

# Plant Pest Diagnostics Center Annual Report 2009



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**Cover Image:** The Henry J. Voss building, home of the California Department of Food & Agriculture's Plant Pest Diagnostics Center.

# Annual Report 2009

## Plant Pest Diagnostics Center

### MISSION:

To serve as a scientific and professional resource, providing timely and accurate plant pest diagnostics to our clients with the aim of protecting California's agriculture and environment.

### VISION:

To continually enhance our professional expertise as an internationally recognized scientific service and research center committed to meeting future scientific challenges to California's agricultural and environmental needs.

### VALUES:

- Leadership in the field of plant pest diagnostics.
- Excellence and Innovation in science, technology, research and service.
- Professional Integrity in taking responsibility for the validity of work based on the best available and accepted scientific protocols and standards.
- Trust established by practicing ethical conduct.
- Empowerment through an organizational culture that promotes delegation of authority, creativity and celebration of accomplishments.
- Mutual Respect, Cooperation and Communication through partnerships and teamwork and the constructive exchange of ideas.

The Plant Pest Diagnostics Center (PPDC) provides timely and accurate diagnostics of plant pests and diseases in support of the pest prevention programs of the Department. PPDC has five laboratories: Botany, Entomology, Nematology, Plant Pathology and Seed with about 50 permanent and 30 seasonal employees. The Branch also serves as a scientific resource and provides professional expertise to a number of clients including the United States Department of Agriculture (USDA), other federal and state agencies, county agricultural commissioners, the University of California Cooperative Extension, the agriculture industry and the public. The PPDC is also a collaborator with the National Plant Diagnostic Network (NPDN), is recognized as the expert lab for the western region, and provides diagnostic service and support to the NPDN. The PPDC scientists, technicians and support staff strive to provide excellence in service and leadership in plant pest diagnostics and biosystematics. More information about PPDC is available at: <http://www.cdfa.ca.gov/phpps/PPD/>

**The staff of the PPDC continues to provide leadership in plant pest diagnostics and excellence in scientific service and research.**

# PLANT PEST DIAGNOSTICS CENTER ACCOMPLISHMENTS

Following is a sampling of some of the various accomplishments of the Plant Pest Diagnostics Laboratory from 2009. It is intended to reflect a few of the highlights of the year but is not an exhaustive list.

- The PPDC laboratory acquired a United States Department of Agriculture (USDA) permit to receive samples for diagnosis from our Western Plant Diagnostics Network (WPDN) diagnostic laboratory partners in the Pacific - Hawaii, Guam, and American Samoa.
- One intercepted Asian citrus psyllid (ACP) was diagnosed positive by the Plant Pathology staff and confirmed by the USDA for the HLB pathogen. It was found on luggage at the Fresno airport.
- Plant Pathology and Entomology staff combined efforts to publish the first report of bamboo rust caused by *Kweilingia divina* on *Bambusa domestica* in Los Angeles County, California.
- A species of the needle nematode, *Longidorus* sp., was detected in rhizosphere soils of walnut trees in Glenn County as part of the ongoing USDA Cooperative Agricultural Pest Survey (CAPS) in California. Dr. Sergei Subbotin made the identification of this pest which is closely related to another species subject to mandatory control in Europe.
- In May, scientists presented displays and interacted with school children from all over California at the annual "California State Scientist's Day" at the State Capitol (Figure 1).



Figure 1. School children at the PPDC Entomology Lab booth meet staff and specimens at the 2009 California State Scientist's Day.



Figure 2. A sample of *Gladiolus* Rust received at the lab.

- *Gladiolus* rust was diagnosed from multiple samples collected throughout the San Francisco Bay Area and for the first time from a sample collected in Santa Cruz County (Figure 2).
- In May the Lab hosted a group of agricultural extension scientists from Iraq as part of a training program through The College of Agricultural and Environmental Sciences at the UCD. The Iraqi scientists were then given a tour of the Plant Pest Diagnostics Center and also interacted with our scientific staff on various pest diagnostic topics. Senior Seed Botanist Dr. Riad Baalbaki, who speaks Arabic, was able to explain the complicated concepts of Polymerase Chain Reaction (PCR) testing as well as phytosanitary seed health testing to the group in their native language. Dr. Dean Kelch, Dr. Andy Cline, Riad, and Mr. Jim Effenberger also evoked much discussion and interest on the part of the group for seed testing and label compliance, weed identification and arthropod pest identification. The group got a real sense of the value and need for such diagnostic tools as seed, botany, and arthropod collections in their own country.
- In June Drs. Suzanne Latham and Cheryl Blomquist detected a rare leaf spot pathogen *Embellisia hyacinthi* on *Scilla* sp. from Monterey County. This is a disease normally found in Europe. This was only the 2nd detection of this pathogen in the USA.
- Three posters were presented by PPDC scientists at the National Plant Diagnostic Network (NPDN) national meeting in Miami, Florida. The posters featured content on palm wilt disease in California, a summary of the exotic fruit fly detections in the state over the last five years, and the diagnostics class taught by our staff at UCD last fall.

