CITRUS RESEARCH BOARD

Citrograph

July/August 2011

Beth Grafton-Cardwell and her team at Lindcove

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 BY TED A. BATKIN, President, Citrus Research Board

It's all about communications…

We are in for a very long battle with this pest in California, and we need all the help we can get from the public.

I recently completed the Annual Media Tour for the Citrus Pest and Disease Prevention Program (CPDPP) where we covered California and Arizona from Yuma to Sacramento. During the week-long tour, we completed 28 interviews with various TV, radio, and print media outlets. Along the way we were joined by John Loghry, John Gless Jr., Nick Hill and Tony Aguilar, all growers from the areas we were covering.

The most interesting thing about the tour this year was the very open and positive response from the media in helping us promote the message to homeowners. The message was very clear: *1. Look at your trees in your yard for symptoms of ACP; 2. Cooperate with the CDFA officials when asked to place a trap or treat a population; and, 3. Please only plant trees from a certified nursery (in Southern California) that carry the blue CDFA tag, and do not bring trees from the Southern California quarantine area to Northern California.* This message is clear and concise and works well with the radio and TV media. They like very short "sound bites".

This strategy was developed to support the CPDPC and CDFA programs in Southern California, mainly in the Los Angeles area. It also was presented to help prevent the movement of ACP into the San Joaquin Valley and points north. We are in for a very long battle with this pest in California, and we need all the help we can get from the public.

One thing I did find from the travels was the amount of interest from everyone about keeping their trees safe from the pest and disease. One of the radio shows was a 30-minute segment on Cindy Dole's Garden Show on KFWB News Talk in Los Angeles. Here we were able to fully develop the story about the problem that both homeowners and growers share. When faced with the reality, everyone wants to get involved and help with the solutions.

So, to answer the question: "Why are you spending time and money with PR and outreach?" The answer is simple. The more cooperation we get from the public, the more successful the detection and treatment programs will be in the urban areas. We all understand the problem as growers, but at present that is not where we are waging the battle with the pest. The members of the Citrus Pest and Disease Prevention Committee understand this formula and have included this public outreach effort as a part of the total program here in California (and the Arizona border). We will continue the efforts as part of a long-term strategy to keep the California citrus industry strong and viable for many years to come.

The Mission of the Citrus Research Board:

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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ABOUT THE COVER

This issue, we are highlighting Dr. Beth Grafton-Cardwell as a way of thanking her for her efforts over the past two years in serving as the Senior Science Editor for *Citrograph*. Beth is stepping down from this position to take on a major role within the University of California system as leader of the Endemic and Invasive Pests and Diseases Initiative. In this role, Beth will also become a member of the UC Agricultural and Natural Resources (ANR) Program Council. The Council reports directly to UC Vice President Dan Dooley for policy and direction input. We look forward to a new relationship with Beth as the UC reorganizes its structure to accommodate recent budget restrictions.

Beth is one of the founding members of the *Citrograph* Editorial Board and has served as Senior Science Editor since CRB began publication with the premier issue in January 2010. Using her skills as an Extension Specialist, Beth has been a major force in shaping the content of the magazine and assuring the high quality of articles that we have been able to publish. Her main focus was the feature science articles and ensuring that they were written in layman's language. She has been joined by Dr. MaryLou Polek, Vice President of Science and Technology for the Citrus Research Board, whose responsibility is reviewing the articles presented by CRB research Project Leaders.

Beth will continue her role as Director of the Lindcove Research and Extension Center and as a research leader for the CRB and other commodity groups. The cover photo of this issue features the crew of LREC. This outstanding group has been the cornerstone of the citrus research program for California for many years by providing support to the many UC research leaders. Beth has also served on the CRB Communications Committee and the Citrus Pest and Disease Prevention Committee's Communications Committee. She will continue to provide input to these groups when possible.

"Beth, we all thank you for your help and service and will continue to support you in every effort you may undertake in your new role!!"

Ted Batkin, Publisher
Margie Davidian, Editor

Pictured on the cover, left to right: Jose Trujillo, Kurt Schmidt, Dan Seymore, Beth Grafton-Cardwell, Angel Sanchez, Anita Hunt, Gerry Perez, Jose Hernandez, and Therese Kapaun. Not shown: Don Cleek.

Citrograph asks:

Irrigation efficiencies: How much more growth can we obtain from our citrus groves with the introduction of these new precision irrigation measuring devices? Fertilizer placement, saving water, groundwater contamination are all reasons for adapting this new technology, but how much more growth and production can be affected?

To date, we see the use of precision irrigation monitoring devices in mature, established groves as a defensive mechanism in terms of crop production and tree growth. While we have seen improvements in irrigation efficiency, nutrient timing and other issues, we have not yet determined if the sensors will enable us to set bigger crops or have better tree vigor. What we do know is that during high stress events throughout the growing season (e.g., high temperatures during crop set, etc.), we have the ability to see exactly how much water the trees use and need. This information helps us better ensure that we don't lose crop volume, size or quality due to environmental stressors. So while we cannot yet say that this technology has led to larger crop volumes, better sizing, higher quality, or better tree growth, we can say that it offers us another layer of protection against Mother Nature's worst. In the future, as our understanding becomes more refined, we hope that these devices will lead to better production, but for now we are happy with them helping us ensure that the crop volumes, sizes and quality we would expect are indeed present at harvest. ***– Randy Skidgel, General Manager, Mittman-Denni Citrus Management***

Intuitively, growers understand the importance of irrigation management and the need for timely, accurate information that is easily interpreted. Precision irrigation monitoring equipment, such as capacitance probes, offers growers access to this information. Water is the single largest input that is applied to a field. With precision irrigation equipment, growers have "eyes beneath the soil", which allows them to accurately define the active root zone and minimize stress events attributed to over/under irrigation. By creating an optimal environment for root growth and root health, trees are able to access the needed nutrients, oxygen and moisture early in the season, which in turn promotes productive growth and increased fruit holding capacity. Managing water stress through the spring and summer allows the trees to build on early-season momentum and encourages early fruit sizing, while reducing fruit shedding through heat events. Going into the fall, as temperatures begin to decrease, timely irrigations help to finish the fruit and reduce issues with fruit quality. Combining stress management through irrigation monitoring with variable rate irrigation system design (VR) and a strong nutritional program, growers have the tools needed to not only increase growth and productivity but also field uniformity. ***– Kris Tomlinson, Tulare Ag Products***

Irrigation effectiveness in the citrus world

Telling a farmer about the general state of irrigation in California is less valuable than the specific numbers relating to his/her own fields. That said, it is safe to note that the quality of irrigation systems of trees has improved dramatically over the last 15 years or so. Over the decades that I have worked in irrigation, I've seen some phenomenal irrigation systems and practices on citrus, as well as some that might generously be described as "needing a little attention".

There are a number of tips I would offer to citrus farmers regarding maintaining the health of their irrigation systems and irrigation management:

1. Consider getting your fields checked for Distribution Uniformity (DU) using ITRC's standard evaluation procedure. DU is a measure of how evenly plants throughout the field receive water (and injected fertilizer). A perfect score is 1.0; the average value for a drip/micro system in California (out of about 800 results we have gathered) is about 0.85. A DU of 0.85 means (approximately) that the 5% of the trees that get the most water receive about 50% more water than the 5% of the trees that get the least water.

Here are a few observations I've made working with citrus irrigation:

• Many citrus groves are on small fields which tend to be a bit difficult to manage very uniformly, compared to the big fields of almonds on the west side of the San Joaquin Valley.

• Many of the small fields are managed by management firms, and there are large differences between them regarding their irrigation expertise and the budget that they have allocated for irrigation system management/repair, etc.

• Many citrus groves are on hilly ground, which means that unless the drip system design and products are very good, the uniformity won't be great.

• I've seen a fair number of drip/micro systems on smaller fields, especially in areas of the southeastern part of the San Joaquin Valley and near Ventura, with system designs that range in quality from terrible to great.

• Put those four points together, and it means that it might be interesting to double-check the uniformity that you have.

What difference does DU really make?

• If you have a 50% difference in water application among trees with relatively good uniformities (and 0.85 is typically considered an "OK" DU), imagine the difference with worse uniformities.

• If trees receive different amounts of water, precise soil moisture measurements at just a couple of points in the field become meaningless because the numbers will vary dramatically throughout the field.

• In most areas of the state, any deep percolation (extra applied water to compensate for drier spots) ends up back in the groundwater. However, the irrigation water deep percolation also carries along things like nitrogen fertilizer and pesticides, which will eventually end up in the drinking supply.

• Non-uniformity can be compensated for with extra water, fertilizer, and pumping, but those aren't exactly inexpensive. And often, there isn't enough water to over-compensate.

• It is not generally possible to obtain accurate samples of foliar nutrition if different trees receive different amounts of water (and injected fertilizer).

2. Soil moisture sensors are helpful indicators of irrigation status. It's also a good idea to look at the leaves or at the weather to indicate the need for more or less water. It's even better when you look at all three. With drip/micro irrigation especially, if you move a sensor even one foot, you will get different readings. Soil moisture sensors, then, should be used as valuable indicators of *trends*. I personally would never automate an irrigation system using soil moisture sensors unless I only used one sensor at one location. Then I would never be confused because there would never be any disagreement between numbers.

3. Use the power of simple tools like Google Earth to look at satellite images of your fields. Non-uniformity of growth is obvious from these images. Maybe some of the non-uniformities (from whatever cause) can be eliminated if you know where to look.

– Dr. Charles M. Burt, Chairman, Irrigation Training and Research Center, Cal Poly San Luis Obispo

The Conservatory at the Sardine Factory, Monterey, CA

There is really no better way to say this… We are absolutely, unabashedly thrilled to be able to give you two recipes from one of California's most famous restaurants, the Sardine Factory in Monterey. Established in 1968 on storied Cannery Row, this internationally recognized fine-dining restaurant which is a favorite of celebrities from the worlds of entertainment, sports, and politics, is renowned not only for its award-winning cuisine but also for having what's described as one of the premier wine programs in the nation. The gourmet menu features fresh, sustainable seafood and USDA prime beef. We venture to say that once you've made these two dishes in your own home kitchen, it won't be long before the Monterey Bay is on your travel itinerary and the Sardine Factory is on your GPS…

Monterey Prawn Salad with Citrus Vinaigrette

Serves 6

Ingredients	Amounts
Whole Baby Iceberg Lettuce, cut in half	6 Ea.
Whole Roma Tomatoes, cut in quarters	6 Ea.
Manchego Cheese, grated	12 Oz.
Asparagus Tips, green, precooked	24 Ea.
Prawns, 21-25 count, precooked	12 Ea.
Small Cucumber, peeled, shredded julienne style	1 Ea.

Citrus Vinaigrette

Orange Juice	¼ Cup
White Wine Vinegar	¼ Cup
Fresh Lemon Juice	1 ½ Tbsp.
Vegetable Oil	½ Cup
Sugar	1 Tbsp.
Dijon Style Mustard	1 Tbsp.
Fresh Orange Peel Zest, grated	1 Tbsp.
Garlic Cloves, finely chopped	2 Ea.
Salt	½ tsp.

Procedure for salad:

For each plate, take an Iceberg cup and put four Roma tomato wedges spaced around each of the lettuce cups, cut side down. Add asparagus tip in between each tomato, and then on top add the two prawns, one on each end so they hang on the cup. Add two ounces of grated cheese and tip with the julienne of cucumber, and pour the citrus vinaigrette on top and around the salad and serve.

Citrus Vinaigrette:

Combine all ingredients in a bowl, blend well. This makes about 1 ½ cups, 2 oz. of dressing per salad.

Chef Bert Cutino, CEC, AAC, HOF
Certified Executive Chef, American Culinary Federation
Co-Founder/COO, the Sardine Factory Restaurant
Monterey, CA 93940

Blackened Halibut with Citrus Salsa

Serves 4

Ingredients	Amounts
Halibut Fillets (6-7 ounces ea.)	4 Ea.
Cajun Blackening Spices	2 Tbsp.
Peanut or Vegetable Oil	2 Tbsp.
Red Bell Pepper, diced	½ Cup
Serrano or Jalapeno Chili, minced	1 Ea.
Lime Juice, fresh squeezed	1 Tbsp.
Ginger Root, fresh minced	½ tsp.
Mint, fresh minced	1 Tbsp.
Passion Fruit Glaze, or Honey	1 Tbsp.

Citrus Salsa

Pineapple, diced	1 Cup
Orange sections, peeled and diced	1 Cup
Jicama, diced	½ Cup
Red Onion, diced	¼ Cup

Procedure for fillets:

Combine all of the ingredients in a medium-size, non-reactive bowl. Cover and refrigerate, allowing the flavors to marry for a few hours before serving. Pat dry the halibut fillets with paper towels. Place the Cajun Blackening spices in a plastic bag, or paper bag; add one fillet. Seal the bag and shake until the fillet is well coated with the spice mixture. Repeat with the remaining fillets. Heat the oil in a 12-inch skillet. Add the fillets; cook over medium heat, turning once, until the spices begin to caramelize and blacken, about 7 minutes. Serve each fillet topped with 4 tablespoons of the Citrus Salsa.

Citrus Salsa:

This salsa is tangy and fruity, with the flavor of pineapple and ginger. It is great with fish, chicken, and pasta dishes; or spoon it on grilled pork chops.

Chef Bert Cutino, CEC, AAC, HOF
Certified Executive Chef, American Culinary Federation
Co-Founder/COO, the Sardine Factory Restaurant
Monterey, CA 93940

OPINION

The role of university technology transfer programs

Charles F. Louis

Publishers Note:

This article is presented to provide a platform for discussion and thought. The positions of the author are not to be viewed as representative of the Citrus Research Board members. We believe that various viewpoints are critical to open dialog and discussion for the future of our industry.

Best Regards, Ted Batkin

In previous generations, it was commonly considered that the single role of public universities was to provide access to a high-quality education for all young people irrespective of race, economic status or beliefs, so ensuring that states produced an educated citizenry that would grow up to live the American dream and contribute to society through growing the U.S. economy.

