India (the presumed geographic origin of HLB).

• Gather additional HLB-associated Liberibacter information from other countries, such as (but not necessarily limited to) Mexico and Pakistan.

• Design a chip to detect all HLB-associated Liberibacter isolates.

• Maintain HLB-associated Liberibacter and ACP genomics databases.

• Analyze the entire HLB pathosystem (i.e., citrus host-Liberibacter pathogen-ACP vector) using functional genomics.

• Conclusively determine the cause(s) of HLB.

• Verification of differentially-expressed genes in HLB-affected trees.

• Identification and validation of early specific biomarkers of HLB.

• Based on the published genome, '*Ca.* Liberibacter asiaticus' has 17-39 predicted secreted proteins that may be involved in Liberibacter pathogenesis. These may be useful for Liberibacter detection or HLB diagnosis, characterization of proteins with citrus host targets, and HLB-specific biomarkers. The interactions of secreted proteins with citrus host targets should be characterized.

Additional action items noted included:

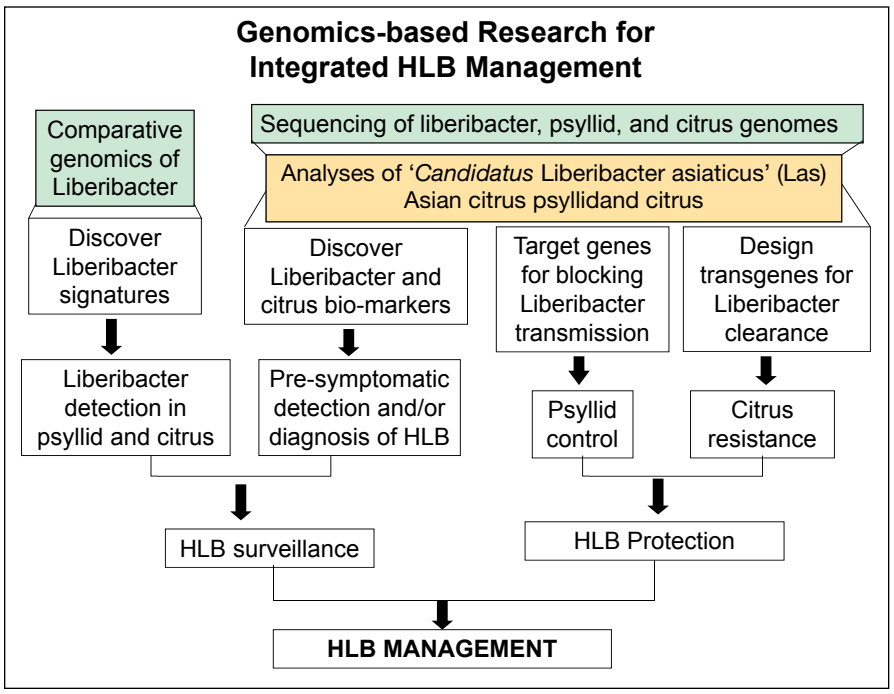
• Analyze the transcriptome(s) of HLB-associated Liberibacters.

• Finish the metagenomic analyses of the ACP.

• Isolate in pure culture, and sequence the genomes of, additional bacterial strains in the ACP.

• Amelioration of HLB symptoms, including development and use of natural or transgenic tolerant or resistant lines, nutritional treatments, and technology to block Liberibacter transmission by the ACP bacteriophages.

• It may be difficult and time-consuming to get transgenic citrus with resistance to HLB through the regulatory approval process, as well as gaining grower and public acceptance.



Accomplishments

Overall, three high-priority, genomics-based research areas to address the surveillance and management of HLB have been identified at the Tesuque Workshops. These are (1) sequencing the genomes of multiple HLB-associated '*Candidatus* Liberibacter species' and completing the ACP genome, (2) disease detection and diagnosis, and (3) therapy.

Some research in these areas is underway. However, several additional targeted, genomics-based research projects have developed within each of these three high-priority research areas for consideration for funding. These targeted HLB and ACP research projects were developed with input from

the researchers from the University of California, University of Florida, Los Alamos National Laboratory, and USDA-ARS (Ft. Pierce, FL; Frederick, MD; CA; and Parlier, CA), and built around research teams.

These research areas include:

Complete sequencing of the genomes of multiple, existing HLB-associated Liberibacters: This research will focus on completing the sequencing and annotation of '*Ca.* Liberibacter asiaticus', '*Ca.* L. americanus' and '*Ca.* L. africanus'. This effort is also related to finishing the sequencing of ACP, bioinformatic analyses to identify signatures that are unique and common to these Liberibacters, and computational and functional genomics analyses to identify intra- and extracellular effectors involved in infection and host responses to Liberibacter infection.

The most problematic area/task/goal has been the sequencing of Liberibacter genomes, as this bacterium has not yet been cultured in the laboratory. So far, most of the attempts have focused on isolating Liberibacter DNA from the ACP and sequencing specifically amplified Liberibacter DNA. This approach has been successful in obtaining complete sequences of a '*Ca.* L. asiaticus' strain.

Why is it necessary to sequence the genomes of multiple Liberibacter species? It is necessary to complete sequencing of multiple Liberibacter species to identify specific genetic signatures for their detection. The main deliverables of this research are the identification of unique Liberibacter gene (protein) signatures for Liberibacter detection, and selection of putative targets (surface or intracellular proteins) for developing HLB therapy strategies. This research is being conducted by scientists at Los Alamos National Laboratory, Los Alamos, NM; USDA-ARS, Ft. Pierce, FL and Parlier, CA; and the University of Florida, Gainesville, FL.

Completing the sequencing of the ACP genome: Completing the sequencing of the ACP genome will lead to a fully annotated genome in the public domain and identification of genes in this insect vector for blocking Liberibacter acquisition and/or transmission. The research team includes scientists at Los Alamos National Laboratory, Los Alamos, NM and USDA-ARS, Ft. Pierce, FL.

Liberibacter detection and HLB diagnosis: Early HLB detection and diagnosis can be enhanced by identification of specific host biomarkers in asymptomatic and symptomatic citrus trees. Various genome-based technologies are available for discovery and validation of host biomarkers for HLB. Several projects are focused on detecting and validating specific genetic (nucleic acid and protein) signatures or biomarkers of HLB-associated Liberibacters.

This research involves correlating HLB-associated Liberibacter genotype and citrus host response patterns, and citrus transcriptome (mRNA and small RNA) and proteome analyses to monitor host responses to Liberibacter infection in HLB-susceptible and -tolerant hosts.

In addition, progress is being made in high throughput screening of citrus host proteins that interact with putative Liberibacter effectors and the effects of host protein-Liberibacter effector interactions on host response and HLB

development. These host factors are expected to be key determinants for the onset and development of HLB.

The research team includes scientists at Los Alamos National Laboratory, Los Alamos, NM; University of California, Davis and Riverside, CA; University of Florida, Citrus Research and Education Center (CREC), Lake Alfred, FL; USDA-ARS, Ft. Pierce, FL and Parlier, CA.

Conventional and real-time polymerase chain reaction (PCR)-based platforms for detecting nucleic acids are somewhat limited due to cost, not very user-friendly, and may not be amenable to detecting multiple citrus pathogens in a single diagnostic assay.

Accordingly, research is underway to develop rapid, reliable (i.e., specific, sensitive) platforms for detection of HLB-associated Liberibacter and pre-symptomatic diagnosis of HLB. This research includes developing simple assays for detecting HLB-specific gene (protein) markers and designing lateral flow-, Luminex- or impedance-based platforms for Liberibacter detection.

This research is being conducted by scientists at Mesa Tech, Santa Fe, NM; Los Alamos National Laboratory, Los Alamos, NM; and University of California, Davis, CA).

Mesa Tech is designing a novel lateral flow microarray platform for low-cost, rapid, and sensitive detection of Liberibacter DNA/RNA signatures. This

platform can be used in both laboratory and field settings.