- Branched Broomrape, *Orobanche ramosa*, was identified from a tomato field in San Benito County. This was the first report of branched broomrape in more than 25 years (Figure 3).

- The first report of downy mildew of Hellebore or Lenten rose caused by *Pero­nospora pulveracea* in the United States was reported by Drs. Colleen Warfield (UC Cooperative extension) and Cheryl Blomquist, in the journal Plant Disease, March 2009 issue.

- Dr. Dean Kelch collected specimens near Lemoore to check for the continued existence of a B-rated pest, Russian knapweed (*Acroptilon repens*), at an historic reported locality. This species was last reported here in the 1970s and no voucher specimen exists. Dr. Kelch confirmed the continued existence of the noxious weed here and collected specimens to permanently document its occurrence.

- Pachysandra blight caused by *Volutella pachysandricola* = *Pseudonec­tria pachysandricola* (pest rating=Z) was confirmed in a large garden planting of Japanese spurge (*Pachysandra termi­nalis*) in Sacramento County (Figure 4). Japanese spurge is an evergreen shrub grown as a groundcover in the shade with attractive dark green leaves and spikes of fragrant white flowers. Although this is the first official confirmation of *Volutella pachysandricola*, this fungus is thought to be present in nearly all pachysandra plantings, but it only becomes a problem when plants are stressed. In the Sacramen­to valley these stressors would include heat, drought and mites. This fungus uses wounds to enter the plant so insect damage can be a way the fungus gains entry. Dr. Cheryl Blomquist made the determi­nation.

- A fungus associated with twig blights and cankers of conifers but un­known in California was indentified from intercepted firewood at a northern border station as *Therrya fuckelii*.



**Figure 3. Branched Broomrape, *Orobanche ramosa*, an A-rated, non-native parasite. Photo by D. Kelch**



**Figure 4. Pachysandra blight caused by *Volutella pachysandricola*.**



**Figure 5. Tipu Psyllid, *Platycorypha nigrivirga*, adults. Photo by G. Arakelia.**

- The National Karnal Bunt survey was completed in December by PPDC staff. Fifty-six samples representing 24 coun­ties were tested; no positives detected. In addition, 50 samples from the quarantine area in Riverside County were also tested by Plant Pathology staff and no positives were detected.

- The tipu psyllid, *Platycorypha nigri­virga*, is reported for the first time in North America (USA, California). PPDC sci­entists Dr. Alessandra Rung and Raymond Gill (retd.) published a paper on the insect. Diagnostic characters for identification of adults (Figure 5), nymphs, hosts, dam­age data and known distribution are given. Originally described in 1987 from Argentina (type-locality), Bolivia, and Uruguay, the tipu psyllid was subsequently recorded in southern Brazil, and Europe. This insect has recently emerged as a serious pest of tipu trees in Curitiba (Brazil), where pest popula­tions are high, trees are being defoliated, and excessive honeydew excretion is fouling concrete sidewalks and vehicles parked under the host trees. Relatively similar levels of damage to tipu trees are observed in West Hollywood, California. In the absence of natural enemies (e.g., predators, parasites, or pathogens) or insecticidal controls, the establishment of tipu psyllid in California represents a significant threat to the health and value of tipu tree plantings in California landscapes. The citation for this publication can be found at the end of the report.

- Plant Pathology staff collaborated with Dr. Francisco Assis of the diagnostic testing company, Agdia, to help with the develop­ment of an improved lettuce mosaic virus (LMV) seed health test.