The role of public universities as research powerhouses is largely due to the efforts of Vannevar Bush, who played a key role in advising the Roosevelt administration in World War II. He believed that basic research was important for national survival for both military and commercial reasons, requiring continued government support for science and technology, leading to the creation of the National Science Foundation in 1950 and the rapid growth in basic science funding for other federal agencies such as the National Institutes of Health (which today has an annual budget of $30 billion), the U.S. Department of Agriculture, and many other federal agencies.

Universities' relations with industry

While this federal beneficence has transformed the quality and quantity of university basic research, it has also led to closer relationships between some parts of the academic enterprise and commercial partners who at the same time have been disestablishing their large research units, the best example of this being the dissolution of Bell Labs in 1984 when AT&T divested itself of its exchange service operating companies creating the "Baby Bells".

This decrease in investment by industry in its own basic science research that has the potential to result in the technologies and products of the future has meant that industry has increasingly relied on universities to produce these new "innovations". And indeed, there are many excellent examples of how such federal funding has led to basic research discoveries that in turn have led to widely used commercial products,

About the author…

Charles Louis, the Vice Chancellor for Research at the University of California Riverside, received his Bachelor of Arts degree in chemistry from Trinity College in Dublin, Ireland, his D.Phil. in biochemistry from Oxford University, and postdoctoral training at Stanford University.

The Office of the Vice Chancellor for Research oversees the Office of Sponsored Programs Administration, Office of Research Integrity, Office of Technology Commercialization, Office of Research Development, and the Campus Veterinarian.

In addition, the Office of Research is responsible for the review and regulatory oversight of campus research Centers and Organized Research Units at UCR. The Vice Chancellor is the Institutional Official responsible for acceptance and investigation of allegations of research misconduct on the campus. Finally, the Vice Chancellor aids UCR faculty and Deans in identifying funding opportunities and facilitating proposal development for multidisciplinary and multicampus research initiatives.

Dr. Louis served as Vice President for Research at Georgia State University from 2000-2004, having previously served for over 20 years on the faculty at the University of Minnesota, where he held a number of administrative positions that included Head of the Department of Biochemistry, Molecular Biology and Biophysics from 1998-2000 and Assistant Vice President for Research and Associate Dean of the Graduate School from 1994-1998. He previously held faculty appointments at the University of Connecticut Health Center and at Leeds University in England.

At UCR, Dr. Louis holds the concurrent title of Professor of Cell Biology and Neuroscience. His biomedical research on the role of calcium as an intracellular signaling molecule, which has been funded by the National Institutes of Health for over 25 years, uses a range of different approaches including cell physiology, molecular biology, biochemistry, cell biology, and biophysics.

His current research program focuses on the role of gap junctions in the development of cataracts in the lens of the eye because an elevation in cytosolic calcium concentration which closes these cell-to-cell channels is one of the critical early steps in the development of lens cataract formation.

Dr. Louis is Chair of the Executive Committee of the Council of Research Policy and Graduate Education (CRPGE) of the Association of Public and Land-Grant Universities (APLU), serving on the Board of Directors of APLU, and a member of the Board of Directors of the Council on Government Relations (COGR). He has served on many peer-review grant committees as well as the boards of biotech industry associations in both Minnesota and Georgia.

such as the Internet as a result of Department of Defense funding to allow direct computer-to-computer communication, or the 153 new FDA-approved drugs and vaccines discovered through National Institutes of Health-funded research carried out over the past 40 years[1].

While the vast majority of the basic research conducted in our public research universities is communicated to the world through the science literature, a small fraction of the research is seen to have direct commercial application. Since the passage of the Bayh-Dole legislation in 1980, universities have become much more active in seeking to commercialize their inventions since this legislation permits a university, small business, or nonprofit institution to take title to inventions made with the federal funding that supports basic research. The authors of the bill believed that the certainty of ownership of federally-funded inventions by universities would increase the commercialization of inventions made with federal funding and would result in the development of new products and services for the general public.

Prior to 1980, the government retained ownership of all inventions resulting from federally-funded research. Indeed, prior to the enactment of this Act, the U.S. government had accumulated 30,000 patents, and only approximately 5% of those patents were commercially licensed. Today, that situation is transformed, with the University of California alone managing over 2,000 utility and plant licenses, and 3,800 currently active U.S. patents in FY10.

Universities and the commercialization of their inventions

Recognizing this increasing role of our research universities in creating the new industries and employment of the future, the current Obama administration has identified key policies to improve America's economic growth and competitiveness. Among these are the strengthening and broadening of American leadership in fundamental research[2] and the development of new and innovative approaches to enhance the commercialization of university research[3]. This administration sees that our public research universities that conduct over 65% of all funded research in the U.S. today[4] are critical for America's competitiveness and economic growth.

Yet, at the very same time that research universities are taking on this broader national economic role, they are being accused of commercialization and greed, and as Dr. Zvi Yaniv argues in a recent edition of *Citrograph*, "In the last ten years, universities have initiated aggressive patent licensing programs and are encouraging lead scientists to become entrepreneurial. All these activities do not have anything to do with the main purpose of universities – to teach and educate – but have to do with for-profit ventures"[5].

Such statements slight the hundreds of universities that have technology transfer offices and the thousands of faculty engaged in the commercialization of intellectual property nationwide. Indeed, the article makes numerous claims that are not based on facts but rather reflect the biased and unsubstantiated opinions of the author.

The statements that "the majority of the universities are very little else than business", that "professors have license to do as they choose thanks to the security of the tenure position", and that "commercialization may destroy the foundation of scientific progress"[4], are not substantiated by any data or facts and represent a disrespect of the good name of the University of California and other major public research universities that exist to serve the people of California and the nation through research, teaching and public service.

Such biased articles only serve to harm this relationship – at the very time when the University of California and other public research universities are struggling for their survival in the face of the most severe budget reductions they have ever faced. This article not only implies that commercializing university inventions is a corruption of the academic enterprise but that those universities that do perform this service, such as the University of California Riverside, are incompetent and rank amateurs.

Indeed, Dr. Yaniv ignores the premise that led to the establishment of the University of California at Berkeley in 1868, when that campus was established as the State's Land-Grant University as designated by the seminal Morrill Act of 1862. This act provided federal funding and land for each state to establish a publicly funded agricultural and technical educational institution whose role was to educate its young people and provide solutions and support for the agricultural and mechanical arts industries of their states. Today, this mission continues to be carried out with distinction by the University of California Riverside and the other University of California campuses, with the Riverside and Davis campuses assuming much of the agricultural role.

The best and most recent analysis of whether the commercial activities of a small number of our faculty has a corrupting influence on universities is the 2010 study by the prestigious National Academy of Sciences, "Managing University Intellectual Property"[6] . The committee that was charged to conduct this study included leaders from the academic, legal, business and ethics communities. Among the conclusions of this study were:

"Despite repeated continuing expressions of concern, research has found little evidence that:

• Commercially oriented faculty are less likely to publish in the open literature (on the contrary, they are more prolific publishers);

• Commercial motives have shifted effort away from fundamental research questions and toward more applied research questions;

• Institutional or sponsor concerns to protect intellectual property rights have resulted in more than modest delays in publication of research results;

• Commercial involvement and intellectual property activity have replaced scholarly output and its quality as the principal criteria for academic employment and advancement."

Thus, the most authoritative independent voice of science in the U.S. attests that the development of university technology programs has not had the corrupting influence that Dr. Yaniv alleges has occurred. Their careful evaluation of all published literature on this issue found no support for Dr. Yaniv's unsubstantiated claims.

Patent and licensing practices

But rather than dwell on these negative aspersions of how universities commercialize their inventions, I would prefer to

describe to the readers of *Citrograph* exactly why research universities have technology transfer offices and what the practices of these offices are. I will speak exclusively about the University of California, as that is the institution with which I am most familiar, albeit what I will describe is largely true for all research universities in the U.S.

Two recent documents provide examples of the values shared across institutions and articulated in public policy that university licensing should reflect. The first of these is a document that has become known as the "Nine Points" document[7] that was developed by a dozen institutions, including the University of California, that drafted a set of points for consideration by universities when making decisions regarding technology licensing. These "Nine Points" have subsequently been endorsed by the Association of University Technology managers (AUTM) and over 70 other research organizations, including a number of non-U.S. universities. The "Nine Points" are:

Point 1: Universities should reserve the right to practice licensed inventions and to allow other nonprofit and governmental organizations to do so.

Point 2: Exclusive licenses should be structured in a manner that encourages technology development and use.

Point 3: Strive to minimize the licensing of "future improvements".

Point 4: Universities should anticipate and help to manage technology transfer related conflicts of interest.

Point 5: Ensure broad access to research tools.

Point 6: Enforcement action should be carefully considered.

Point 7: Be mindful of export regulations.

Point 8: Be mindful of the implications of working with patent aggregators.

Point 9: Consider including provisions that address unmet needs, such as those of neglected patient populations or geographic areas, giving particular attention to improved therapeutics, diagnostics and agricultural technologies for the developing world.

These nine points, endorsed by the leading research universities in the U.S., speak clearly to the importance of ensuring that their inventions maximally benefit the public. Indeed, point #9 indicates the importance of addressing unmet needs such as those of neglected patient populations or geographic areas, providing clear evidence that universities are not as Dr. Yaniv claims "little else than businesses" or "using their laboratories and their students as private property".

Rather, universities seek to ensure the public at large has access to the inventions resulting from the massive federal investment in university research and that where this may be a product rather than a publication, this commercialization is done in a mindful manner that respects and ensures the integrity of the academic enterprise.

The second example that documents the goals of university technology transfer offices derives from a study conducted by a University of California committee that I chaired that sought broad input from across the University of California, the nation, and international colleagues. This committee had been charged to define the success criteria for the University's technology transfer program and to identify and describe the metrics for measuring these criteria.

The committee decided to first identify what were the goals for the University of California Technology Transfer Program and then to suggest possible metrics for each goal. While I won't describe the metrics here, the five goals identified by this committee again provide a clear picture as to what technology transfer offices aspire to in their patent and licensing work. These goals are:

1. To create public benefit: The public benefits when the innovations and discoveries of the faculty and staff of the University of California are made available to the public and commercial sectors. Thus, transferring university research outside of the institution enables further research, the creation of new companies, and the development of products and services. By facilitating this transfer, Technology Transfer Offices are instrumental in promoting innovation and public benefit.

2. To provide service to the UC academic community: Technology Transfer Offices serve the academic community in all types of intellectual property-related activities such as the transfer of proprietary materials into and out of the university. They provide policy guidance, mentoring and education about protecting and commercializing intellectual property, supporting faculty, postdocs and graduate students who have the desire but not necessarily the experience to champion the development of promising early-stage technology and to start new ventures.

3. To create, support, and maintain research partnerships with industry: Research is a primary mission of the University of California, and partnerships with industry allow for the expertise of university researchers to be focused on solving problems and answering questions of interest to industry and also to allow for innovations resulting from these interactions to be made available to industry. Technology Transfer Offices enhance research partnerships by offering university intellectual property to support and expand interactions with industry.

4. Support economic development: Technology-driven businesses create new jobs and drive regional and national economic development. Effective technology transfer from land-grant universities is an essential first step in creating new companies employing highly skilled graduates and contributing to the economy through increases in the tax base and the purchase of goods and services.

5. Secure fair compensation for UC technologies: Technology Transfer Offices are the stewards of public intellectual property assets, so they seek to secure fair compensation for their available technologies keeping in mind the need to provide service to all of the stakeholders involved in the technology transfer process. Finally, revenue generated from the technology transfer program is invested back in the university's education and research programs.

Technology Transfer Offices serve the research mission of the University of California

The University of California is the premier research university in the U.S. today, and the five goals of University of California Technology Transfer Offices outlined above make clear that these programs exist primarily to support the research mission of the university.

To put some perspective on this issue, the University of California received over $4 billion in sponsored research funding in FY10. This compares with a little over $100 million from patent and licensing income – a number that has been reasonably constant over the past few years.

Clearly, the University of California faculty are not looking to the income from patent and licensing as the underpinning for the operation of their laboratories, but rather they compete for sponsored funding from the federal government, foundations, and industry where the University of California excels, attracting almost 10% of all the federal funding that supports research in U.S. universities and research institutions.

Following the principles outlined above, University of California Technology Transfer Offices in support of the Land Grant mission of our institution will continue to build strong relationships with our industry partners, bringing forward the products resulting from the research of our outstanding faculty to ensure it benefits the public in California and the nation.

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NOS Festival celebrates 100 years down memory lane

Amber Sommerville

For five days, from May 26-30, 2011, thousands of individuals from the Inland Empire attended the National Orange Show Festival in San Bernardino as the show celebrated 100 years since its inception in 1911. Begun as a Citrus fair, the show has become a family-friendly activity featuring a full carnival, fair-food, art exhibits, concerts, circus acts and the like.

The event's long and storied past actually goes back as far as the 1800s. As history would have it, the Washington navel orange was first brought to the Inland Empire area in the early 1870s, giving a tremendous boost to the area's fledgling citrus industry. Along with the growing industry, a series of citrus fairs were held in the 1880s and 1890s. In 1889, the very first "Orange Show" was staged in San Bernardino. Since financial success was apparent and the show was so well received by the community, the event was extended to an eleven-day run.

The "Orange Show" went "National" in 1911 with tents pitched at Fourth and "D" Streets in San Bernardino. By that time, the impact of the citrus industry on San Bernardino economics had escalated. This introduction provided the setting and circumstances for the genesis of the National Orange Show organization, a non-profit benefit corporation formed to serve as an asset to the citrus industry.

The Orange Show Fair became so popular that by 1923, the National Orange Show purchased the current and permanent location for the show and began construction on the property the following year.

As the decades progressed, the directors and governors of the Orange Show added new dimensions to the venue for year-round activity. Today, the National Orange Show Events Center spans 120 acres with 150,000 sq. ft. of indoor space and has evolved into one of the Inland Empire's premier event locations, hosting hundred of events, including concerts, trade shows, and year-round attractions. But, the annual fair has always remained at the heart of the organization.