Los Alamos National Laboratory offers a Luminex-based technology for the detection of Liberibacter DNA/RNA signatures. This technology can be transferred to research laboratories and regulatory agencies.

Research to design electrochemical sensors for the detection of proteins on the surface of intact Liberibacter using single-chain antibodies generated in vitro has also been proposed. This approach is a significant improvement over conventional enzyme-linked-immunosorbent assay (ELISA) using poly- or monoclonal antibodies developed in animals.

Research is also focused on detection of HLB-specific volatile organic compounds (VOCs) by differential mass spectrometry (University of California, Davis, CA).

HLB therapeutics: Transgenic rootstocks expressing anti-Liberibacter therapeutic proteins that are translocated specifically into the phloem of commercial scion cultivars are an attractive method for long-term, sustainable HLB protection.

In this regard, two classes of therapeutic proteins are promising. These are antimicrobial peptides (AMPs) and a chimeric protein consisting of an AMP and elastase. The elastase is chosen to specifically target one or more Liberibacter membrane proteins. Thus, research is focused on: designing synthetic peptides and recombinant proteins to inhibit or kill HLB-associated Liberibacters in a variety of ways (e.g., disrupting membranes and/or interfering with metabolism); testing the anti-Liberibacter efficacy of these synthetic peptides and recombinant proteins *in vitro* using Liberibacter surrogates; and constructing transgenic citrus rootstocks expressing anti-Liberibacter peptide or protein in the phloem and testing the HLB protection efficacy of these *in planta*.

This research is being conducted by scientists at Los Alamos National Laboratory, Los Alamos, NM; Texas A&M Research and Extension Center, Weslaco, TX; USDA-ARS, Ft. Pierce, FL; and University of California, Davis, CA.

Summary

In summary, completion of the HLB-associated Liberibacter genome sequences, ACP and citrus genomes will allow researchers to analyze Liberibacter-ACP-citrus host interactions.

This will result in the discovery and identification of specific Liberibacter and citrus biomarkers for enhancing pre-symptomatic detection and/or diagnosis of HLB, identification of genes to target for blocking Liberibacter transmission by the ACP and control of this Liberibacter vector, and lead to the design of transgenes for enhancing citrus host resistance to Liberibacter infection and/or HLB development.

The comparative genomics of HLB-associated Liberibacters will lead to the discovery of specific signatures of these bacteria that will enhance our ability to detect them in citrus and the ACP, thereby enhancing HLB surveillance capability.

This genomics-based research should lead to development of effective, sustainable integrated HLB management strategies.

Success in achieving the objectives of this research will require effective coordination of the research and transfer of the technologies that are developed. An important step to success will be the building of the appropriate collaborations and the design of focused research in suitable timeframes. This line of research is costly; therefore, the challenge now is to secure sufficient funding to implement new, and continue and extend ongoing, research.

Successful completion of the research objectives will advance and enhance the capabilities of the citrus industry, with state and federal regulatory agencies, for HLB surveillance and management. Through interaction and communication, various small teams working in different subject areas, but focused on a common goal, will come together to build a multidisciplinary team, which is absolutely needed to address various aspects of HLB surveillance and management. Ultimately, this is an opportunity to build a community of researchers, industry stakeholders, and regulators to solve a critical U.S. citrus industry problem.

Dr. Edwin L. Civerolo is a retired plant pathologist who, at the time of his retirement at the end of December, was the Center Director of the USDA-ARS San Joaquin Valley Agricultural Sciences Center in Parlier, CA. As a researcher, his work has focused on pathogen characterization, pathogen detection and identification of disease epidemiology, and disease management. He was a co-organizer of the citrus huanglongbing strategic research planning workshops in Tesuque, NM.

Gless Ranch family farming

Anne Warring

When you're writing about John J. Gless, it's easy to let some clichés slip in, because as descriptors go, they're spot-on accurate. You'll want to use expressions like "self-made man" and "do what you love and success will follow".

John J., who is very well known in citrus circles, identifies himself as a third generation citrus producer, which he absolutely is, but before you make any assumptions, there is more you need to know. (And, yes, we are using his middle initial for a very good reason, which you will soon understand.)

His heritage in citrus dates all the way back to 1907. His grandfather, Juan Pedro Gless, who went by the name John, was a Basque immigrant sheepherder on the rangelands near El Toro in Orange County, and Juan Pedro's land had five acres of oranges.

The next generation, John J.'s father John Pierre Gless, farmed 40 acres of Valencias and lemons in El Toro, but in 1960, with the wells running dry, he sold his land to developers. As fate would have it, unlike many of his fellow growers in Orange County who moved on to other areas and planted citrus again, John Pierre was unable to resume farming due to a serious setback with his health.

John J. had been farming alongside his dad through high school and college, but when the ranch was sold and his father was taken ill quite suddenly, he found himself without a job and in need of a future. And so, at the age of 22, with a wife of two years and a young son to support, he struck out on his own.

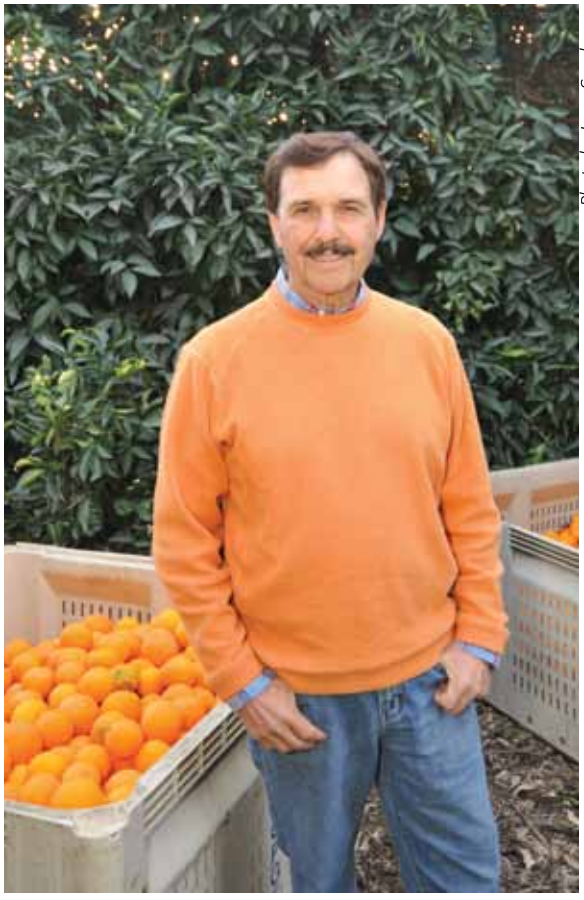


Photo by Lynn Sanderson

"I love to come to work every day."
– John J. Gless

'There was absolutely nothing there'

As Janet remembers vividly, "My husband brought me to Riverside in the Woodcrest area to look at a possible orange grove location. He knew that Metropolitan Water was bringing water to the area, and they were offering it a very reasonable price to people who were willing to pay to have the lines put in.

"My first reaction when I saw the site was 'but, this is desert!' He assured me that once water was brought in, it could be turned into an orange grove, and this could be the New Frontier for citrus in Southern California." At that time, Janet recalls, "there was absolutely nothing there."

The property was mostly decomposed granite, and other farmers weren't the least bit interested, but John knew exactly where to go for a second opinion. His experience in farming with his dad had shown him that Cooperative Extension farm advisors and University scientists were not only knowledgeable about citrus but willing to help with suggestions. They told him exactly what he needed to do to rip that "dg" so his orchard would thrive.

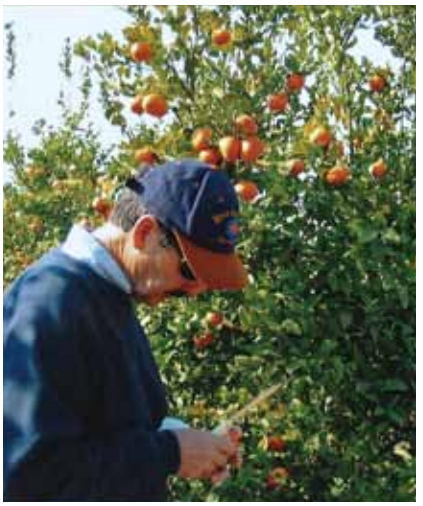
Suffice to say, there were skeptics. In fact, one of his friends bet him $100 -- a lot of money in 1961 -- that trees in that ground would never grow. (You have to wonder what that friend would think now, these 50 years later, seeing what John J. and his family have been able to accomplish!)