- Dr. John Chitambar was invited to serve as a member of the American Phy­topathological Society (APS) Widely Prevalent Phytopathogenic Nematodes Sub­Committee (APS-WPPNL). The Sub-Com­mittee (of APS' Nematology Committee) in response to the United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA-APHIS) is charged with development of a list of about 100 widely prevalent phyto-pathogenic



**Figure 6.** *Rotylenchulus reniformis*; A: mature female, B: male; C: immature female

nematodes. USDA's goal, with concurrence from individual state plant regulatory departments, is ultimately to improve and streamline the PPQ 526 permit granting process. The opportunity for CDFA Nematologist to have direct input in this project should prove very valuable to both state and federal agencies.

- Plant Pathology staff provided special training to a University of California, Davis environmental horticulture class in diagnostics, including a lecture by PPDC Plant Pathologist Dr. Cheryl Blomquist on the benefits and limitations of molecular diagnostics.

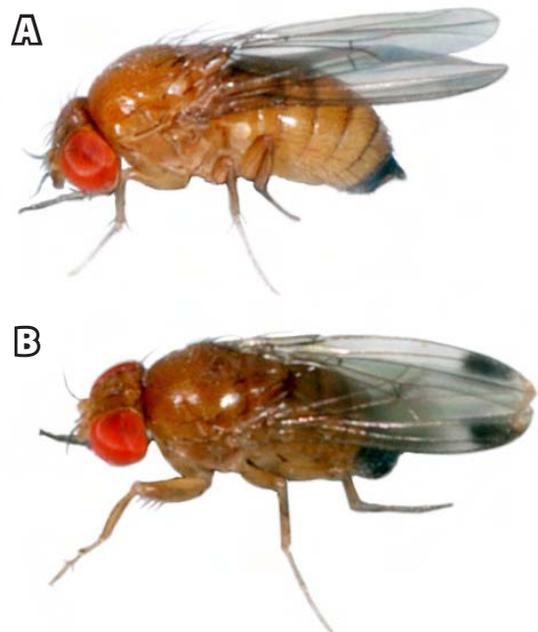
- The reniform nematode, *Rotylenchulus reniformis*, was detected in several shipments of *Dracaena* spp. plants imported from Hawaii during Fall 2009 (Figure 6). At least, thirteen shipments originating in five Hawaiian nurseries were intercepted and inspected by three destination counties, namely, Orange, San Francisco and San Diego. The nematode species was identified and confirmed by nematologists at CDFA's Nematology Laboratory. The reniform nematode is not present in California and is an invasive agricultural pest subject to quarantine action. It can infect a large range of plant hosts. If allowed to enter and establish in California, the reniform nematode can cause significant economic damage mainly to the State's cotton, grape, and citrus production.

- Drs. Cheryl Blomquist and Susanne Rooney-Latham in collaboration with Pat Nolan of San Diego County published a "First Report of Downy Mildew on Field-Grown Sweet Basil Caused by a *Peronospora* sp. in San Diego County, California" in the September 2009 issue of the journal *Plant Disease*. The pictures of the disease symptoms were featured on the journal cover. The citation for this publication can be found at the end of the report.

- Staff Botanists curated several dozen plant specimens collected in Louisiana. As California continues to import millions of nursery plants from the Southeastern United States, it is crucial to have a good collection of common Southeastern plants for diagnosis of received samples. Although many Southeastern weeds require too much water to thrive in much of California, several species from this region have become wetland or nursery weeds in California and there is potential for more weed pests to enter and establish here in California.

- In August, the fungal pathogen that causes thousand cankers disease of walnut species (*Juglans*) was confirmed in California by PPDC Pathologists. The disease is associated with widespread dieback of black walnut trees in Colorado and other parts of the western U.S. Branches of Southern California black walnut (*Juglans californica*) showing typical canker symptoms of the disease were collected by CDFA officials in Yolo County. The fungal pathogen, *Geosmithia* sp., was readily cultured in the lab from the cankers.

- The spotted winged drosophila, *Drosophila suzukii*, was identified in California by Dr. Martin Hauser - a new record for continental North America (Figure 7). This insect belongs to a family of flies that usually feed on decaying fruit or mushrooms, but this species attacks healthy fruit and causes significant damage. In California it has been feeding primarily on cherries, but has a wider host range on soft-skinned fruits and has since been found to be widespread in the state as well as in Oregon, Washington, Florida and British Columbia.