During the 2011 run of the show, The National Orange Show was proud to celebrate its 100th birthday with a special room of history exhibits and orange displays. (Incidentally, the 2011 fair was technically the "96th annual Festival" because there were no shows for four years during World War II). Also, for the first time this year, the Citrus Research Board participated as a new exhibitor to bring awareness to the public on current citrus-related issues – the most urgent of which, of course, is the Asian citrus psyllid threat.

Although a lot has changed over 100 years, what remains and will continue is community-oriented fun, rich tradition, and a homegrown appreciation of California oranges.

Amber Sommerville is Marketing and PR Coordinator, National Orange Show Events Center, San Bernardino.

The National Orange Show was launched with the stated purpose of being an asset to California's citrus growers, and in its heyday as a festival that was closely aligned with the industry, the annual fair became famous for its enormous and elaborate exhibits of fresh citrus. Here are just two examples, from 1923 (top) and 1930 (bottom). *Photos courtesy of the NOS Events Center.*

Renewed interest in a rich heritage…

Despite changing times and a dwindling number of citrus groves in the Inland Empire, the first question many guests ask upon arriving at the National Orange Show (NOS) Festival is "Where are the Oranges??"

Beginning in 2008, thanks to generous donations from the Inland Orange Conservancy in Mentone, CA, the NOS refocused its emphasis on citrus by bringing back several orange displays consisting of four tons of fresh local oranges.

In 2010, the Orange Show entered a 40-foot parade float adorned with several tons of oranges, into San Bernardino's Bicentennial parade. The float was on display during the 2010 Festival. In addition to several orange displays in 2011, for the first time the NOS invited the Citrus Research Board to be present on the grounds during the Festival to educate guests on California citrus.


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Renewed focus on Fuller rose beetle control

Jim Cranney

When Japan dropped its phytosanitary requirements for Fuller rose beetle (FRB) in the mid-1990s, interest in FRB control subsided. However, FRB is in the spotlight again as trading partners in Korea and Thailand have raised phytosanitary concerns about the possible movement of FRB eggs on fruit destined for those countries.

Except for clogging sprinkler heads from time to time, FRB is not a major pest of California citrus, and adult beetles rarely if ever make it into a packed carton for shipment. The primary concern is eggs, which are difficult to remove once laid under the calyx. Since it is difficult to remove or kill FRB eggs once they are laid, it is important to kill as many adults as possible before eggs can be laid.

While Korea allows fumigation for FRB at the port of arrival, other destinations such as Thailand refuse entry of fruit where FRB has been detected. With more markets raising barriers because of FRB, control of this pest is becoming more important. When fruit is denied entry in export markets, it must be sold in the domestic market. Since the domestic market is already well-supplied, it is difficult to market more domestic fruit without reducing the price and in turn reducing grower prices.

FRB control

FRB has proved difficult to control because adults emerge from the soil every month of the year with peak emergence taking place over the July-October period. When adults emerge, they instinctively look for avenues to climb trees to lay eggs because they cannot fly. When foliage is touching the ground, there are many available avenues for adults to reach foliage and fruit. Skirt pruning and removing weeds can minimize avenues for entry to the tree, so fewer adults reach the canopy to lay eggs.

In addition to skirt pruning, the University of California is experimenting with trunk sprays, and both cryolite and carbaryl can be effective as preharvest foliar sprays.

To detect FRB, look for typical jagged patterns of feeding on foliage and tap branches over a white cloth to dislodge the adults. They will drop and "play dead" so they are easy to spot against the white cloth.

An FRB pupa with two larvae.

Leaf damage caused by Fuller rose beetle.

Fuller rose beetle adult.

FRB eggs under the fruit button of citrus.

All photos courtesy of UC Statewide IPM Program, copyright 2000, Regents of the University of California.

Research for new control measures

With the emerging importance of FRB, UC Riverside's Dr. Joseph Morse and the Lindcove Research and Extension Center's Dr. Beth Grafton-Cardwell plan to evaluate existing and new foliar pesticide treatments, how to make trunk sprays more effective, and whether *Fidiobia citri* (an egg parasitoid), will control FRB. The Agricultural Research Service's Dr. Spencer Walse in Parlier plans to evaluate fumigants that could be used to kill FRB eggs.

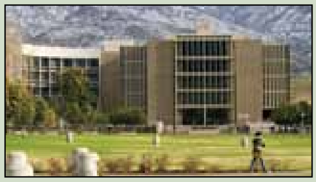
The goal is to find more and better ways to control FRB and keep export markets open. Meanwhile, growers are encouraged to evaluate their groves for the presence of FRB and take steps to reduce the populations.

In closing, I would like to add a special note of appreciation to Dr. Morse for his invaluable input to this article. As many readers will recall, it was Morse who took the lead on FRB research when the pest first became an issue for California in the 1980s.

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

Citrus Roots
Preserving Citrus Heritage Foundation





The Citrus Label Era (1887 to 1955)

Tom Spellman

Early California citrus

During the latter half of the 18th century, California (then known as Alta California) was still in Mexican territory. The Spanish padres were busy establishing the mission system and bringing with them as many plant food sources as possible. Transportation of live plants was difficult and cumbersome, so the preferred source was propagation material. They brought dormant cuttings of figs and grapes as well as seed for citrus and other fruits and vegetables.

The first orchards and vineyards were established in the 1760s. Within a few years, fruitful plantings stretched from the tip of Baja to the northern end of the California territory. The first varieties were seedling strains of sweet and sour oranges as well as the lemon-like citron. By the 1830s and 40s, many early Californians traded and bartered with the missions and established orchards of their own. One of these early pioneers was William Wolfskill, who became a citizen of Mexico in order to purchase land and start his farming operation at the pueblo de Los Angeles.

The first shipments

Due to very limited and slow transportation, all early California citrus fruits were for local consumption only. By the time of the California gold rush, Wolfskill was in full production and began to ship citrus fruit north to San Francisco via sailing ship. Citrus fruit was of great demand to the early gold miners, as it was the only reliable prevention for scurvy. Oranges and lemons were selling in the gold fields for as much as $1 each.

By the 1860s, the railroad system was establishing itself as a reliable source of transportation from east to west. It was during this time that Joseph Wolfskill (William Wolfskill's son) sent the first shipment of California citrus east to St Louis via Southern Pacific Railroad. Wolfskill's shipment was successful, and soon rail shipments of citrus fruit to the eastern markets were frequent. The next decade was dramatic for citrus. During this period of rapid expansion, California citrus acreage exploded from a few hundred acres to over 40,000 acres by 1885.

The need to market

With this huge increase in acreage came huge increases in harvest. But these increases in production were not necessarily a good thing for the fledgling citrus industry. When citrus fruit was rare, the eastern markets absorbed each and every shipment at great profit to the grower. At this point in citrus history, shipments outgrew the marketability of the produce,

PERIOD OF NATURALISM

Argonaut, circa 1910-1915

Mountain Lion, circa 1900-1905

La Mesa, circa 1890-1899

Upland Quail, circa 1905-1915

Camp Fire, circa 1905-1910

and many shipments sent east on speculation were left rotting on Midwestern and eastern rail docks.

The need for marketing organizations and a cooperative marketing strategy was apparent and was soon met by newly organized groups like the California Fruit Growers Exchange (now Sunkist) and the Mutual Orange Distributors.

The first labeling

As early as the mid-1880s, proud growers saw the need to distinguish their fruit from other growers' product. The first labeling was crude and informational, consisting of hand-painted or stenciled box heads with grower and geographic information only.

With this increase in marketing effort, eastern produce buyers began to recognize where the quality fruit was being grown. Areas like Riverside, Redlands, Ontario and Pomona became known for their quality fruit. As the influence of marketing organizations increased, so did the need for advertising and influential labeling.

It is believed that the first true labels were used in 1887. Some were done as single color wood block prints and others as multicolor stone lithographs. Some early packers in the Riverside area used small round labels depicting brand and grade of fruit, centered on a partially stenciled box end with exchange information. Simultaneously, some packers were using full-size square labels that covered the box end and printed all information in full color. Round labels were approximately 6" in diameter, and square labels were approx. 9" x 10" in size. The larger size square labels were soon the standard of the industry as more information could be offered in a larger, bold, artistic format.

Several west and east coast lithographic printers began to specialize in fruit box labels of all types and designs. Many prominent artists of the time were employed by the lithographers to design images and lettering. One such artist was Herman Hansen, who was employed by the H.S. Crocker Litho Co. of San Francisco. Many of the early western design labels were designed by Hansen.

Citrus industry researcher and art historian Gordon Mc Clelland has divided the label era into three distinct periods: Naturalism, Advertising and Commercial Art.[1]

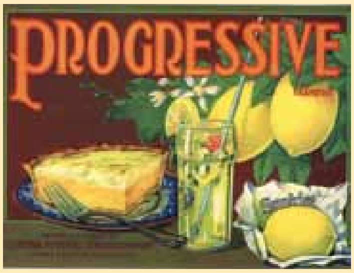
Naturalism (1887 – 1920): This period played on the mystique of the western frontier. Little effort was made to represent the fruit itself. Labels of this period depicted images of western geography, Native Americans, pioneer heroes, Mexican heritage, beautiful women, birds and animals.

These wonderful images of western life not only sold the fruit, but sold the virtues of the west itself. It's been said that many an easterner made their final decision to go west while eating a delicious California orange and viewing the compelling image depicted on the label. One can certainly understand how on a bitterly cold winter

ADVERTISING PERIOD

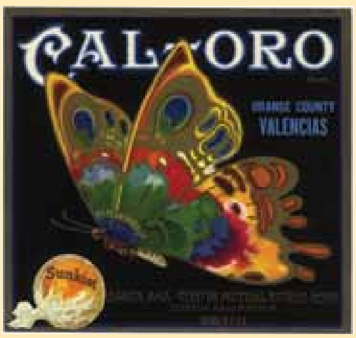
Tesoro, circa 1930-1935

Flavorite, circa 1925-1930



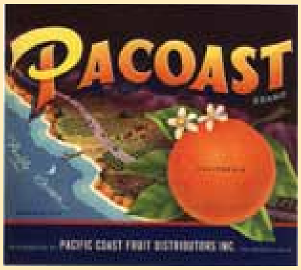
Progressive, circa 1925

Corona Cooler Lemon, circa 1930

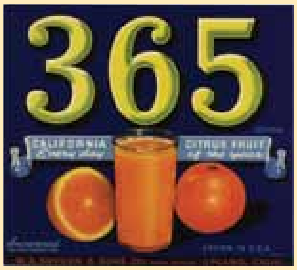


Cal Oro, circa 1930

COMMERCIAL ART PERIOD

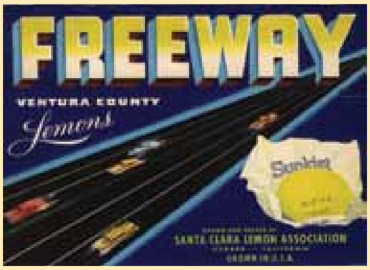


Pac Coast, circa 1935-1940



365, circa 1950

Orange Circle, circa 1940



Freeway Lemon, circa 1950

day in the eastern United States, a person could be inspired to go west by the beautiful label scene of a sun-drenched California orange orchard.

Advertising (1920 – 1935): In the years following World War I, lifestyle in the United States changed dramatically. Advancements were being made in transportation, agriculture, construction, communication, and most other aspects of daily life. Americans were living the so-called good life. Many new and improved products were being advertised and distributed nationally, and citrus was no exception.

The advertising era of citrus labels changed the way citrus was marketed. The value of the label as a vehicle for advertising was being recognized. The labels of this period featured the fruit itself. More attention was paid to the origin, quality, flavor and health aspects of the fruit. Images of fruit in daily use were commonplace – oranges in crystal bowels, orange slices on a plate, pitchers and glasses of orange juice and lemonade, as well as lemon meringue pies were popular label subjects of the time. Also popular during this era were images of children with fruit, storybook characters, and exaggerated images depicting fruit. California citrus was now a worldwide business.

Commercial Art (1935 – 1955): By the mid-1930s, the success of the advertising era had paid off. Citrus was now a staple of the world diet. California was growing, packing and shipping more than 35 million boxes of citrus fruits per year.

Again, the labels of this period changed dramatically. Bold block letters and geometric images changed the lines and look of the labels. Many images from the previous era were re-worked and streamlined to reflect a new modernized style and boldness. Marketers wanted the labels to be recognizable from a distance of 40' to 50' away. The method of lithography had also evolved, and new modern photo-litho processes lowered printing costs and cut production time considerably.

The end of an era

By the mid-1950s, the American marketing system was again changing. Small grocery and produce stores were closing at record rates and being replaced by giant supermarket chains. Most produce, including citrus, was being purchased by the chains in large lots, and the value of the label became less and less important. Also in the mid-1950s, the wooden citrus shipping crate was being replaced by preprinted cardboard boxes depicting lackluster images with little color. The 70-year run of the citrus box label was over.

It's been estimated that during the label era, close to 10,000 different citrus box labels were created. Some were used for very short periods (maybe only one or two years), while popular brands have been used through the entire period and some – in very evolved forms – are still in use today.

[1] Mc Clelland, Gordon, Last, J.T., "California Orange Box Labels", Hillcrest Press, Inc. (1985).

Tom Spellman is southwestern sales manager for Dave Wilson Nursery, which specializes in the production of fruit and nut trees for the U.S. wholesale and commercial markets. Tom has been involved in the production and sales of avocado, citrus, fruit and nut trees since 1981. Tom is a board member of the Citrus Roots-Preserving Citrus Heritage Foundation and also serves on the board of the California Citrus State Historic Park in Riverside. He is the 2011 president of the Citrus Label Society and an avid collector of original citrus packing crate labels. To learn more about the Society, go to www.citruslabelsociety.com

Research Project Progress Report

Identification of odor-based lures and repellents for the Asian citrus psyllid

Anandasankar Ray, Lisa Forster and Robert Luck

The Asian citrus psyllid (ACP) is known to transmit a bacterium called *Candidatus* Liberibacter asicaticus, which causes the deadly citrus greening disease (also known as huanglongbing (HLB)) around the world. This psylllid has recently been found in areas of Southern California, which is a major cause of concern for the citrus industry here.