And so, Janet continues, "having convinced me that this was, indeed, a viable area for growing citrus, we obtained a loan and purchased 20 acres at Iris and Gamble. Thus, the first orange grove in Woodcrest was planted by hand, by John Gless. "

'We were young and had a goal'

"We worked and worried and waited. We worried about a freeze for which we had no protection. He wrapped the young trees with bamboo shoots to keep them warm. He worked seven days a week. To help pay the bills, I took in ironing and sewing. We were still living in Orange, so he commuted, and if we wanted to see him we went to work with him and helped. I also did babysitting. Money was scarce, but we were young and had a goal."

Janet's father, Charles McCandless, was a tile setter and developer who had never farmed "but had great faith in what we were doing at Woodcrest and was John's biggest cheerleader." Soon he and Janet's brother went in on some nearby property and hired John to plant



Upper left: Taken in 1985, this "three generations" portrait shows John S. holding son John C., then Jason in the blue shirt, Jeff in gold, and John J. on the right. For obvious reasons, this picture is one of Janet's all-time favorite photos. Lower left: John J. cutting fruit at his Murcott Ranch. Upper right: Jeff refreshes a display at the front of their fruit stand in Riverside. Lower right: John S. in a block of navels on their Sunshine Citrus Ranch in the Arvin/Edison area, Kern County.

it and farm it for them. It wasn't long before other landowners did the same, and John was in the custom farming business.

In 1976, John and Janet, who by then had four children, moved to Riverside, and the next year they decided to set up a roadside stand at the edge of their orchard on busy Van Buren Boulevard.

They started with just their oranges, a table and some hand-painted posters, and while John was farming, Janet and the kids kept the fruit stand going. "We learned about marketing and promotion by trial and error," she says. They were open seven days a week, and sales were brisk. A small trailer was brought in to replace the table, and by 1980 they were moving enough fruit to need a permanent building.

Expanding beyond Riverside

They knew it was important to always offer a full range of citrus to their customers, which John says was a major consideration in the family's decision to expand their farming operations beyond Riverside.

Fast forward to 2012, and the business known as Gless Ranch produces citrus on several thousand acres and in several parts of the state. They still have orchards in the Riverside area, including that original Woodcrest property "ranch #1", and also in Hemet. They grow citrus in the Coachella Valley, on both sides of the Salton Sea. And, they farm in Kern County, in the Edison/Arvin area and also along the Maricopa Highway.

They first went to the desert in 1980, in part to have grapefruit for sale in the fruit stand year-round, and in the late 1980s they started farming in Kern County to produce early navels.

Today, they seemingly grow it all —numerous varieties of navels (early, midseason, and late), Valencias, lemons, grapefruit, and mandarins, plus avocados in Riverside and dates in the desert.

In addition, they continue to run the orchard development and orchard

If you're a citrus grower eager to soak up knowledge, it doesn't hurt if you live just a few miles from the UC Riverside campus.

care operation that throughout the years has been a steady part of their business. And, they continue to sell directly to the public at what is a hugely successful fruit stand which, given its appearance and the amount of fruit that moves through there every day, is really more "store" than "stand."

As if that weren't enough, for 20 years they had a Christmas tree farm and pumpkin patch across the street from the store, and for 30 years, they sold their citrus at certified farmers markets —not just in Southern California but in other parts of the state as well. Over time, they cut back on the number of markets they traveled to but continued making the haul to Santa Monica until just this past year, when the price of gasoline and the time taken up with freeway traffic meant it wasn't economically feasible any longer.

To be clear, the fruit they've sold directly to consumers has always been a relatively small percentage of their overall production, John says, "but those outlets have helped stabilize things at times when prices through the regular channels weren't all that great." They ship through a number of commercial packinghouses and work with several different marketers.

Family farming in the fullest sense

In an industry where, despite the surge in corporate production, family farming still predominates, Gless Ranch stands out as a remarkable example for a number of reasons. For one, John J.'s grandson John C. is, as you've figured out from reading this, a fifth generation grower. *Fifth generation*. Then, there's the fact that each and every member of John J.'s immediate family has, at one time or another, been involved in the business to some extent, and today two of them are fully involved.

All four of John and Janet's children are on the Gless Ranch board of directors, and two of their sons are in full-time management. John S. runs the farming operations in Kern County, and son Jeff runs the company's direct selling operation which now includes not only the main store but also a satellite fruit stand at the entrance to the California Citrus State Historic Park. Jeff also managed the farmers market program when it was active.

Son Jason and daughter Betsy are less involved in the day-to-day functioning, but Betsy handles much of the PR and promotion for the fruit stand including their gift basket operation, and Jason, an attorney based in Riverside, provides legal counsel.

All four, mom Janet reports, had their hands in from the time they were youngsters, with the boys helping their dad in the orchard and, after the move to Riverside, with Betsy making fresh-squeezed orange juice to sell at the stand. Mother

John C. ("Little") Gless at the equipment yard near their headquarters office in Riverside.

Amanda Gless Etter staffs the counter.


Janet Gless at the fruit stand. *Photo by Betsy Gless Demshki.*

and daughter would get up at 4 a.m. to make the juice. When they still lived in Orange and John was commuting to the ranch in Woodcrest, his sons would go with him on weekends and nearly every day during summer vacation.

When we interviewed her, Janet was reluctant to talk about her own contributions, but Betsy says her mother has been "hugely instrumental in absolutely everything to do with Gless Ranch."

Betsy tells the story of how, one day, a fruit stand suddenly went up on a neighboring property, in a location where people driving in from Los Angeles would happen upon that competitor's fruit stand before they would theirs. By that time, Gless Ranch was enjoying good name recognition, and Janet wasn't about to lose customers without putting up a fight, so she immediately dropped what she'd been doing that morning and the family went to work crafting the "Gless Ranch " logo.

More proof that this is a remarkable family comes from the fact that today there are several members of the fifth generation working in the business full-time. As mentioned earlier, John S.'s son John C., who goes by his nickname 'Little", runs the Gless Ranch farming operations in the Coachella Valley and in Riverside and Hemet. And, Jeff's daughter Amanda works as his right-hand assistant in the fruit stand.

It's obvious that tradition and heritage mean a great deal to this family, because they have carried the name John to each successive generation. John C. (Little) has a baby boy, and yes, his name is John. Do you suppose that young man, John M. Gless, will one day be a citrus grower?

By the way, there is yet another John in this family because Betsy's husband is John Demshki, the manager of Corona-College Heights Orange and Lemon Association.

Hard work, dedication, and staying current

So, how did they get to where they are today? We asked John J. for his opinions on the keys to success in growing citrus, and he said "hard work and dedication, staying current and keeping up with all the research, and being willing to change your varieties to adjust to what the public is asking for… You need to anticipate where the market is going."

We would add to that list "lifelong learning and embracing innovation and new technologies." Janet says John "stepped right in to the technical aspects from the very start, and he's very open to considering and implementing new approaches."

For instance, he was the first producer in the area to use biological control and also one of the early users of low volume irrigation and chemigation. The one constant through all his years of farming, he says, has been the University. Needless to say, if you're a citrus grower who is eager to soak up knowledge and consult the experts, it doesn't hurt if you live just a few miles from the UC Riverside campus.

One of the ways he made sure he was keeping up with technology was by serving on the Citrus Research Board. He was a District 2 member from 1984-85 through 1989-90 and then an alternate member from District 3 from 1990-91 through 1997-98.