The adult psyllids feed on citrus plants, and females gather in numbers and lay eggs on the young leaves. In order for a psyllid to spread the disease, it needs to first find and feed on an infected plant to pick up the bacteria and subsequently find and feed on a second plant, thereby inoculating the tree.

Like many other insects, the ACP relies heavily on the sense of smell to find the plants. The olfactory system provides an ideal target to design methods to interfere with the ability of the insect to smell and therefore disrupt its ability to find host plants and subsequently transmit the bacterium.

In our project we are using sophisticated methods to study the olfactory system in ACP to find odors that can be used to block the insect from finding citrus plants. These methods allow us to precisely measure the signals generated in the nose of the psyllid, called the antenna, when it comes in contact with plant odors.

In the first part of the project, we are interested in finding a highly effective odor lure that can be used to attract ACP effectively to traps for surveillance or to larger traps for population control. In the second part of the project, we are interested in finding odors that ACP avoid strongly and can therefore be effective in repelling ACP from citrus plants and groves.

All of our experiments are currently being performed in the confines of the secure quarantine facility at the University of California Riverside. We have established a disease-free rearing facility inside the quarantine facility that supplies us with healthy adult ACP to perform our experiments. Inside this facility we take several precautions to contain the insects securely, such as cages with double walls, tightly sealed containers, and careful handling of insects by highly trained personnel.

After setting up a healthy colony, we embarked upon the process of setting up the sensitive instrumentation inside the quarantine facility, which would enable us to identify the various lures and repellent odors for ACP. Specialized equipment has been designed to perform behavioral testing of psyllids at high-throughput to test for attraction and repellency. These assays will enable us to quickly and reliably identify odors that can act as attractants or repellents.

We believe that ours is the first and only single-unit electrophysiology instrument (Figure 1.) that is currently used to study the ACP antenna in close detail. Once the instrumentation was set up and an appropriate protocol was established, we started testing compounds that are potential candidates for attractants.

Tiny hairs which house sensory cells called neurons cover the surface of the psyllid antenna. Along with the hairs, the antennae have pit-like structures that also house sensory cells (Figure 2). Odor-detecting cells are found inside every pit-like structure, however only a few hair-like structures contain them. Since very little is known about the different types of sensory cells, we first asked which of these cells on the antenna are involved in the detection of odors and act as sensors for the insect. We were able to identify several cells on the antenna that specifically respond

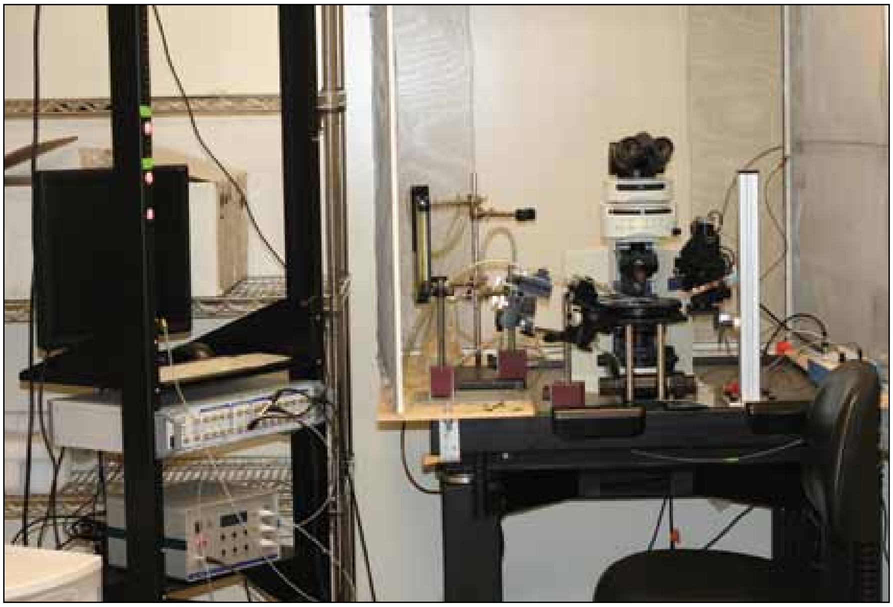


Fig. 1. Photograph of a single-unit electrophysiology apparatus that is used to measure activity of the ACP antennal cells.

to odors. Based on this initial work, we are now able to target our efforts to the odor-detecting pits and hairs.

In order to identify potential attractant odors, we have started recording the responses from single sensory cells of the psyllid antenna to odors that are emitted by citrus fruits and citrus flush. We find that a small number of the odorants from citrus are able to activate specific sensory cells on the psyllid antenna (Figure 3) suggesting that they may therefore be important for the attraction to the citrus plants. The other interesting finding is that we have been able to identify sensory cell types that appear to detect mostly citrus-related odors, suggesting that activation of these cells leads to attraction behavior in the psyllid.

Knowing the identity of such citrus-specific detector sensory cells allows us to identify other odors (natural and artificial) that can activate these sensors even better and could potentially be useful as strong lures. We are currently testing the activities of a number of compounds identified by a company called Inscent Inc, California, against these sensory cells on the ACP antenna which they predict will activate the olfactory system. Once specific odors from citrus are identified that strongly activate the ACP antenna, we plan to test them in various behavioral assays in the laboratory to identify the strongest attractants. Odors that are strong attractants in the laboratory assays will be transferred to field testing in Florida with our collaborator Dr. Lukasz Stelinski.

The final goal of the project will be to use these odors as lures to create a better trap in the field. The current monitoring trap is based on yellow color alone, and this is not a strong attractant for psyllids. Adding an odor attractant would greatly improve our ability to trap and find the ACP and so increase the success of the control program.

In the second part of the project, we plan to identify potential repellent odors from guava by measuring the activity of the different sensory cells on the ACP antenna. Using this approach, we have been able to identify sensory cells that respond to odors emitted by guava plants. These guava odors are ideal candidates for being tested as repellents that can be environmentally safe and affordable as a spray-on application or to reduce contact of the ACP with citrus.

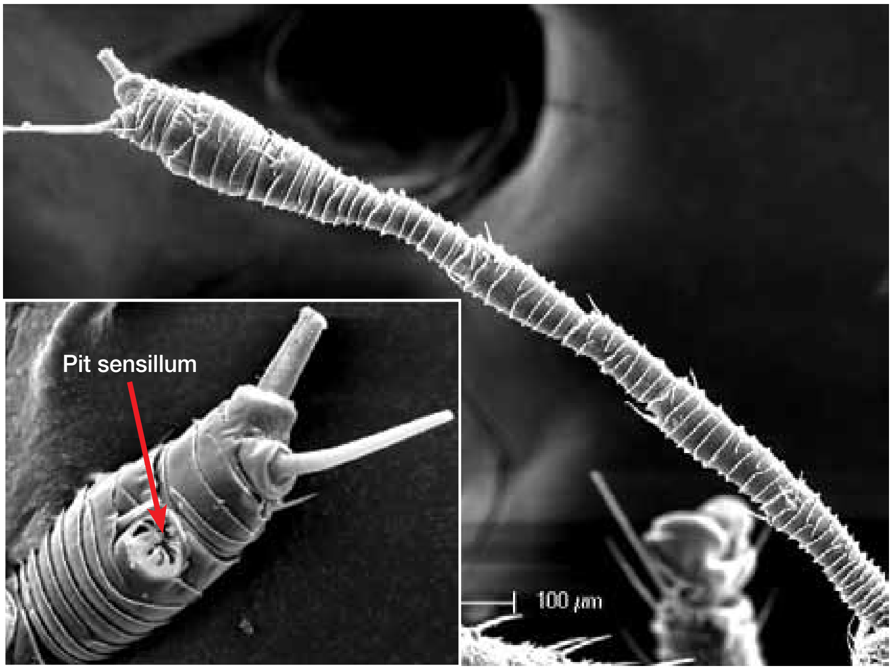


Fig. 2. A scanning electron micrograph of ACP antenna (dorsal view). Inset: the tip of the ACP antenna showing hair-like and pit-like sensilla that detect odors.

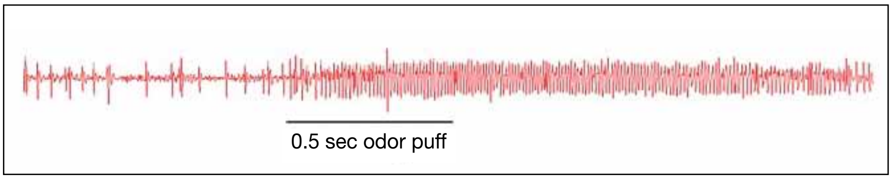


Fig. 3. A sample trace of electrical activity of a sensory cell in the pit-like sensilla of ACP responding strongly to an odor from citrus.

We have also started to design specialized equipment to perform behavioral testing of psyllids at high-throughput to test for attraction and repellency inside the secure quarantine facility at UC Riverside. These assays will enable us to quickly and reliably identify odors that can act as attractants or repellents.

Results from this ongoing project have allowed us to understand the ACP olfactory system in great detail. Although it is a complicated organ, the discovery pipeline that we have established and the information we have obtained has helped us streamline the identification of attractants and repellents.

The use of odors to control behavior is very attractive for ACP control from several different perspectives since they can be useful in very small quantities, be affordable, be environmentally friendly, and be compatible in combination with a variety of other types of control programs. We expect that by the time we complete the project, we will be able to identify both optimal lures and repellents to help with the control of ACP.

All authors are with the Department of Entomology, University of California Riverside. Project leader Dr. Anandasankar Ray is an Assistant Professor of Entomology, Lisa Forster is a Staff Research Associate, and Dr. Robert F. Luck is a Professor of Entomology.

(CRB research project reference number 5500-186.) ●.

CALENDAR

Aug 22-24	CRB Research Proposals and Reports, CRB Board Meeting Bakersfield, CA
Aug 25	CRB-UCCE Citrus Research Grower Seminar Parlier, CA
Aug 26	CRB-UCCE Citrus Research Grower Seminar Exeter, CA
Sept 20	CRB Annual Meeting Visalia, CA

Please support the Harry Scott Smith Biocontrol Scholarship Fund at UC Riverside

A special message from invasive species researcher Mark Hoddle

Invasive species are an ever-increasing problem in California agriculture, and obviously citrus is no exception. One tool that can be used to combat invasive species is biological control. The science of biological control – the use of a pest's natural enemies to suppress its populations to less damaging densities – was pioneered in Southern California. This new discipline in entomology was in large part driven by the citrus industry's need to control invasive species, especially the cottony cushion scale which was devastating citrus in the late 1880s.

The phrase "biological control" was first used by Harry Scott Smith in 1919 at the meeting of Pacific Slope Branch of the American Association of Economic Entomologists at the Mission Inn in downtown Riverside. In 1923, Smith, who had been working on the biological control of gypsy moth with USDA, moved to the University of California Riverside to form the Division of Beneficial Insect Investigations, a unit separate and distinct from the Department of Entomology.

Prof. Smith, affectionately known as "Prof. Harry", went on to create and chair the Department of Biological Control at UCR, which offered the only graduate degrees in biological control in the world. He is considered the "father" of modern day biological control. Prof. Harry brought recognized entomological training in biocontrol to California for the first time, encouraging work on the applied and practical aspects. Under Prof. Harry's supervision, the science of biological control was developed in Southern California, and, naturally, a major research focus was the biological control of citrus pests.

The *Harry Scott Smith Biological Control Scholarship Fund* in the Entomology Department at UCR was started with a small gift from Prof. Harry, and regular fundraising is necessary to maintain and grow the fund. The sole purpose of the fund is to attract the brightest students to UCR to study biological control. To do this, awards are made annually to provide assistance to students studying biocontrol so they can attend conferences to present the results of their research or to participate in training workshops.

With an ever-increasing number of production challenges facing the citrus industry, biological control is still one of the best tools available for reducing economic damage from invasive pests, and projects on Asian citrus psyllid and Diaprepes root weevil are attempting to do this.

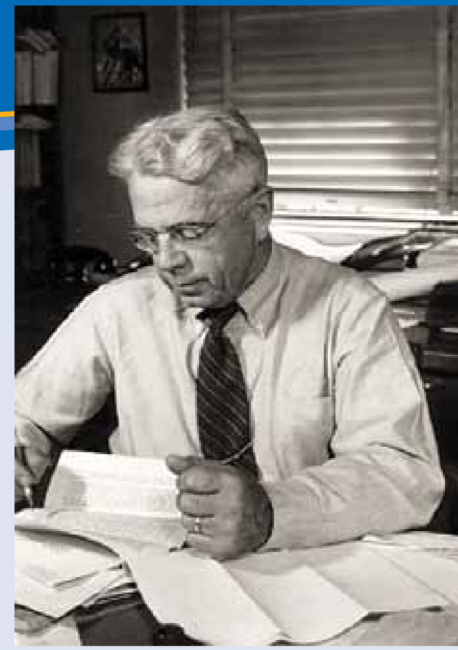
If you are interested in supporting the *Harry Scott Smith Biological Control Scholarship Fund* at UCR, tax deductible donations made payable to the "UC Foundation" can be mailed to Mark Hoddle, Department of Entomology, University of California, Riverside, CA 92521. More information on the Scholarship, past awardees, and a list of donors can be reviewed at http://biocontrol.ucr.edu/hoddle/harrysmithfund.html.

Any level of financial support you can provide for the Harry Scott Smith Biological Control Scholarship Fund at UCR will be greatly appreciated.

Thank you,

M. S. Hoddle

Dr. Mark S. Hoddle
Director, Center for Invasive Species Research
UC Riverside



Professor Harry Scott Smith

Mark Hoddle collecting Asian citrus psyllid natural enemies in the Punjab of Pakistan.

Background and initial evaluations of recently introduced cultivars distributed by the Citrus Clonal Protection Program

Toni Siebert, Georgios Vidalakis, Robert Krueger, John Bash and Tracy Kahn

Each year the Citrus Clonal Protection Program (CCPP) distributes budwood of new, potentially important commercial citrus cultivars as they are released from quarantine after completing a thorough "Variety Introduction (VI)" disease testing and therapy program. An overview of this process was outlined in the March/April 2010 (1: 20-26) issue of *Citrograph*, and a more detailed discussion of national citrus quarantine and introduction programs was presented in a two-part series in the *Citrograph* in 2010 (Part I May/June 2010, 3: 26-35 and Part 2 July/August 2010, 4: 27-39).

New cultivars for California come from the University of California Riverside citrus breeding program or are an introduction of cultivars or selections from within or outside the state. The CCPP provides budwood from these sources as soon as they are released from quarantine to make it possible for researchers to evaluate these selections and cultivars for the California citrus industry.

Trees are propagated from budwood provided by the CCPP and are planted in three Introduction and Discovery Demonstration Blocks (Demonstration Blocks) of trees at Riverside (UCR Citrus Variety Collection), Exeter (Lindcove Research and Extension Center), and Thermal (Coachella Valley Agricultural Research Center). Demonstration blocks provide systematic means of collecting tree and fruit quality data on a large number of cultivars introduced from other parts of the world. Each location has one to three trees on one or two rootstocks. In addition, demonstration blocks provide venues for growers to view new cultivars in comparative plantings and provide feedback to the researchers. Introductions and promising scion selections from the breeding program that demonstrate promise will be selected for incorporation into replicated trials for more comprehensive evaluation for their commercial potential.

This article is the second in a series of articles compiled by the staffs of the UCR Citrus Variety Collection (CVC), USDA National Clonal Germplasm Repository for Citrus and Dates (NCGRCD), and the CCPP. The first article appeared in the March/April 2010 (1: 20-26) issue of *Citrograph*. The purpose of this article is to provide information about these new cultivars. Although the CCPP staff provides budwood of new introductions to researchers soon after release, very little or no data on the performance of these cultivars in California are available prior to when the CCPP distributes budwood of new cultivars to the industry as part of their Early Release Budwood Program.

For the cultivars described below, listed under the Early Release Budwood program, we have information about them from their country of origin and the CCPP VI identification number used for budwood distributions. For most, we also have one to two years' data on their performance in California. The final two cultivars included in this article are Rubidoux grapefruit hybrids which have been available from the CCPP for a while but for which very little was known. Below we provide available background information on these two hybrids and data on their fruit quality characteristics.

Early release budwood

"Early Release" budwood is budwood provided from selected cultivars that are recently out of quarantine and are maintained by the CCPP at the LREC Protected Foundation Blocks for the "Early Release" program. Young trees of these cultivars are grown in pots under protective screen and as a result, produce limited amounts of budwood which can be distributed. A signed "Waiver and Release" form must accompany all orders for Early Release Budwood since these cultivars are newly available and were released prior to extensive evaluations for trueness-to-type. The "Waiver and Release" form is available on the CCPP website (http://www.ccpp.ucr.edu).

SRA 489 Marumi kumquat (VI 673): *The first distribution of buds from the CCPP occurred September 2010.* This kumquat variety is also known as the Round Kumquat. Willits and Newcomb Nursery in Arvin, California sent budwood of 'Marumi' kumquat to the Germplasm Agrumes Collection at Station de Recherches Agronomiques (SRA), Corsica, France, in 1966. Budwood of this SRA 489 selection of Marumi was received by the Citrus Clonal Protection Program from INRA, San Giuliano, Corsica, France, in 1997. According to "The Citrus Industry" (1967), 'Marumi' kumquat is the same as the 'Maru' or 'Marumi kinkan' of Japan.

The fruit of 'Marumi' closely resembles 'Nagami' kumquat or oval kumquat fruit, but 'Marumi has a thinner and somewhat sweeter rind. Hume (1926) describes the fruit of 'Marumi' kumquat as shaped like a sphere or a sphere flattened at the poles, "1 to 1 1/4 inches [2.5-3 cm] in diameter; golden yellow, short stalked; calyx small; rind smooth, thin, spicy to the taste and aromatic when bruised; oil cells large; pulp sparse; juice acid; sections four to seven; seeds one to three, small, oval, greenish; cotyledons two, greenish". Hume also reports that the season for 'Marumi' is the same as Nagami kumquat, maturing in the winter and holding well on the tree.

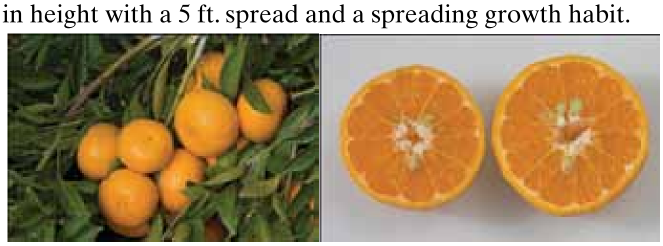
According to Hume (1926), 'Marumi' kumquat trees are somewhat thorny, and leaves are oval in shape and somewhat smaller and rounder at the apex with veins slightly more conspicuous than Nagami kumquat. The leaves of 'Marumi' are borne on short rigid, inconspicuously winged petioles. "The Citrus Industry" (1967) also describes Marumi kumquat trees as less vigorous than Nagami kumquat trees.

SRA 489 'Marumi' kumquat, CVC, Riverside, CA. 1/19/2009. *Photo by D. Karp and T. Siebert*

Avana tardivo di Ciaculli mandarin (VI 687): *First distribution of buds from the CCPP: September 2010.* 'Avana' is the Italian name for the common mandarin of the Mediterranean basin which is known as Willowleaf mandarin or less commonly as Mediterranean mandarin in the US. This selection of 'Avana' was developed in Sicily, Italy and named tardivo after the Italian word for late and Ciaculli after a city in Sicily. 'Avana tardivo di Ciaculli' was donated to INRA, San Giuliano, Corsica, France, in 1966, and received by the CCPP in 1997. This particular selection of 'Avana' has become the most popular of the 'Avana' selections in recent years due to its sweeter flavor (Saunt 2000). This selection is also flatter at the poles in shape and later maturing than other 'Avana' selections (Saunt 2000).

The first evaluation of trees of 'Avana tardivo di Ciaculli'grown in California occurred in 2009 at the Demonstration Blocks in Exeter and Riverside. Based on this and the 2010 fruit quality evaluations of 'Avani tardivo' from Exeter, the fruit reach legal maturity in late December to early January (a month later than 'Avana apireno') but taste best in February (average solids to acid ratio 11.6) . Saunt (2000) reported that the fruit mature up to two months later than other 'Avana' selections. Australian researchers report that this selection is six to eight weeks later than 'Imperial', which has a maturity similar to 'Owari' satsuma.

Based on the 2010 evaluations of fruit from four trees for five sample dates from mid-October through early February, the fruit 'Avana tardivo di Ciaculli' averaged 10.0 seeds per fruit. The fruit are somewhat flattened in shape (average length/width ratio of 0.84, Exeter 2010) with a pale orange rind and medium orange flesh color. The three-year-old trees in Riverside have strong vigor and are approximately 5.5 ft. in height with a 5 ft. spread and a spreading growth habit.



'Avana tardivo di Ciaculli' mandarin, CVC, Riverside, CA. 2/25/2010. *Photo by D. Karp and T. Siebert*

Avana apireno mandarin (VI 688): *First distribution of buds from the CCPP: September 2010.* This cultivar is also a selection of a Willowleaf mandarin. According to the INRA San Giuliano website, 'Avana apireno' originated in 1810 in Italy. However, Russo *et al* (1975, 1977) reported that 'Avana Apireno' mandarin was discovered in an 'Avana' orchard in the Picanello area of Catania in 1962. At that time, three trees that produced fruit had few seeds". Russo et al (1977) also reported that clonal offspring of those original trees were grown in different locations within Southern Italy, and all produced fruit that were low seeded. The name of this 'Avana' selection, 'Avana apireno' comes from the Italian word for "seedless".

The Instituto Sperimentale per l'Agrumicoltura, Acireale, in Sicily, Italy, donated budwood to INRA, San Giuliano, Corsica, France, in 1983, and it was received by the CCPP in 1997. This selection is commonly grown in Sicily, particularly the area near Catania. Information from Australia indicates that fruit of this selection mature three to five weeks later than 'Imperial' mandarin, which matures about the same time as 'Owari' satsuma.

The first evaluation of trees of 'Avana apirenoi 'grown in California also occurred in 2009. Based on the 2009 and the 2010 fruit quality evaluations of 'Avani apireno' from Exeter, the fruit reach legal maturity by early December. Results of the 2010 evaluations of fruit from four trees for five sample dates from mid-October through early February demonstrated that the fruit 'Avana apireno' averaged 3.5 seeds per fruit. The fruit of 'Avana apireno' are also flattened in shape like 'Avana tardivo' (average length/width ratio of 0.82, Exeter 2010) with a pale orange rind and medium orange flesh color. The four-year-old trees in Riverside have strong vigor and are approximately 5.0 ft. in height with a 5 ft. diameter with a dense and spreading growth habit.

'Avana apireno' mandarin, CVC, Riverside, CA. 2/25/2010. *Photo by D. Karp and T. Siebert*

USDA 6-15-150 mandarin (VI 691): *First distribution of buds from the CCPP: September 2010.* Also known as 'USDA 15-150', this cultivar is a hybrid of 'Lee' mandarin and 'Orlando' tangelo. The cross is believed to have occurred sometime in the 1960s or 1970s and was developed in Florida by C. J. Hearn. The CCPP obtained 'USDA 6-15-150' in 2006 from the USDA-ARS Horticultural Research Laboratory in Ft. Pierce, Florida. According to the donor, characteristics of this selection under Florida growing conditions include outstanding taste, good internal color, and problems with degreening. This hybrid is also reported to have the distinction of being the most cold-hardy scion hybrid to be considered for release from the USDA breeding program and can be best compared to Satsuma in hardiness but has much better overall characteristics than other cold tolerant varieties.

Results from fruit quality evaluations of 'USDA 6-15-150' conducted in Florida indicate that the fruit are medium in size, very easily peeled by hand, pleasant tasting, and should have less than 10 seeds in the absence of cross pollination. Further, harvest usually requires clipping of the fruit, although the cultivar is not quite as good as Sunburst in this respect. External fruit color at maturity is brilliant orange in contrast to the interior, which is a deep shade of orange reminiscent of 'Fallglo' tangerine. Yields for 'USDA 6-15-150' in Florida have been consistent and are good to excellent as long as the fruit are not left hanging on the tree. The harvest season for this cultivar in Florida should occur from the middle of November through the end of the calendar year.

The first evaluation of trees of 'USDA 6-15-150' grown in California occurred in 2009. Based on the 2009 and 2010 results at both Exeter and Riverside demonstration blocks, fruit were already above legal maturity by mid-October at Exeter and mid-October to early November at Riverside, but the external rind color was still very green and did not reach color break until about a month later at Exeter. Two samples of 10 fruit of 'USDA 6-15-150' collected from Exeter and Riverside for three sample dates in 2009 and four sample dates in 2010 had an average of 11.8 seeds per fruit. The fruit from both locations at all sample dates were only slightly flattened in shape (average length/width ratio of 0.90) with medium orange flesh color. The four-year-old trees in Riverside have medium vigor and are approximately 5.0 ft. in height with a 5 ft. diameter with a spreading growth habit.

'USDA 6-15-150' mandarin, CVC, Riverside, CA. 1/12/2011.
Photo by T. Siebert

SRA 513 Bahianinha navel (VI 699) and Bahianinha Araras navel (VI 700): *First distribution of buds from the CCPP: September 2010.* These two selections of Bahianinha navel oranges have slightly different introduction histories. 'SRA 513 Bahianinha' navel was apparently developed in Piracicaba, Sao Paulo, Brazil, and donated to INRA, San Giuliano, Corsica, France, in 1971. It was received by the CCPP in 1997. 'Bahianinha Araras' navel is reported to have been developed at the Instituto Agronomico do Estado Sao Paulo Campinas, Sao Paulo, Brazil. It was received by the USDA-ARS Horticultural Research Station in Ft. Pierce, Florida, in 1940 and obtained by the CCPP in 1999.

The origin of the variety 'Bahianinha', which is the source of these two selections, is a bit of a mystery. Although 'Bahianinha' (also called 'Bahianinha Piracicaba') was presumed to have originated as a bud mutation from the 'Washington' or 'Bahia' navel orange, in the 1st edition of "The Citrus Industry" (1943), Webber presented evidence that it may not have originated in Brazil, as commonly supposed. This variety was found in a planting of navel orange trees at Piracicaba, Sao Paulo State of Brazil, about 1907-1908 with budded trees imported from the United States, presumably Florida(Hodgson, 1967). This variety is also reported to be unstable and to have given rise to two smaller-fruited selections, Ivers and Thomazzelli (Hodgson, 1967).

According to "The Citrus Industry" (1967), 'Bahianinha' differs from 'Parent Washington' in having smaller, more oval-shaped fruit with a smaller, closed navel and a thinner rind. It is stated to be productive but smaller and less vigorous than 'Parent Washington'. It is one to two weeks earlier than 'Parent Washington' and has good fruit quality when grown on an appropriate rootstock. It is stated to be less prone to alternate bearing than 'Parent Washington'. These differences are stated to be less pronounced in California as compared to Brazil. 'Bahianinha' ('Bahianinha Piracicaba') became popular in Brazil due to its desirable size for the export market. It is better adapted to hot, tropical climates than is 'Parent Washington' and has more recently been planted extensively in the Corrientes Province of neighboring Argentina due to this characteristic (Hodgson, 1967). The differences between the various strains of 'Bahianinha' and the selections imported, especially under California conditions, remain unclear.