It would seem from reading his bio that networking would be another of John J.'s keys to success. He has always been and still is incredibly active in industry organizations, which means he has opportunities nearly every day to exchange information with colleagues and gain insights. And of course, it also gives him a voice when decisions are made on issues that will impact his business. That being said, his wife points out that his main motivation for all this

Betsy Gless Demshki with custom gift baskets ordered by UC Riverside.

The family's fruit stand on Riverside's Van Buren Boulevard, a major thoroughfare. Open seven days a week, it's a local landmark and a "must do" destination for loyal customers. They sell fresh citrus picked daily and fresh-squeezed orange juice plus Gless Ranch avocados and dates. They also offer dried fruits and nuts, and jams and jellies.

activity has been to give something back to the industry

He is a member of the Citrus Pest and Disease Prevention Committee (CPDPC) and the Chancellor's Agricultural Advisory Council at UC Riverside, and he serves on numerous boards including Blue Banner Fruit Exchange, Corona-College Heights Orange & Lemon Association, Riverside-Corona Resource Conservation District, and Gage Canal Company. His past board service includes Riverside County Farm Bureau, Western Growers Association, and the California Regional Water Quality Control Board (Santa Ana Region.) He has also served as an Alternate on the Sunkist Growers board.

As far as the business goes, he could be retired and taking it easy these days, but that's obviously not in his nature. He continues to serve as the President of Gless Ranch, is "hands on" in all areas, and keeps a very busy schedule.

We would have to say that job satisfaction and pure enjoyment might be the most important key of all in considering

what John J. has done with his life.

"I love to come to work every day," he says. "I love to plant and watch the trees come into production. It's just so satisfying… I really love it."

When we interviewed the rest of the family, to a person they all seemed to share his passion and dedication. Naturally, we asked them how they view the future for citrus in California, given today's problems and challenges and, of course, the specter of HLB.

John J. answered by saying that he had just signed the papers renewing their lease on the acreage at the California Citrus State Historic Park. And that lease is for another 20 years.

Anne Warring is a third generation member of the California citrus industry who currently runs a communications consulting business. She is based in Visalia.

LETTER

Nov. 15, 2011

Dear Ted,

I read with considerable interest the Sept/Oct 1911 issue of *Citrograph*. The NAVEK program was well-written with particular emphasis on Septoria-free citrus to South Korea.

Of special interest to me was the write-up and pictures of the frost damage in the winter of 1990. At that time, I was in contact throughout the growing season with the late Bob Bream. He had told me that he had lost 90% of his navel orange crop that December!

I wish to express my appreciation to your staff for continuing to produce a well-documented and factual update on our great citrus industry.

Dan Rosenberg
Agricultural Consultant
Sacramento, CA

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Jerome E. Dimitman, Ph.D.
September 24, 1920 – December 14, 2011
Remembering Jerry...

Dr. Jerome E. Dimitman, who advised the Citrus Research Board for 13 years as the Research Consultant and then became a member of the Board, passed away Dec. 14 after suffering a stroke. He was 91.

A memorial service for Jerry was held Dec. 20, and it was truly a celebration of his life, with an array of family photos and mementos on display and with upbeat mariachi music blending with the somber tones of bagpipes.

He was accorded military honors for his service as a Commander in the U.S. Navy which included duty in the Pacific during World War II and the Korean War and additional service in the Navy Reserve.

Interspersed among the flowers were samples of the Asian specialty fruits he loved so much and had cultivated with such care on a small ranch tucked away in the hills of Covina. As a friend recalled after the service, "Jerry's eyes were always sparkling but never more so than when he was talking about his lychees, longans, and wampees." He had a second property in Fallbrook, and in addition to the exotic fruit he produced, he also grew pummelos, mandarins, mangoes, and avocados.

Jerry was best known in the citrus industry for his work with the Citrus Research Board, but that was really just a second chapter in his professional life. His principal body of work was as a professor at Cal Poly Pomona, where he taught for 35 years in the Biological Sciences department. He served 12 years as the department Chair and established the school's master's degree program in that field of study. He officially retired in 1983 but continued to teach part-time for another seven years.

As a scientist who was known internationally, Dimitman's primary focus was plant pathology, and he specialized in diseases of citrus and avocado. His Ph.D. was in plant pathology and biochemistry (UC Riverside, 1958), his MS degree was in plant pathology and entomology (UC Berkeley, 1949), and his BS degree was in botany (UC Berkeley, 1943).

He was the CRB Research Consultant from 1987 to 2000 and then was appointed to a seat on the Board. He served from 2000 to 2009, including a three-year term as the Alternate Public Member and two terms as the Public Member.

In 2010, the Board formally recognized his contributions by naming the industry's diagnostic facility in Riverside the "Jerry Dimitman Laboratory", and that same year he received a Lifetime Achievement Award at the National Citrus Institute in San Bernardino. (See *Citrograph*, September/October 2010.)

A tribute by nationally acclaimed journalist David Karp appeared in the *Los Angeles Times* obituary section on Jan. 3, and can be easily found online by searching for "Jerry Dimitman".

Citrograph asked several of Jerry's friends and colleagues to share their thoughts:

■ We received this note from Limoneira's Dan Galbraith, a past chairman of CRB who now represents District 1 as an alternate: "In the fall of 1972, I stepped onto the campus of Cal Poly Pomona for the first time. My goal was to receive a quality education that would help to position me on whatever career path I would follow and, if I was lucky, to make a few friendships that would continue on into the future. As I sat in Dr. Dimitman's plant pathology class, little did I know that a connection between us had been made that would continue for the next 37 or so years. Jerry was a wonderful teacher and possessed a real knack for converting complex concepts into understandable applications.

Well, I did manage to graduate, and our paths did not cross again for about a decade or more. I was a member of the Citrus Research Board at the time, and Jerry was hired as a Research Consultant to help the Board with the increasingly complex basic research that was becoming standard in the university. His teaching style was most helpful in separating the wheat from the chaff on many projects and enabled the Board to move projects forward with more clarity and confidence. His contributions to the citrus industry were numerous and continue on to this day with many of his former students actively engaged at all levels of endeavor."

■ CRB President Ted Batkin comments: "During the years that Jerry served as a science consultant to the Board, he was responsible for evaluating the research projects funded by the Board for scientific merit and contribution to the industry. This was a critical period for the research program in that the Board was faced with providing critical information on *Citrus tristeza virus* to the industry for guidance and direction with

the various programs. Jerry's background in plant pathology was extremely valuable in sorting out the issues surrounding CTV and other disease problems as well. His input helped the Board with decisions about technical issues and funding. Jerry also provided valuable insight and background information in the areas of plant improvement, new variety development, and entomology. His vast experience and knowledge base helped guide me and the Board though a wide variety of problems. I miss his helpful and cheerful presence in our program."

■ Dr. Peggy Mauk, a Cooperative Extension Specialist and Director of Ag Operations at UC Riverside, says,"Jerry Dimitman was a dear friend, mentor and professional. I will miss him! He was one of the first to welcome me into the citrus family and worked with me on numerous projects. Jerry was passionate about citrus, research, and solving everyday problems. I got to know Jerry when he came to me, on behalf of the citrus industry, and asked me to work on a grapefruit rind pitting problem. This problem was, at the very least, nebulous. No one was willing to work on it, and the growers needed solutions. I was reluctant but listened to him, and Jerry's passion for solving this problem won me over. Jerry always had a smile on his face, was eager to work, and would do whatever it took to solve a problem. Jerry was also an incredible teacher. I will miss his lessons about life and science. Thank you , Jerry, for your dedication and most of all your friendship."

■ And finally, Dr. Georgios Vidalakis, Director of the Citrus Clonal Protection Program, recalls that, "Kali-méra", meaning 'good morning' in Greek, was Jerry's greeting when I first met him in the winter of 2005. I remember thinking 'Who is this guy speaking Greek to me, thousands of miles away from home?' Sometime later, on my way to a CRB meeting, we started what would become a routine. I would swing by Covina on the way north from Riverside to pick up Jerry. The first time I gave him a ride, he tapped my right shoulder to get my attention. He pulled his wallet out of his pocket and gave me a business card. Jerry's name was printed in Greek, and the mailing address was in Athens. I was surprised, but what truly caught my attention was the four-digit telephone number. I had never seen a four-digit telephone number for Athens! When I was studying in the Agricultural University of Athens, the city's population was 5 or 6 million, and I can guarantee you that the phone numbers had more than four digits.

As it turns out, Jerry had been working with the Greek government a long time ago, to establish the curriculum of the agricultural schools in Greece including the Agricultural University of Athens. Moments like this have made me say, 'life definitely has a bigger imagination than I do.' Here I am, decades later, on the other side of the planet, with a man who shaped the course of my life before I was even born. The curriculum that Jerry worked on qualified me for Ph.D. studies at UCR, and UCR is the place where I began my professional career, met my wife, and started my family. Jerry changed the lives of so many young people. Jerry enriched the lives of his students, friends and colleagues. He will be missed, but he will always be present in our stories." ●

Research Project Final Report

The Asian citrus psyllid and its relatives: insights from phylogenetics

Christiane Weirauch

Revealing the "Tree of Life", the evolutionary relationships of Earth's biological diversity, is one of the fundamental endeavors of the biological sciences. It may come as a surprise that we still know relatively little about phylogenetic relationships, even of species that are crucial for society including disease agents and disease vectors.

This ignorance applies to species relevant to the citrus industry including plant pathogens, pathogen vectors, insect pests, and beneficial parasitoids. Notable among these are citrus thrips, parasitic wasps, and citrus psyllids.

This lack of knowledge impedes our understanding of the relationship between pathogens and insects and the development of preventive strategies to protect the citrus industry.

Using the Asian citrus psyllid (ACP) as an example, in this article we outline how phylogenetic methods improve our comprehension of an insect vector and generate a predictive framework that may eventually impact the control of this and related potential vectors. At the same time, this is a report for a two-year project funded in fall 2009 to generate a molecular phylogeny of ACP and their relatives and investigate the evolution of host-plant associations within this group of psyllids.

Phylogenetics is the study of genealogical relationships among groups of organisms. Modern phylogenetics uses morphological and molecular data and a set of analytical methods to produce diagrams of relationships.

Fig. 1. Two species of ACP related psyllids in the genus *Diaphorina* from South Africa and Madagascar.

Background

The Asian citrus psyllid, *Diaphorina citri* Kuwayama, is the vector of the bacterium *Candidatus* Liberibacter asiaticus that causes citrus greening or huanglongbing (HLB) worldwide. ACP, which was first detected in California in September 2008, is one of the primary disease vectors on citrus and a serious risk to the citrus industry in California. Despite the prominent role of this psyllid species, little is known about closely related species and nothing about phylogenetic relationships of ACP within the genus *Diaphorina*.

The genus *Diaphorina* comprises about 70 described species (i.e., these species have a scientific name), but in addition dozens of species that have not yet been formally named.

ACP was described from Taiwan in 1908, but other species of the genus are broadly distributed throughout the Mediterranean and tropical climates of the old world. More than 30 species are known from South Africa, but *Diaphorina* species also occur in other areas of Africa, Europe, the Near and Middle East, and Southeast Asia.

Psyllids are generally host-plant specific, meaning that species within one genus often only target a closely related group of host plants. As an example, species of *Neophyllura*, that also occur in California, are usually associated with plants that belong to the Ericaceae, the heath family.

This is very different in the genus *Diaphorina*, where species target at least 17 different plant families, among them Rutaceae (citrus and relatives). Three of the described species are known to be associated with Rutaceae (*D. citri, D. punctulata, D. auberti*), but there are additional undescribed species recorded from this plant family as well. To complicate things, host plants are known for less than half of the described species of *Diaphorina*.

We currently do not know if *Diaphorina* psyllids invaded citrus and citrus relatives once or multiple times, and we also do not understand from which other plant groups this invasion happened.

In summary, the patterns of host plant relationships, but also the degree of invasiveness of different *Diaphorina* spe-

cies and the potential to vector bacteria in the Liberibacter complex, are unknown. The research funded here assembles and analyzes molecular data of a comprehensive sample of *Diaphorina* species that will allow us to get the first glimpses into answering these questions.

Procedures

The first step in this endeavor was to collect fresh specimens together with host plant data. Psyllid taxonomists Daniel Burckhardt (Museum of Natural History, Basel, Switzerland), David Ouvrard (Museum National d'Histoire naturelle, Paris, France), and Ian Millar (Plant Protection Institute, Pretoria, South Africa), all of whom are collaborators on this project, conducted field work in Israel, the Philippines, and South Africa, respectively, and collected ~20 species of *Diaphorina*. Two are represented in Figure 1. Additional species of psyllids from other genera were collected by our team and used in the analysis to shed light on the relationships of *Diphorina* to other genera.

We developed a workflow to identify species, photograph the different species, deposit voucher material in relevant natural history collections, and extract DNA from specimens. PCR was performed for both mitochondrial and nuclear markers, sequenced at the UCR Genomics Core Facility and assembled and edited in our lab. To determine comparable sites within the DNA for further analysis, sequences were aligned using an alignment software package. Diagrams of relationship, called phylogenetic trees, were then generated using different software packages for phylogenetic analysis.

Findings

Current, and still preliminary, results show that the genus *Diaphorina* is in fact monophyletic, meaning that it is derived from one common ancestor that gave rise to all the species contained in this genus. We further found that ACP is a relatively early offshoot in the evolution of the genus *Diaphorina*.

Based on the current analysis, ACP is closely related to *Diaphorina lycii* Loginova that is found in North Africa, the eastern Mediterranean, and between the Near East and Mongolia. This species is associated with different plant species that belong to the nightshade family (*Lycium* spp.), a group of plants that is not closely related with Rutaceae.

The current analysis includes one additional species of *Diaphorina* that occurs on Rutaceae, an undescribed species from South Africa that feeds on *Diosma hirsuta* L. The analysis indicates that this species is distantly related to ACP, indicating that dependence on citrus and its relatives evolved at least two times independently within the genus *Diaphorina*. Including additional species of *Diaphorina* in this analysis will eventually reveal the complex pattern of host-plant evolution within this genus of psyllids.

Summary

- Knowledge on the evolutionary history of an insect pest or pathogen vector can help develop preventive strategies, e.g. by estimating which additional species have the potential to threaten our crop.
- The evolutionary history of relationships of ACP and potentially closely related psyllid species were previously unknown.
- Using molecular and phylogenetic methods, we reveal the first patterns of relationship among ACP and its relatives.
- We found a complex evolution of host-plant relationships among ACP and its relatives, indicating that host-switching is a common phenomenon in this group of psyllids.
- Our research indicates that multiple genealogical lineages of *Diaphorina* independently invaded citrus and citrus relatives.

Project Leader Dr. Christiane Weirauch is an Associate Professor of Entomology, Department of Entomology, University of California Riverside. Dr. Weirauch joined the faculty at UCR in early 2007 as a systematic entomologist.

CRB research project reference number 5500-180.

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Ouvrard, D. (2011) Psyl'list - The World Psylloidea Database. http://rameau.snv.jussieu.fr/cgi-bin/psyllesexplorer.pl.

CALENDAR

Mar 8	2012 Citrus Showcase. Visalia, CA. For information, contact California Citrus Mutual, (559) 592-3790.
Mar 27-29	CRB Research Review and CRB Board Meeting. Ontario, CA. For information, contact the Citrus Research Board at (559) 738-0246.
Apr 19	Kern Spring Citrus Meeting, UCCE Kern County. Bakersfield, CA. For information, contact Craig Kallsen, (661) 868-6200.

Research Project Progress Report

Small RNA for HLB plant response

Hailing Jin

Citrus greening or HLB disease is considered the most destructive disease of citrus in the world. The disease is associated with the bacterium '*Candidatus* Liberibacter' species, including '*Ca*. L. asiaticus' (Las), '*Ca*. americanus' (Lam) and '*Ca*. L. africanus' (Laf), around the world,

HLB and the Asian citrus psyllid (ACP) are established in Florida, and the ACP occurs in Texas. Recent introduction and spread of the ACP in California seriously threatens the California citrus industry. How to prevent the spread of HLB in California is a high-priority issue.