The first evaluation of trees of these two selections of 'Bahianinha'' grown in California occurred in October 2010. Based on the 2010 fruit quality evaluations from Riverside, where fruit of both 'Bahininha' selections were available, 'Bahianinha Araras' (averaged solids to acid ratio 8.8 and Brim A 5.0) and 'Washington' (averaged solids to acid ratio 11.9 and Brim A 7.0) navel fruit reached legal maturity by mid-October, but the rind was green in color. The other SRA selection reached legal maturity by the early November sample date (averaged solids to acid ratio 10.7 and Brim A 6.3). All three cultivars were past color break by this early November sample date. In Riverside, the four-year-old trees of the SRA 513 selection had strong vigor and are approximately 6.0 ft. in height with a 6.0 ft. diameter with a spreading dense growth habit. The four-year-old trees of the Araras selection had strong vigor as well but were approximately 5.5 ft. in height with a 5.0 ft. diameter with a spreading dense growth habit.

'SRA 513 Bahianinha' navel, CVC, Riverside, CA. 2/25/2010.
Photo by D. Karp and T. Siebert

'Bahianinha araras' navel, CVC, Riverside, CA. 2/25/2010.
Photo by D. Karp and T. Siebert

Verna lemon (VI 701): *First distribution of buds from the CCPP: September 2010.* 'Verna' lemon (also known as 'Berna' lemon) is a Spanish variety of unknown origin, possibly arising in Murcia, Spain, from 'Monachello' lemon (Agusti, 2000). Verna was obtained by the Instituto Valenciano de Investigaciones Agrarias in Valencia, Spain, and sent to the CCPP in 2002.

The 'Verna' is a well-established lemon variety in Spain but has not been planted outside of that country to any extent. Gonzalez-Sicilia (1968) states that 'Verna' is the lemon variety most cultivated in the Levant, accounting for 90-100 %

of the plantations in that area. However, Saunt (2000) states that it accounts for only 60% of Spain's crop, with most of this production from the Murcia district, Alicante province. Therefore, 'Verna', although decreasing in the proportion of Spain's lemon production, remains the most important variety.

Hodgson (1967) describes 'Verna' as having fruit that are medium sized with an oval to broad-elliptical shape with a short neck and well-developed nipple. The seed number is reported to vary from usually few to none, and the fruit are bright yellow at maturity with a medium thick rind that is thinner in the summer crop and somewhat rough and tightly adherent. The fruit have a high juice content but with lower acids than other lemon varieties (Agusti, 2000). 'Verna' is reported to produce the main crop in the winter, holding well into the summer but with undesirably large summer fruit; the trees as very vigorous, large, productive and upright spreading.

Saunt (2000) and Agusti (2000) asserted that this variety flowers twice or occasionally three times per season but that the second crop is of inferior quality. According to Gonzalez-Silicia (1968), the main period of production is from February to July. When another crop is forced by the verdelli method (referred to as "redrojo" in Spain), 'Verna' fruits gave the finest and least thick rind of any produced in this time period. 'Verna' tends to be alternate-bearing, especially following a verdelli treatment, and is out-yielded by 'Fino' (Saunt, 2000). In California, 'Verna' is reported to appear much like 'Lisbon' ("The Citrus Industry" 1967). This particular selection of 'Verna' ('Verna 50') is reported in Spain to have medium to high vigor, usually flowering twice, with most fruit held inside the tree (Gardiabzabal-I et al., 2001).

Verdelli process

The verdelli process is used in parts of Italy to produce summer lemons. It consists of subjecting the lemons to water stress in the summer months, producing an off bloom in the early fall. This results in lemons being ready to market the following summer, when prices are high. This method is hard on the trees and can weaken them if done consistently.

The Citrus Variety Collection has an older selection of 'Verna' ('Berna') that was originally from Spain but received as budwood from Dr. Joe Furr at the USDA Date and Citrus Station in Indio, CA in 1965 (http://www.citrusvariety.ucr.edu/citrus/berna_lemon.html). There is no current plan to plant this new selection at the other two Introduction and Demonstration blocks at Exeter and Thermal or to evaluate this selection, but will do so if there is interest in this new selection.

'Verna' ('Berna') lemon, CVC, Riverside, CA. 4/8/2011. *Photo by D. Karp and T. Siebert*

Hansen mandarin (VI 709): *First distribution of buds from the CCPP: September 2010.* 'Hansen' mandarin is reported to have been developed in South Australia and originated on the property of Mr. Hansen of Renmark, South Australia. It was introduced as seed by the Germplasm Agrumes Collection at Station de Recherches Agronomiques, Corsica, France, and obtained as budwood by the CCPP in 1997. 'Hansen' is most probably a tangor and probably arose as an open-pollinated chance seedling. 'Hansen' is a late variety that follows 'Ellendale'. Although it is Australian in origin, it has not become an established variety there. The trees are not very vigorous. The fruit are medium in size and oblate in shape. The thin rind is yellowish-orange in color. The flesh is orange, moderately juicy, and quite seedy with up to 12 seeds per fruit. Fruit quality is only moderate with good sugars but high acid levels. In the cool production area of New Zealand, it matures from August through September and is considered a "poor quality, medium sized mid-to late-season mandarin" (Mooney et al, 1991).

The first evaluation of trees of 'Hansen' mandarin in California occurred in October 2009. Based on our evaluation data from Exeter, 'Hansen' begins to reach color break in mid-November but does not reach legal maturity until early January. The acid level remains high until late in the season, giving 'Hansen' good flavor from February to March, but the fruit can be quite seedy with approximately 12-15 seeds per fruit. As of Feb. 2011, the four-year-old trees of 'Hansen' growing in the Citrus Variety Collection in Riverside had strong vigor and were approximately 6 ft. tall and 5 ft. in diameter with a spreading growth habit. Results of these evaluations will be posted on the Citrus Variety Collection website along with evaluation data for other citrus cultivars (http://www.citrusvariety.ucr.edu).

'Hansen' mandarin, CVC, Riverside, CA. 2/25/2010. *Photo by D. Karp and T. Siebert*

Bouquetier de Nice sour orange (VI 720): *First distribution of buds from the CCPP: January 2011.* 'Bouquetier de Nice' sour orange is said to have originated and been developed in Pamplona, Navarre, Spain, around 1421. This variety was obtained by the Institut Francais Recherches Fruitieres Outremer Rabat, Morocco, and introduced into the Germplasm Agrumes Collection at Station de Recherches Agronomiques, Corsica, France, in 1960. The CCPP obtained 'Bouquetier de Nice' in 1997.

The Bouquetier-type sour oranges represent a distinctive group of bigarade-type sour or bitter oranges. They are generally small trees with few thorns and many flowers. They are grown primarily for their perfumed flowers, which are used in the production of high quality neroli oil and its byproduct of orange flower water. 'Bouquetier de Nice' is vigorous and upright growing. The flowers are double with a very large pistil, which gives rise to a flat fruit of medium size that is also double, having a secondary fruit deeply embedded within the primary fruit. The leaves are large, broad, and slightly tapered (Chapot, 1964) (Hodgson, 1967).

This selection was chosen for introduction to the U.S. due to the attractive horned fruits observed by the staff of the UCR Citrus Variety Collection (CVC), USDA National Clonal Germplasm Repository for Citrus and Dates (NC-GRCD), and CCPP during the ISCN post-conference tour to Corsica in 1997. However, 'Bouquetier de Nice' is consistently described and shown in the literature as having flattened fruit. The pictures in this description show fruit in a basket on display in Corsica. The budwood that was given to the CCPP was supposedly from the tree of which the fruit was taken for the display. It is possible that the Corsica selection was mislabeled and did indeed represent a corniculated selection, a fruit possessing hornlike extensions. The photograph of the single fruit was taken from one of two trees in the Citrus Variety Collection in 2011. Most of the fruits on the trees in the CVC did not have the horns; only a few did. All of the fruits that were cut open showed the secondary fruit. It is possible that this variety needs time to mature before producing fruit with horns. More information on this variety will be distributed as it becomes available.

Left: 'Bouquetier de Nice' sour orange, Station de Recherches Agronomiques, Corsica, France. 1997. Right: 'Bouquetier de Nice' sour orange, CVC, Riverside, CA. 3/4/2011. *Photo by T. Siebert*

SRA 507 California Rojo orange (VI 760): *First distribution of buds from the CCPP: September 2010.* SRA 507 California Rojo orange (also known as California Roja orange) is presumably a mutation of a standard navel orange. This variety was donated to the Germplasm Agrumes Collection at Station de Recherches Agronomiques, Corsica, France, in 1984 and donated to the CCPP in 1997. 'California Rojo' was selected as potentially being of interest to the California citrus industry by members of the California Citrus Nursery Society during a tour of INRA-CIRAD, Corsica, in conjunction with the Congress of the International Society of Citrus Nurserymen in 1997.

According to Franck Curk, curator of the Germplasm Agrumes Collection at Station de Recherches Agronomiques, "in Corsica, 'Cara Cara' navel and 'California Roja' navel are not at the same location, so sometimes we notice some differences in ripening time or coloration, but globally they really look like the same. 'California Roja' was introduced to Corsica from Venezuela in 1984, and 'Cara Cara' was introduced from Spain to Corsica in 1991"(email of 10/20/2009). Although at some point the SRA website provided California as the origin of this variety, it apparently actually was introduced from Venezuela and so the source of the name is unknown. In any case, it is apparently the same or very similar as 'Cara Cara'.

Once the young trees of this cultivar begin producing fruit in the Introduction and Discovery Demonstration blocks at Riverside and Exeter, fruit quality traits of this cultivar will be compared with those of 'Cara Cara' from the same locations to determine the degree of similarity in California.

Miyamoto Satsuma mandarin (VI 779): *First distribution of buds from the CCPP: September 2010.* 'Miyamoto' Satsuma is reported to be a limbsport of 'Miyagawa' discovered on the property of L. Miyamoto, in Wakayama, Japan, and was donated to the Fruit Tree Research Station in Okitsu, Shizuoka, Japan. Budwood was sent to the Instituto Valenciano de Investigaciones Agrarias in Valencia, Spain, in 1988 and donated to the CCPP in 2007.

Of the different cultivars in the Goko Wase very early maturing group of satsuma mandarins, 'Miyamoto' is currently the most popular variety with an estimated 2,500 ha in production (Saunt 2000). Fruit of 'Miyamoto' matures 10 days earlier than 'Okitsu' and 15 to 20 days earlier than 'Miyagawa' and has other superior traits such as good rind and flesh color and high sugar content at maturity (Saunt 2000). The fruit is reported to be medium in size and more spherical in shape than 'Okitsu' or 'Miyagawa' with high yield (Saunt 2000). In China, the marketing season commences in middle-late September. In those areas of China with higher heat accumulation, the fruit matures 15 days earlier than 'Miyagawa' fruit (Deng 2008).

Trees of 'Miyamoto' were planted in the Demonstration blocks at Exeter and Riverside last spring. Once the young trees of 'Miyamoto' begin fruiting in CA, quality traits of this cultivar will be compared with other satsuma selections from the same locations to determine the degree of similarity in California.

Nichigan Ichi Go Satsuma mandarin (VI 780) and Iwasaki Satsuma mandarin (VI 781): Both of these satsuma selections are believed to be a limb sport of an existing cultivar. 'Nichigan Ichi Go' (also known as 'Nichinan ichigo') and 'Iwasaki' Satsuma mandarins were donated to the Instituto Valenciano de Investigaciones Agrarias in Valencia, Spain, in 1994 from the Wakayama Fruit Tree Experiment Station Oki, Kibi-cho, Arita-Gun, Wakayama, and donated to the CCPP in 2007. Very little information is available about these two Satsuma selections. They are apparently in the very early (Goko Wase) Satsuma group and would be expected to mature sometime in October in the northern hemisphere.

Trees of ''Nichigan Ichi Go' and 'Iwasaki' were planted in the Demonstration blocks at Exeter and Riverside last spring. Once the young trees of 'Nichigan Ichi Go' and 'Iwasaki' begin producing fruit in CA, fruit quality traits of these cultivars will be compared with current ongoing evaluations of Satsuma mandarin selections. These varieties are proprietary; however, a license agreement for their distribution in California is anticipated to be in place before data on fruit quality traits in California become available.

Figure 1. First year evaluation of Rubidoux Pummelo cultivars from Exeter, CA, and Riverside, CA.

Lindcove	Sample Date	Soluble Solids (SSC)	% Acid	Solids to Acid Ratio	Length per Fruit (CM)	Width per Fruit (CM)	Weight per Fruit (GRAMS)	Rind Color Rating	Rind Thickness (CM)	Seed Number per Fruit	% Juice
Rubidoux Pummelo #1	1/2/2011	9.8	1.1	8.8	10.3	10.3	405.2	6.1	1.5	16.4	33.4%
Rubidoux Pummelo #2	1/2/2011	10.6	1.1	9.9	10.8	10.2	428.3	6.6	1.3	25.0	33.6%
Rubidoux Pummelo #1	3/2/2011	9.7	0.9	10.8	11.7	11.8	557.2	9.8	1.8	13.5	24.4%
Rubidoux Pummelo #2	3/2/2011	10.9	1.0	11.2	11.9	11.4	536.4	9.9	`1.8	27.7	31.8%

Riverside	Date	Soluble Solids (SSC)	% Acid	Solids to Acid Ratio	Length per Fruit (CM)	Width per Fruit (CM)	Weight per Fruit (GRAMS)	Rind Color Rating	Rind Thickness (CM)	Seed Number per Fruit	% Juice
Rubidoux Pummelo #1	1/2/2011	12.8	1.1	11.3	9.3	9.5	320.0	6.5	1.5	25.8	29.8%
Rubidoux Pummelo #2	1/2/2011	12.8	1.2	11.0	9.1	9.1	294.2	6.0	1.3	26.5	30.5%
Rubidoux Pummelo #1	3/4/2011	12.8	1.1	11.3	10.4	10.1	397.7	9.6	1.4	29.6	24.4%
Rubidoux Pummelo #2	3/4/2011	13.1	1.1	12.5	9.5	9.4	335.3	9.2	1.4	24.9	31.7%

Rind color and texture are visual ratings. Rind color is based on a scale of 0-13, with 0 being green and 13 being red-orange. Rind texture based on a scale of 1-8 with 1 being very smooth and 8 being extremely coarse.