My lab and others have demonstrated that bacteria-induced small RNAs target negative regulators of plant defense responses and contribute to plant immunity. Under normal growth conditions, plant defense systems need to be 'off' to allocate all the energy towards plant growth and development. Plant defense systems also need to be switched 'on' quickly in response to pathogen attacks.

Pathogen-induced small RNAs play an important role in the gene regulation of this on-and-off switch. Our small RNA and mRNA profiling will identify additional signaling components, which will help elucidate the host natural responses and pathogenesis of the disease.

We have two specific aims in this project. The first aim is to utilize host rapid defense responses and identify unique host biomarkers, i.e.,-endogenous small RNAs for early diagnosis of HLB. The second aim is to understand the mechanisms of host natural responses to HLB and to identify important components regulating such defense responses. Early detection before the appearance of the symptoms is particularly important, but is also very difficult due to the low titer and uneven distribution of the bacterium '*Ca*. L..'

Our recent studies have discovered that some small RNAs are induced by various pathogens more rapidly and specifically than mRNA transcripts and may play an important role in regulating gene expression in defense responses.

Figure 1 illustrates a few such examples. The left panel shows three different small RNAs that are induced by the same bacterium *Pseudomonas syringae pv. tomato* (*Pst*) carrying different effector genes. nat-siRNAATGB2 is induced specifically by *Pst* carrying effector gene *avrRpt2* (top left), but not other effectors carried by the same bacterium. The right panel shows two other small RNAs that are induced by fungal pathogens *Botrytis cinerea* and *Alternaria brassicicola*, but not by bacterium *Pst*. These results demonstrate the high specificity of small RNA induction by various pathogens.

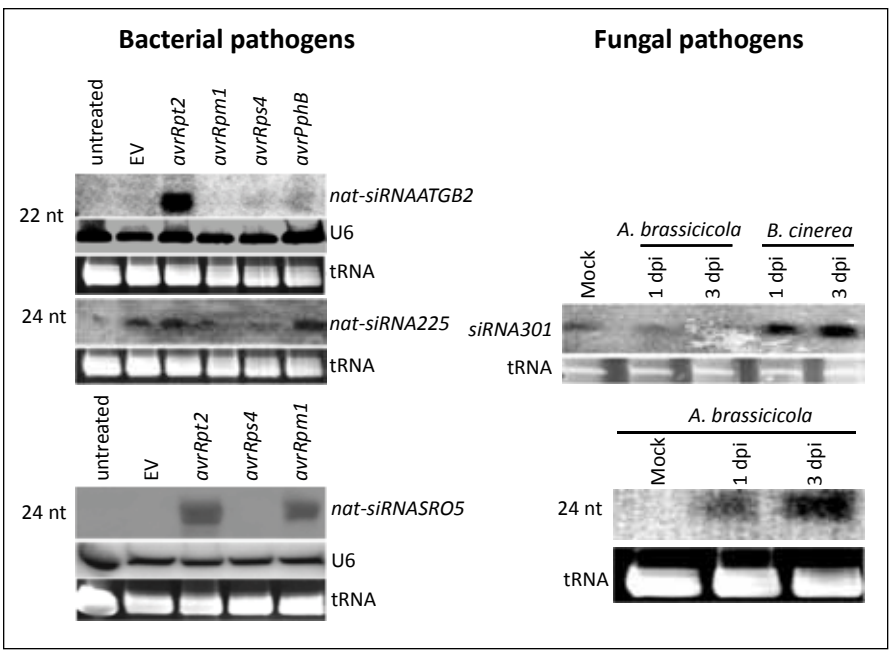

Fig. 1. Small RNAs induced by bacterial or fungal pathogens. Examples of host endogenous small RNAs that are induced by the bacterial pathogen *Pst DC3000* carrying different effector genes at 14 hours post inoculation (hpi) or fungal pathogens *Botrytis* and *Alternaria brassicicola* at 1 and 3 or 2 and 4 days post inoculation (dpi). Small RNAs were extracted from 4-week-old plants inoculated with different bacterial or fungal pathogens and resolved on a 17% denaturing PAGE gel for Northern analysis.

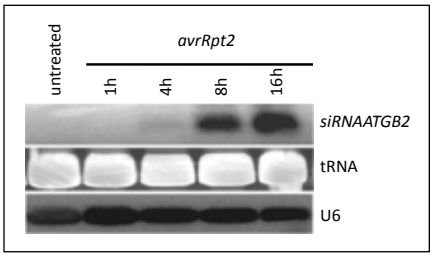

Fig. 2. Bacterial pathogen *Pst* (*avrRpt2*) induces the siRNAATGB2 as early as 4 hours post infection. The small RNA Northern blot analysis was performed as described in Figure 1. The oligo probe that is complementary to siRNA sequence was used.

In addition, some small RNAs can be induced rapidly. Figure 2 shows one such example. This small RNA can be detected as early as 4 hours post bacterial inoculation, which indicates that its induction is very rapid. The high specificity and rapid induction nature of these small RNAs makes them one of the most attractive markers for early detection of pathogen infection.

With the support of CRB, we have identified several small RNAs, including both microRNAs and endogenous small interfering RNAs, that are induced by HLB (data not shown because we are in the process of applying for a patent). We are currently conducting further analysis on the specificity and expression patterns of these small RNAs.

In addition, we would like to expand the small RNA expression profiling study to different citrus genotypes that show large differences in defense responses after '*Ca*. L.' infection. Folimonova et al (2009). have examined the pathogenicity and distribution of '*Ca*. Liberibacter' in different citrus varieties under greenhouse conditions. Although '*Ca*. L.' is able to multiply in all of the plants, a wide range of responses was observed among different hosts (Folimonova, 2009).

We aim to profile the small RNA and mRNA populations of two distinct varieties – tolerant and susceptible varieties. Both psyllid-infected HLB citrus trees and graft-inoculated citrus trees will be included.

In summary, this study will not only lead us to the discovery of HLB-induced small RNAs for early disease detection marker development, but in addition this will also help us understand the nature, basis and/or mechanism(s) of citrus greening as well as identifying important components in natural defense responses to HLB disease.

Project leader Dr. Hailing Jin is Associate Professor and Associate Molecular Geneticist, Department of Plant Pathology and Microbiology, University of California Riverside.

CRB research project reference number 5300-131.

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The Parent 'Washington' navel orange tree
Part 2 – Its decline and recovery

Chester N. Roistacher

Preface

The early history of the parent navel orange was presented in the last issue of *Citrograph* as "The Parent 'Washington' navel orange tree: Part 1—its first years". Included in that article were the early shipments of budwood and trees of a navel orange from Bahia, Brazil to the gardens and grounds of the Department of Agriculture in Washington D.C. From there, a shipment of two trees was made by rail from Washington D.C. to Los Angeles and then by horse-drawn wagon to the home of Eliza and Luther Tibbets in Riverside, California.

When the trees came into fruit, there was much interest and excitement for this new, large and colorful seedless orange. Greater recognition came when the fruit were exhibited at the local fairs. Shortly thereafter, a new industry was born, beginning in Riverside and extending to the surrounding communities in Southern California.

What was it about this navel orange that made it become such a popular and important fruit? This was a citrus fruit unlike any of the seedy oranges that existed at that time growing on seedling trees. The navel orange was larger, seedless, had a superb sweetness and flavor, it peeled easily, had a bright orange color, and matured for the winter and spring months around the Christmas and New Year periods.

In the concluding part of the previous article, two photos were shown of the parent Washington navel orange tree in the early 1900s. One photo was taken about 1910 and showed the tree in good health in its dedicated park at the corner of Magnolia and Arlington avenues. The second photo was taken about 10 years later and showed the tree in decline with leaves yellowing. The tree was suffering from a disease which was later confirmed as *Phytophthora* (gummosis) root rot.