Protected Foundation Block budwood

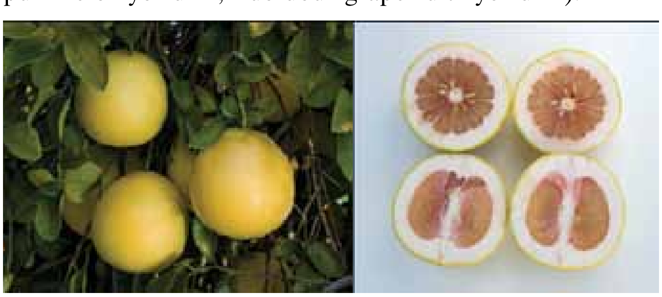
"Protected Foundation Block Budwood" is budwood provided from CDFA-registered CCPP citrus trees from the LREC screenhouses and is available from the University of California in accordance with the CDFA regulations for citrus registration and certification. Protected Foundation Block Budwood is produced from trees grown in pots and in the ground under protective

screen and is intended for individual nurseries or growers to produce their own registered budwood source trees or for the production of nursery increase blocks from which additional budwood may be harvested in accordance with CDFA (or other appropriate) regulations and used for the production of certified nursery stock. A signed "Waiver and Release" form must accompany all orders for Protected Foundation Block Budwood. The "Waiver and Release" form is available on the CCPP website (http://www.ccpp.ucr.edu).

Rubidoux grapefruit hybrid #1 (VI 570) and Rubidoux grapefruit hybrid #2 (VI 571): These two varieties became of interest last year when the Citrus Variety Collection started "deaccessioning" varieties from the collection to make room for new varieties. Duplicate accessions or those having little to no information went on a list of candidates for possible elimination. The 'Rubidoux' grapefruit hybrids had no information to describe origin, pedigree, or any other characteristics, however the fruits were found to be quite delicious. When the Citrus Variety Collection staff began to share them with visitors to the collection, they agreed and were delighted to hear that these hybrids were on the budwood cut list for the CCPP.

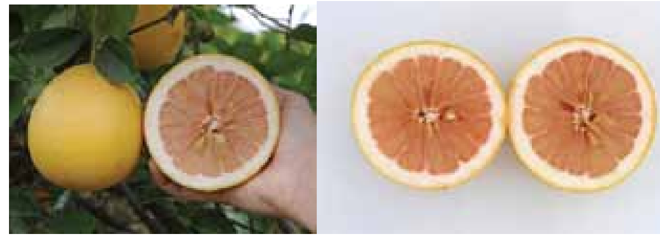
Both varieties are now believed to have been bred at the USDA Date and Citrus Station in Indio, CA and released to UCR when the Station closed. The 'Rubidoux' varieties were propagations that were left in the CCPP Rubidoux screenhouse when Ed Nauer of CCPP and Botany and Plant Sciences retired in 1990. Information on these propagations was lost or misplaced, so Dr. David Gumpf decided to index these varieties and plant them to see what they were. Both appear to be a grapefruit-pummelo hybrid of unknown parentage. Fruits of both varieties have light pink to pink flesh that has been described as tender, juicy, with a very fine texture. The flavor is sweet with very low bitterness and low acidity similar to Oroblanco. They have a thick pummelo-like rind and tend to be fairly seedy. We began evaluating both types in Riverside in January and have continued to eat them through June when they are very sweet. Of the two hybrids, Rubidoux grapefruit hybrid (VI 571) (also known as 'Rojo Blanco' in the Citrus Variety Collection) tends to be the sweeter of the two with a darker yellow rind and continues to be favored above VI 570.

Rubidoux grapefruit hybrid (VI 570): *First distribution of buds from the CCPP: June 2010* (Also known as Rubidoux pummelo hybrid #1, Rubidoux grapefruit hybrid #1):



'Rubidoux #1' grapefruit hybrid, CVC, Riverside, CA. 1/6/2011 *Photo by D. Karp and T. Siebert*

Rubidoux grapefruit hybrid (VI 571): *First distribution of buds from the CCPP: June 2010* (Also known as Rubidoux pummelo hybrid #2, Rubidoux grapefruit hybrid #2, Rojo Blanco):



'Rubidoux #2' grapefruit hybrid, CVC, Riverside, CA. 6/10/2009 *Photo by D. Karp and T. Siebert*

For more information

Additional results on the evaluations of the tree and fruit quality characteristics of these new cultivars and other cultivar grown in California are available at the Citrus Variety Collection website (http://www.citrusvariety.ucr.edu) and at the Citrus Clonal Protection Program website (http://www.ccpp.ucr.edu).

To find out how to obtain budwood of these varieties, visit the Citrus Clonal Protection Program website (http://www.ccpp.ucr.edu). Registered users of the online budwood ordering system may visit http://ccpp.ucr.edu/budwood/budwood.php. If you are not a registered user you can e-mail ccpp@ucr.edu with your name, address, e-mail, and phone number or call (951) 684 8580 and the CCPP will generate a username and password for you. After becoming a registered user of the budwood ordering system you will also receive announcements about future budwood distributions for other citrus varieties.

Toni Siebert is a Museum Scientist with the Citrus Variety Collection, Botany and Plant Sciences, University of California Riverside. Dr. Georgios Vidalakis is a Cooperative Extension Specialist in Plant Pathology and Microbiology at UCR and Director of the Citrus Clonal Protection Program. Dr. Robert Krueger is a horticulturist with the USDA-ARS National Clonal Germplasm Repository for Citrus and Dates, Riverside. John Bash is a staff research associate with the Citrus Clonal Protection Program. Dr. Tracy Kahn is a Principal Museum Scientist in Botany and Plant Sciences and serves as the curator of the UCR Citrus Variety Collection.

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Research Project Final Report

Development of novel attractants for the Asian citrus psyllid, *Diaphorina citri* Kuwayama

Spiros Dimitratos, Robin Justice and Daniel F. Woods

Background

The Asian citrus psyllid (ACP), *Diaphorina citri*, is a vector for citrus greening disease and is responsible for very serious damage to citrus crops in affected areas. *D. citri* is endemic in Asia but has now reached California according to USDA and CDFA data. It is believed that the psyllid can spread from shipments of infected citrus or rootstocks and from related host plants on which the insect can feed, such as orange jasmine. Particularly alarming is the psyllid's ability to survive and propagate using host plants either *in lieu* of or in addition to agricultural citrus, and also its ability to spread from tropical or subtropical Asia to a variety of geographic locations, each with its own particular climate, geography, and flora.

Although *D. citri* feeding on citrus damages leaves and shoots, and the insects' excretions encourage mold growth, by far the most significant damage caused by *D. citri* is due to its ability to transmit citrus greening disease (huanglongbing or HLB). HLB is a very serious disease that effectively limits citrus production. HLB causes stunted tree growth, chlorosis with yellow shoots, leaf mottling, sparse foliage, and fruit loss. The disease is devastating; infected trees soon become non-productive, and most die and must be replaced.

KEY POINTS

- The objective of this project was to identify compounds that are suitable for development as novel attractants for the Asian citrus psyllid (ACP). Effective attractants are necessary in order to better assess the extent of ACP infestation in California and to enable the gathering of reliable ACP population data. Attractants can also be utilized in future bait-and-kill stations.
- Our approach was to start by identifying the ACP proteins involved in odor detection and then use methods developed by the pharmaceutical industry to isolate odor "mimics". Briefly, we take chemosensory (associated with the sense of smell or taste) proteins from ACP, synthesize them in the laboratory, and then use them as targets for screening a large library of small molecules. These high throughput screens allow the identification of numerous novel molecules that are potential ACP attractants.
- Molecules isolated from these high throughput screens are now being evaluated in behavioral assays to determine how they affect psyllid behavior; those identified as attractants can be identified and incorporated into future trapping devices.
- Using these small molecule libraries or other molecule collections has several advantages:
  - Molecules can be selected for, or altered to yield improved physical and chemical characteristics such as volatility, solubility, and so on which would enhance their application.
  - Molecules can be isolated to take advantage of new modes of action.
  - Molecules can be isolated to manipulate behavioral responses for which there is no known odor or pheromone; knowledge of natural pheromones is not necessary. It also allows the possibility of isolating "super" attractants that are more active than the original natural odors.

Since *D. citri* is a vector for HLB, efforts to control HLB rely on an effective means of assessing the extent of the psyllid's range in California. Efficient and sensitive means of detection are necessary in order to alert growers immediately in the event that psyllids appear on their land. Trapping efforts utilizing sticky traps could be augmented using attractants since key psyllid behaviors are associated with olfactory (chemosensory) cues. Effective attractants are key to rapid psyllid capture in the field, particularly since sticky traps are not a reliable means of predicting adult ACP densities.

The goal of this project was therefore to develop a novel, effective attractant that would greatly improve trap efficacy and allow the collection of reliable population data.

Research focus

Recent studies have shown the dependence of psyllid behavior on chemosensory cues from the environment. However, it has been shown that psyllids in various developmental stages seem to have specific host plant and localization preferences. For example, eggs, nymphs, and adults are significantly more abundant on sweet orange than on grapefruit in Texas, while immature individuals are found in significantly higher population densities in the southeastern part of trees compared to the rest of the available canopy. Moreover, work has been done to investigate reports from Vietnam that interplanting guava with citrus reduces the extent of *D. citri* infestations, although the data are not yet sufficiently strong to verify this phenomenon.

Female psyllids and mated psyllids of both genders are the most strongly attracted to plant odors; in fact, mated psyllids are attracted to plant odors regardless of the presence or absence of a visual cue such as the color green or yellow. Psyllids exhibit strong evidence of attraction when visual cues are combined with plant odors, and maintain attraction even in the absence of visual cues. Moreover, studies conducted to evaluate the behavioral responses of male and female psyllids to either gender in the presence or absence of citrus odors have provided evidence for a sexual attractant produced by female *D. citri*. The sum of these data supports the use of specific volatiles to alter or control ACP behavior.

To meet our goal of developing novel psyllid attractants, this project began by using our platform technologies to first characterize the chemosensory system of *D. citri*, with emphasis on the protein components that initiate or control key insect behaviors such as feeding or host plant location. These chemosensory proteins are expressed *in vitro* and targeted in a high-throughput screening assay that identifies compounds that bind to them.

The compounds will then be passed on to a different laboratory to be evaluated for their potential behavioral effects on living ACPs under quarantine conditions, and those compounds that attract or repel the insects will form the basis of novel attractant or repellent formulations respectively.

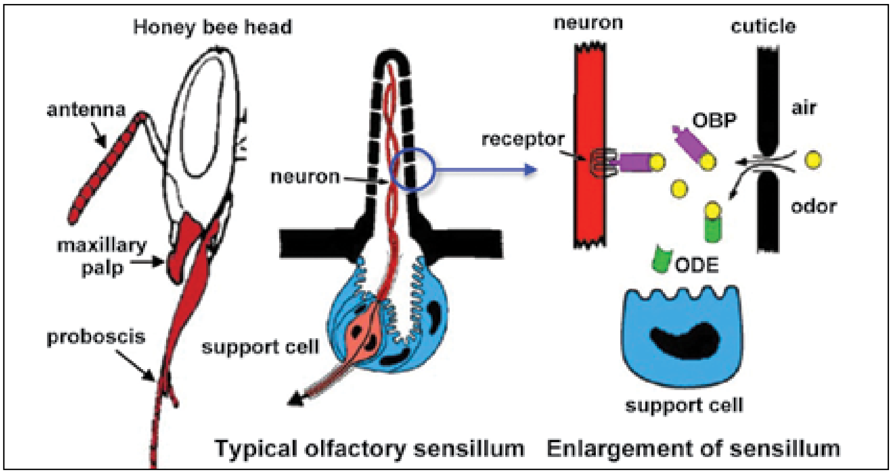


Fig. 1. Insect olfactory system. A: Bee head with the major chemosensory organs (antenna, maxillary palp, proboscis) in red. B: An enlargement of a typical olfactory sensillum found on the antennae, consisting of two main cell types: olfactory neurons (red) and the support cells (light blue). C: Important chemosensory proteins are shown. The odor molecule (yellow) enters through a pore in the cuticle and is bound to the odorant binding protein (OBP, purple). The OBP/odor complex binds the odorant receptor or OR, a G-protein coupled receptor (GPCR, black) on the neuron (red) cell surface to stimulate a response. Finally, the odor is degraded by the odor-degrading enzyme (ODE, green), re-sensitizing the system.

Research overview

Since psyllid behavior is controlled by olfactory or chemosensory cues, elucidating the nature and composition of the psyllid chemosensory system will allow the identification of chemosensory proteins suitable for use as targets in the development of future attractants or control products. A generalized depiction of the insect chemosensory system, using a honeybee as an example, is shown in Figure 1.

As seen in Figure 1, the insect antennae contain olfactory sensilla that are responsible for providing the insect with its sense of smell. Within each sensillum, an entering odor molecule must pass through the sensillar lymph – the aqueous medium between the cuticle and the sensory neuron surface.

Odorant binding proteins (OBPs) are the first components of the insect chemosensory system that come into contact with odor molecules from the environment, and their function has been proven crucial to the control of insect behavior by several research groups (see Further Reading, below).

The odorant binding proteins bind odor molecules, and this complex of OBP::odor molecule interacts with the odorant receptor (a type of transmembrane receptor called a G-protein coupled receptor or GPCR) to initiate a signaling cascade that results in a response from the insect to the particular odor. Odorant degrading enzymes are responsible for "re-arming" the system. Not depicted are sensory appendage proteins (SAPs); these are soluble proteins that fulfill a similar role to OBPs.

Inscent's approach to insect pest control involves identifying and selecting OBPs and SAPs from a given species as targets for the development of products capable of altering that species' behavior. This approach has been validated in economically and medicinally important species (see Further Reading, below), and provided the basis for this project. The approach is summarized in Figure 2.

The psyllid chemosensory proteins

■ **Combinatorial chemical libraries** refers to large, randomly constructed libraries of small molecules. These libraries will be used in screening for potential substitutes to naturally occurring pheromones.

■ **Ligand** usually means a small molecule specifically bound to a macromolecule by noncovalent bonds. In this case, it refers to the small molecules that bind the chemosensory proteins from *D. citri*.