This declining tree was one of the two original trees which had been transplanted from the Tibbets' home yard to this dedicated park and is shown in decline in Figure 1. The loss of this historic tree would have been tragic, since its sister tree at the Riverside Glenwood Mission Inn was also showing signs of decline. This sister tree, also taken from the home of Luther and Eliza Tibbets, had been transplanted to the world-famous Mission Inn in Riverside in 1903, and President Theodore Roosevelt was at the planting and dedication ceremony. Figure 2 shows this tree at the Mission Inn about 1920.

Fig. 1. The parent Washington navel orange tree in its small park in Riverside began to show decline about 1920. We can see the tree in very poor condition and suffering from *Phytophthora* (gummosis) root rot. The lesions of *Phytophthora* on the original sweet orange rootstock can be seen in the picture in Figure 5.

Fig. 2. The parent Washington navel orange tree at the Glenwood Mission Inn about 1920. This tree was one of the two original trees removed from the home yard of Luther and Eliza Tibbets. In 1922, this tree died of *Phytophthora* gummosis.

On Dec. 4, 1922, the *Riverside Daily Press* reported that the tree at the Mission Inn had died and been removed. It was noted by local townspeople that the tree had begun to fail rapidly after the death of President Theodore Roosevelt in 1919. President Roosevelt had personally assisted in the transplanting ceremony (Figure 3, upper left).

After its death, the stump of the parent Washington navel orange tree was given as a gift by Archibald Shamel, a leading horticulturalist, to Sir Percy Fitzpatrick who was visiting Riverside at that time. Sir Percy Fitzpatrick was a famous writer and owner of Amanzi Citrus Estate near Port Elizabeth, South Africa. The plaque on the stump in the lower right of Figure 3 reads:

"Parent Washington navel orange tree planted at Riverside, California 1973; died and removed 1922 . This section of trunk 2 ft. above ground is presented to Sir Percy Fitzpatrick as a memento from California. A.D. Shamel, the Mission Inn, Riverside, December, 1922."

This historic stump of the parent Washington navel orange tree resided at the home of Patrick and Marina Niven at the Amanzi Estate in Uitenhage, South Africa. Shown holding the stump in Figure 3 is Patrick Niven, the grandson of Sir Percy Fitzpatrick. Patrick Niven was a highly respected citrus nurseryman in South Africa who passed away in 2009. Note the distinct large lesion of *Phytophthora* on the sweet orange stump in the lower left photo in Figure 3.

Inarching

Facing the inevitable loss of this parent Washington navel orange tree, which was dying with *Phytophthora* root rot in its dedicated park in Riverside, a decision was made by the scientists at the University of California to try to save this tree by inarching. Figure 4

shows the original inarches from a photograph taken by Dr. L.J. Klotz in 1918. The tree had been girdled by gummosis and was rapidly deteriorating as shown in Figure 1.

The inarching was done by Dr. H.J. Webber, H.W. Mertz and Glenn Blackman. They used seedlings of sweet orange, rough lemon, and sour orange for inarching. The inarches were again photographed by Dr. Klotz 26 years later, on July 17, 1944, and are shown on the right in Figure 4.

In 1951, it was noted that some of the original inarches were showing lesions of *Phytophthora* gummosis. Therefore, in that same year, a second inarching was done using three seedlings of 'Troyer' citrange and one of trifoliate orange. The grafting was done by Denard C. Wylie, Senior Superintendent of Cultivations at the Citrus Experiment Station.

The inarches as they appeared in 2009

The survival and preservation of the parent Washington navel orange tree was dependent on the successful inarches made in 1918 and repeated again in 1951. Shown on the left in Figure 5 is a view of the inarches as they appeared in 2009. On the right in Figure 5 is a close-up view of the inarches showing the distinct bark lesions of *Phytophthora* on the original sweet orange rootstock growing upright in the center of the picture. These lesions were responsible for the decline of the

Fig. 3. The upper left shows President Theodore Roosevelt assisting in the transplanting of one of the two parent navel orange trees taken from the yard of Eliza and Luther Tibbets and transplanted to the courtyard of the Glenwood Tavern, now known as the Mission Inn. This famous photo was taken on May 8th, 1903. This tree at the Mission Inn died in 1922, and the stump was given as a gift to Sir Percy Fitzpatrick who was visiting Riverside at the time. Shown are three pictures of this historic stump taken in 1999 at the home of Patrick and Marina Niven at the Amanzi Estate in Uitenhage, South Africa. Patrick Niven, the grandson of Sir Percy Fitzpatrick, is shown holding the stump. Note the distinct lesion of *Phytophthora* on the sweet orange trunk in the picture in the lower left.

Fig. 4. Shown on the left are the original inarches grafted into the trunk of the Parent navel orange. The photo was taken by Dr. L. J. Klotz in 1918. The Parent tree had been girdled by *Phytophthora* gummosis and was rapidly deteriorating. The seedlings used were sweet orange, rough lemon and sour orange. Dr. Klotz again photographed the inarches (right) on July 17, 1944, which was 26 years after the initial inarching.

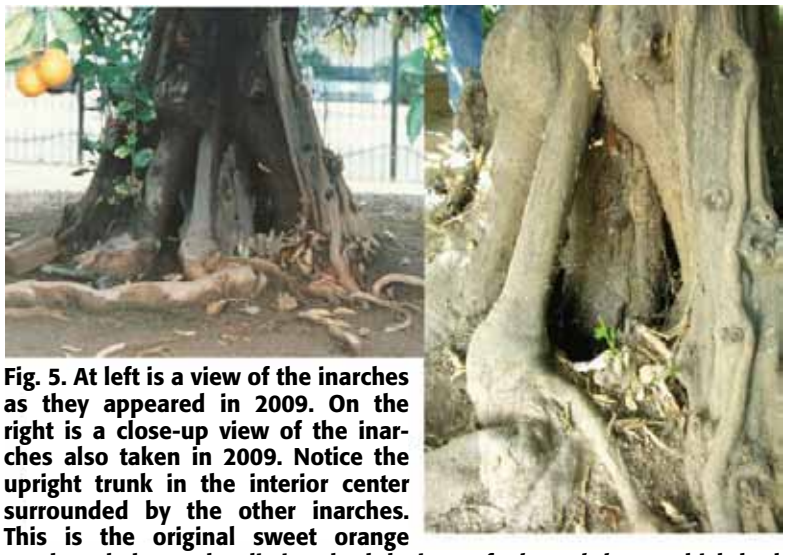


Fig. 5. At left is a view of the inarches as they appeared in 2009. On the right is a close-up view of the inarches also taken in 2009. Notice the upright trunk in the interior center surrounded by the other inarches. This is the original sweet orange trunk and shows the distinct bark lesions of *Phytophthora*, which had been responsible for the decline of the tree in 1920 (see Fig. 1). Without the inarches, the parent navel tree would surely have died as had its sister tree at the Mission Inn.

tree in 1915-1917 as shown in Figure 1. As noted earlier, this same fungus had killed its sister tree at the Riverside Mission Inn in 1922. Thus, the timely inarches saved this historic tree.

Figure 6 shows the 136-year-old parent Washington navel orange tree as it appeared in December 2009. The tree was in good health and bearing a good crop of fruit. In the foreground in this picture is a plaque honoring Mrs. Eliza Tibbets which reads:

"To honor Mrs. Eliza Tibbets and commend her good work in planting at Riverside in 1873, THE FIRST WASHINGTON NAVEL ORANGE TREES in California, native to Bahia, Brazil, proved the most valuable fruit introduction yet made by the United States Department of Agriculture. 1920".

Note in Figure 6 the sign on the lamppost adjacent to the parent Washington navel orange tree which reads *"Historical Landmark No. 20."* This landmark was included in the first group of 20 landmark choices when historic landmarks were created by the State of California, showing the importance and significance of this tree.