■ **Chemosensory protein** refers to a protein component of the chemosensory system including the olfactory and gustatory system. Chemosensory proteins can be soluble, insoluble, membrane-bound, extracellular, secreted, or intracellular.

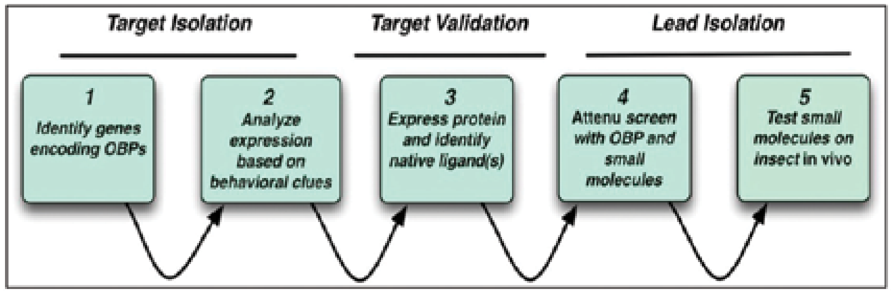


Fig. 2. The discovery process.

that were expressed in the laboratory are one OBP and four SAPs: DcOBP1, DcSAP1, DcSAP2, DcSAP3, and DcSAP4; no functional data exist for the role of these proteins in the psyllid chemosensory system, but their presence and relative abundance in a genome that is relatively poor in chemosensory genes suggests these proteins play a key role in odor recognition. Each of these proteins is a target for the development of a novel attractant. Each protein was used to screen a combinatorial library comprising 30,000 compounds selected for their diversity; the proteins were also used to screen citrus extracts in order to identify natural ligand(s). The objective of these screens was to identify compounds or molecules that each protein could bind; these compounds are potential attractants since the binding event has the potential to initiate the signaling process necessary for odor recognition (see Figure 1).

These screens identified hundreds of compounds or molecules to which the psyllid proteins could bind. To limit the amount of time, effort, and expense necessary in order to test these compounds for behavioral effects on live psyllids, and to exclude compounds that would not be well suited for use as attractants, *e.g.*, compounds predicted to be highly toxic, the compounds' structures were analyzed with the aid of computers. This *in silico* analysis allowed the grouping of compounds and the selection of representative compounds from within each group that maintained the characteristic core structure of the group and were not predicted to pose significant toxicity risks. It is these selected compounds that will now be evaluated for their potential to affect psyllid behavior.

Behavioral assays on living psyllids cannot currently be carried out in our laboratory in California. We are therefore collaborating with Dr. Joseph Patt (USDA-ARS) who has laboratory, greenhouse, and field facilities in Texas with suitable psyllid populations in order to evaluate the behavioral effects of the most promising compounds on living insects.

Compounds that are identified as having attractant effects on living psyllids can be used to develop novel attractant formulations. These initial compounds may not have the ideal physical or chemical properties, that is, they may not have the correct solubility, volatility, stability when exposed to typical field conditions, *etc.*, but they can serve as the basis of product development, and their core structure can be modified or manipulated to yield the desirable characteristics. In this sense, the discovery process depicted in Figure 2 is reiterative; initial or pre-curser compounds are refined and re-evaluated by being subjected to the tests listed in the process once again until they are suitable for use in the field.

Summary of benefits to the industry

D. citri has shown a remarkable capacity to adapt to new environments and to expand its territory. As a vector for HLB, perhaps the most serious disease with which modern citrus farming is faced, *D. citri* must be monitored closely, and ultimately it must be controlled. Knowing the extent of psyllid infestation in the state and having the ability to obtain solid data on psyllid population densities in any given area will allow the industry to assess the situation realistically – a crucial first step in responding to any pest invasion. The work described here is intended to provide citrus growers with novel psyllid attractants that can be used in next-generation bait stations; the functions of these bait stations are:

• Assessing psyllid population densities and territories.

• Monitoring the extent of psyllid infestation in any given area.

• In the future, these attractants can be used in bait-and-kill stations such as those being developed by Dr. Joseph Patt (USDA-ARS), with whom we are collaborating.

All authors are with Inscent, Inc., a technology development, gene discovery, and functional genomics company based in Irvine, CA, dedicated to the identification and refinement of novel, small molecules for application in the control of biological organisms, principally insect pest populations. Dr. Daniel F. Woods is the founder, president, and chief scientific officer. Dr. Spiros Dimitratos specializes in functional biology, and Dr. Robin Justice works in applied genomics. Address correspondence to dan@inscent.com.

Further reading

The components of the chemosensory system and the merits of using the chemosensory system to control insect pests are summarized in Justice et al., (2003) *Genomics spawns novel approaches to mosquito control*, Bioessays (25)10, pp 1011-20.

The crucial nature of odorant binding proteins to insect odor recognition and thus to insect behavioral responses is shown in Matsuo et al., (2007), *Odorant-binding proteins OBP57d and OBP57e affect taste perception and host-plant preference in* Drosophila sechellia, PLoS Biol (5)5, pp e118.

The high through-put assay system used to identify potential attractants or repellents and the ability of odorant binding proteins to modulate insect behavioral responses are shown in Biessmann et al., *The* Anopheles gambiae *odorant binding protein 1 (AgamOBP1) mediates indole recognition in the antennae of female mosquitoes*, PLoS One, vol. (5)3, DOI 10.1371/journal.pone.0009471.

Acknowledgements

The authors thank the California Citrus Research Board for its support and encouragement, and the editors of *Citrograph* for the opportunity to present this work.

Dr. Joseph M. Patt, USDA-ARS has graciously offered to test lead compounds for behavioral effects on live psyllids.

This project was funded by the California Citrus Research Board (5500-177) and is now being continued with funding from the National Science Foundation (IIP- 0956877).

(CRB research project reference number 5500-177.)

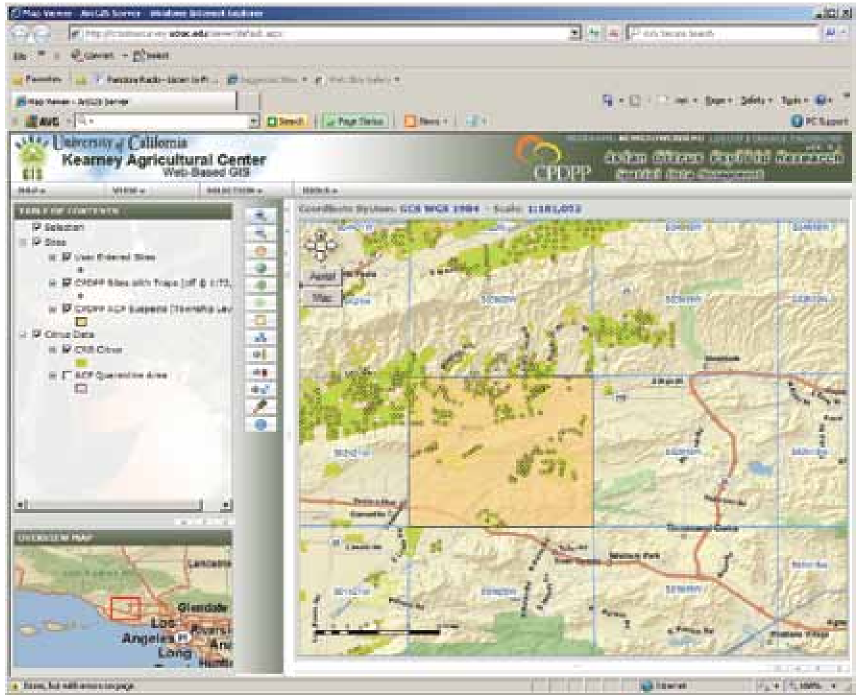
Looking back...

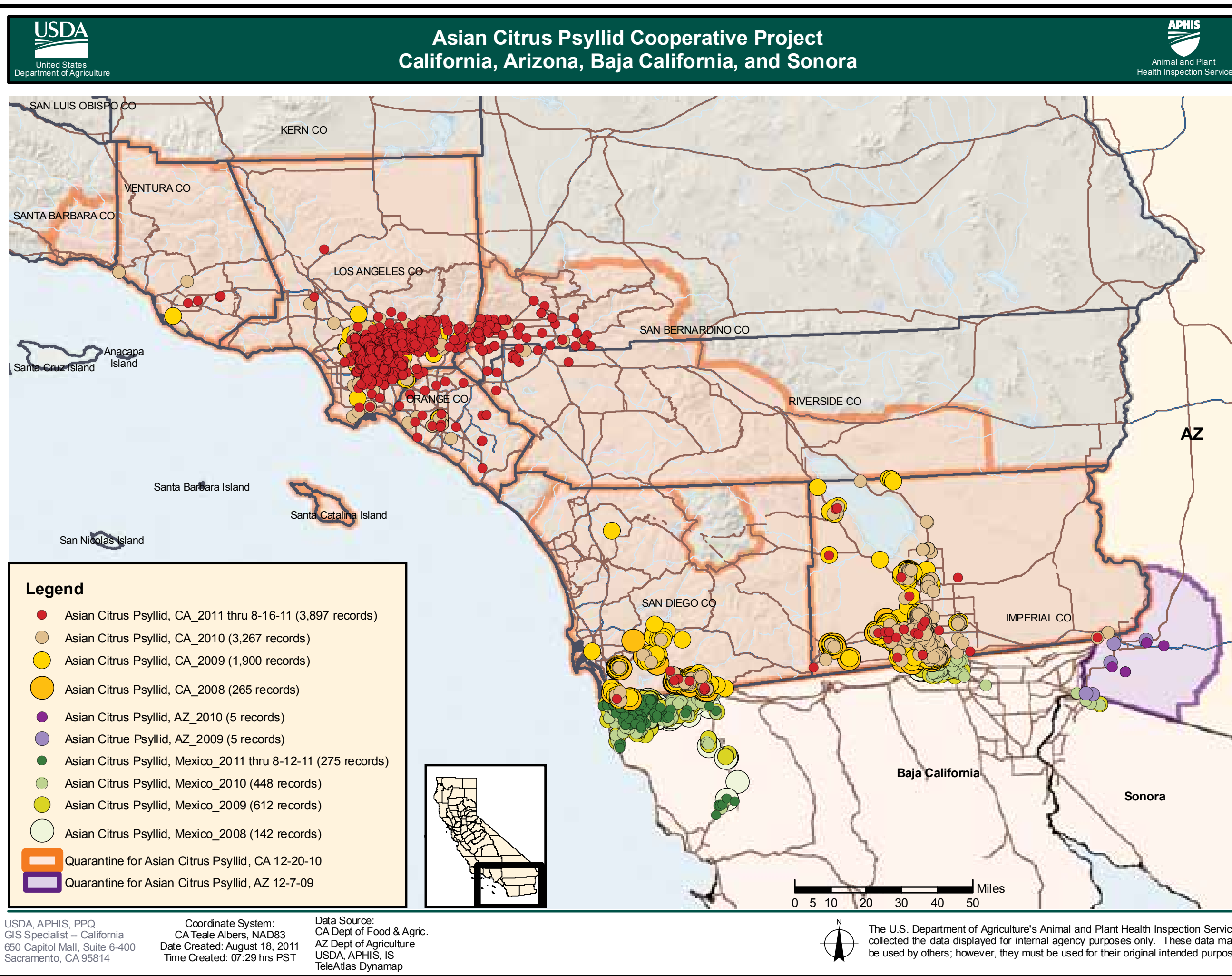
In the May/June issue, in the Citrus Roots feature (pages 11-15), author Richard Barker noted that "During 1904, George Frost, with Messrs. Merryman, Carney, Hamilton, Davis and others, set out 400 acres of citrus and named the area Bonnie Brae Orchards in Exeter. Mr. Merryman later absorbed the share of his associates, and his orange holdings were said to be 750 acres. It was a 'showpiece' for the area." Well, just a day or two after that article was finalized, Barker uncovered this wonderful photo depicting the first fruit being shipped from the Bonnie Brea packinghouse, in October 1908.

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 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 November, the username is NewGrowerDemo, and the password is RealEasy! For more information, contact Richard Dunn, CPDPP/CRB 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 8/18/11.

Citrus Orchard Service, Inc.

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18 Oct 88

Why should a dozen citrus growers, many of them well into geezerhood, spend several days a year figuring out how to spend $4000 a day on citrus research? Why even tax themselves at all? Sounds stupid, especially when:

There will be no benefits for several years;

The success of these projects is nebulous; there are no guarantees in research;

Some of these guys will be dead before there's any payout;

Growers in Florida, South Africa, Chile, Israel and Brazil will get the results--free!

Why do it?

Unlike the self-centered "Now Generation", these men care about the future. They are proud to be a part of growing good healthy food for people to eat. Creating a future validates their life work

Farmers generally are sharing of trade and production information; it's a win-win situation to work together. The fact is: A farmer must <u>give</u> before he can <u>get</u>.

Sharing of information with other farmers and scientists stimulates those in other countries. International citrus and agriculture societies benefit all of us. Secretiveness ultimately excludes one from the gossip and information loops.

This organization, the Citrus Research Board, was voted in by the citrus growers under California law as a "Marketing Order". Growers elect the Board, and the Board sets the tax rate--this year at 9 mills per box, which translates into about 1.4 million$ assuming about 150 million boxes to be produced in California in the 88/89 season.

The Board listens to the research proposals from earnest, erudite educated PhDs pleading for money to save the industry and make the growers rich. Then the negotiations start. Each Member has his priorities and prejudices, wish lists, alliances and policies. You see lobbying, politic and persuasion, and a dedicated group held together by a common interest in the future.

Only in America.

Editor's Note: When Ted Batkin was moving to his new office on Encina, he found this letter. He had discovered it years earlier in the CRB files and, realizing that it was something quite special, had carefully preserved it. The composition is by the late Allen Hardison, who wrote it during his first year of service on the Citrus Research Board. He was famous – and well respected by his colleagues – for being a "devil's advocate" in the finest sense. In virtually every meeting, he asked pointed questions to make sure all aspects of a situation had been considered, and his approach ensured a full debate. Hardison represented District 2 for 15 years, from 1987-88 through 2001-2002.

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