A new book, *Creating an Orange Utopia: Eliza Lovell Tibbets and the Birth of California's Citrus Industry*, written by Patricia Ortlieb (the great-great granddaughter of Eliza Tibbets) and Peter Economy, tells the fascinating story of the lives of Eliza and Luther and their part in bringing the Washington navel orange to Riverside. This excellent book can be obtained through Swedenborg Foundation Press, http://www.swedenborg.com.

Fig. 6. The 136-year-old parent Washington navel orange tree as it appeared in December 2009. The tree was in good health and bearing a good crop of fruit. In the foreground is a plaque honoring Mrs. Eliza Tibbets. A sign on the adjacent lamppost reads "Historical Landmark No. 20".

A conference on the health of the parent navel tree, Sept. 2006

At the request of Robert Johnson and Alisa Sramala with the Planning and Design Division of the Riverside Parks and Recreation Department, a meeting was organized at the parent Washington navel orange tree with the objective of studying the general health of the tree and obtaining directions on the best way of maintaining it to ensure its longevity.

In response to this request, Dr. Tracy Kahn organized a meeting of concerned individuals at the tree site on September 29, 2006. At that time, the tree was in excellent health with large leaves and a good crop of large-sized fruit. A discussion was held on various aspects for the continued maintenance and improvements for the health of the tree.

The impact of the Parent navel

The impact that this single tree had on the city of Riverside and on the surrounding communities in the early 1900s was profound. Considering that Riverside had been founded in 1870 and that most of the cities in the region were also founded about that same time, the commercial impact of this tree was of great importance to the development and prosperity of a number of cities in the immediate region and also throughout Southern California.

One can still see the large two-storied homes when traveling from Riverside to Redlands. These older homes were designed so that one could see above the orange groves which filled much of area in the region at that time. The population of Riverside in 1880 was only 368 and a little over 1,000 in the surrounding areas. Citrus orchards increased and flourished throughout the region, and the navel orange became its most important major agricultural crop.

Riverside and its surrounding areas were ideally suited for this tree. The two navel orange trees which were sent from Washington D.C. and nurtured in the Tibbets home yard by Eliza Tibbets could not have been planted in a more favorable environment for the full development of its deep orange color and superb fruit flavor.

Our indebtedness to this mother tree

Little did Eliza or Luther Tibbets fully realize, or could they have predicted, the impact that this tree would have, not only on the development of Southern California but on world citriculture. The success that came with the introduction of the navel orange was responsible for important progress that took many forms.

This tree was responsible not only for the creation of a citrus industry in California but significantly contributed to the establishment of the world-famous Citrus Experiment Station. It was responsible for development of the iced railroad cars, for the creation of Sunkist and other cooperative marketing organizations, for the introduction of various insects to control serious pests, for research on decay control, for the creation of packinghouses and the many jobs and small industries associated with citrus. In many ways, it was also responsible for the growth and early development of many cities in Southern California extending from Ventura by the sea to Yucaipa at the foot of the San Bernardino Mountains and extending north to the cities in the rich farmlands of Central California.

We in California and throughout the world are indebted to Eliza Tibbets and to those who preserved this remarkable tree, listed as the most important plant introduction ever made into the United States!

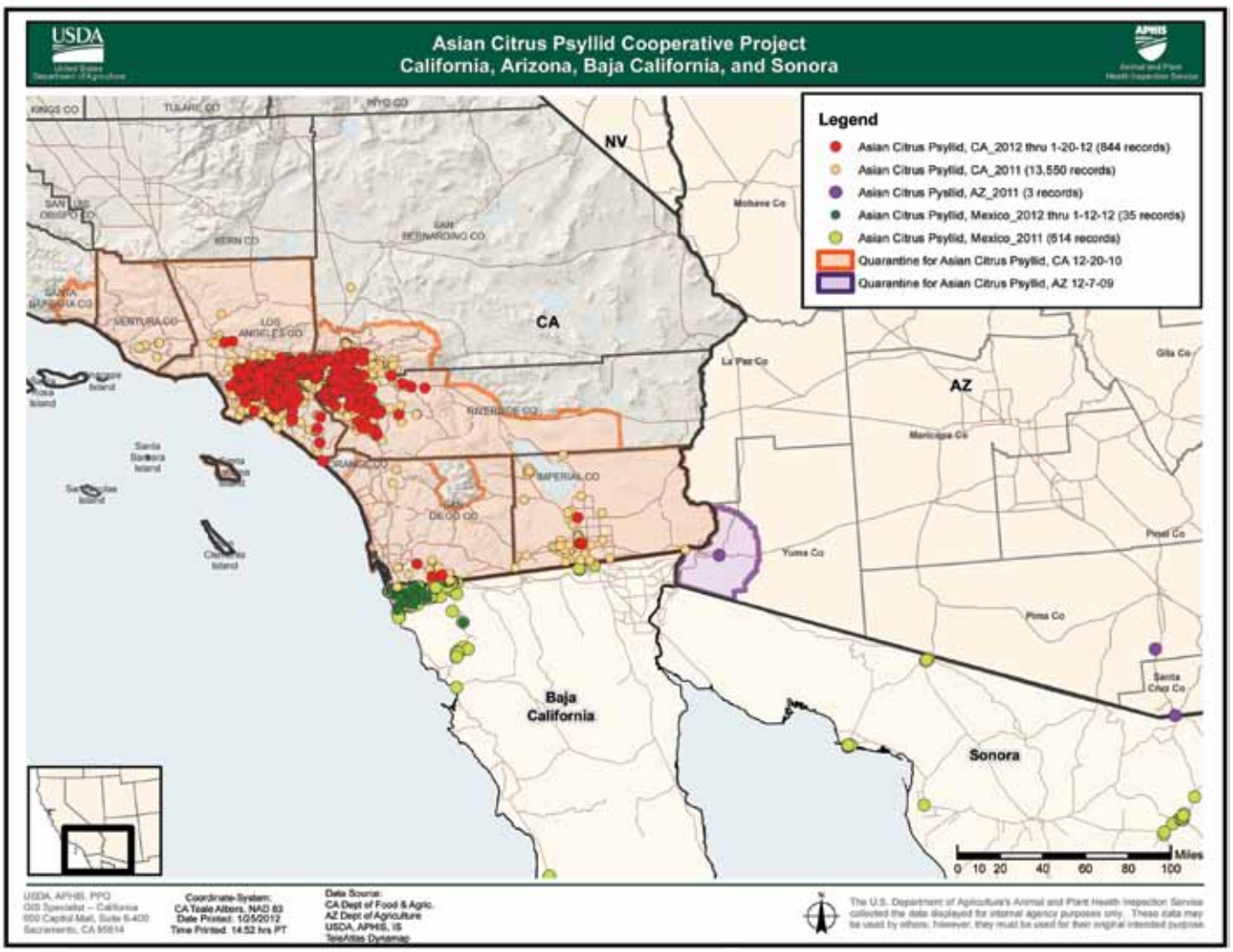
For a full history with many illustrations of this extraordinary and famous tree, see the EcoPort slide show #79. This URL will get you directly to this slide show: http://ecoport.org/ep?SearchType=slideshowView&slideshowId=79.

Chester N. Roistacher is a retired Citrus Virologist, Department of Plant Pathology, University of California Riverside.

CPDPP asks for feedback on special survey site

The Citrus Pest and Disease Prevention Program is working to detect the Asian citrus psyllid and HLB in commercial citrus groves across the state with a crew of 23 trappers working in 16 counties. With the help of the University of California, the first phase of constructing a special citrus invasive pest mapping website has been completed, and industry members are invited to provide feedback. Access will be limited to legitimate stakeholders in the California citrus industry.

Go to https://crbcitrussurvey.uckac.edu/viewer. Through March, the username is: NextGrowerDemo, and the password is: Easier! For more information, contact Richard Dunn, CRB's data, information & management director, at rick@citrusresearch.org or by phone at (559) 738-0246.



Map of Asian citrus psyllid detections in California and neighboring portions of Arizona and Mexico through 1/20/12.

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