**Figure 7.** The spotted winged drosophila, *Drosophila suzukii*, A female, and B male.

- The fungal pathogen *Botryosphaeria corticola* (*Diplodia corticola*) was diagnosed from a residential oak tree in Plumas County—a new record for this fungus in California and the Western U.S. The fungus is typically associated with stressed oak trees in Europe but has also been found on a redbud and an oak tree in the Eastern U.S. According to the county biologist that collected the California sample, the oak tree appeared to be severely overwatered.

- The Burrowing Nematode, *Radopholus similis* (Figure 8 B), was detected in shipments of Pothos, *Epipremnum aureum* plants. Sixty plants in 6-inch pots, originating in Mount Dora, Florida, had been inspected and sampled at their destination at Half Moon Bay, California, by the San Mateo County Commissioner’s Office. CDFA Nematologists identified the nematode species. The Burrowing Nematode, an A-rated pest not present within the State, is of quarantine significance to California. Its introduction and spread has been prevented through CDFA’s effective External Quarantine program for Burrowing and Reniform Nematodes established in 1953. If left undetected and allowed to establish, the nematode species would be a serious problem to mainly California’s citrus, strawberry, carrot and ornamental industries.

- Dr. Fred Hrusa annotated over 1500 specimens of Russian thistle (*Salsola* sect. *Kali*) from other collaborating institutions as part of his revision of the section in California. He completed his treatment of *Salsola* and five other chenopodiaceous genera for the second edition of the Jepson Manual - Higher Plants of California, due for publication in 2011. His treatments are currently online. The species of *Salsola* are important imported weeds in the Western United States. Taxonomic confusion has added to the problems in controlling these species.

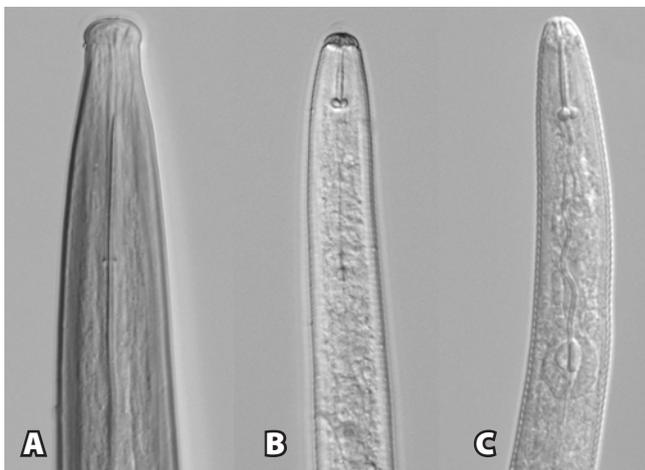


Figure 8. anterior ends: A. *Longidorus* sp; B. *Radopholus similis*; C. *Rotylenchulus reniformis*



Figure 9. *Centrocoris variegatus*, photo by Alice Cavette

- An introduced leaf-footed bug, *Centrocoris variegatus* (Figure 9) from the Mediterranean was identified from Yolo County (new county record) on June 10<sup>th</sup> by Senior Insect Biosystematist Dr. Andrew Cline. The species was only recently identified by PPDC in May 2009, which was then the first report of this true bug in North America. Thus far, the species has been reported from three counties: Alameda - 1<sup>st</sup> record, Sacramento, and Yolo.

- A leaf spot disease caused by the fungus *Mycosphaerella handelii* (*Cercospora handelii*) was recently detected on three different native Manzanita species. The fungus was found on *Arctostaphylos pallida* and *A. montarensis* from Contra Costa County and *A. imbricata* from Alameda County. The pathogen, *M. handelii* occurs worldwide as a foliar pathogen of *Rhododendron* spp. Both *Rhododendron* and *Arctostaphylos* are in the same plant family (Ericaceae).

- The botany laboratory received and identified a specimen of squarrose knapweed (*Centaurea squarrosa*) from Shasta-Trinity National Forest. This is only the third report of this A-rated pest from Trinity County and the first report in 15 years. Squarrose knapweed is quite similar to diffuse knapweed (*Centaurea diffusa*, another A-rated pest), but is perennial, has smaller heads that form the diaspore rather than individual seeds being the dispersal unit. The region of Mad River appears to have a localized infestation that was reported first in 1996.

- The PPDC tested citrus samples from nursery propagative sources. The sampling and testing was for compliance with citrus tristeza virus (CTV) state quarantine. All samples were tested by Enzyme Linked Immunosorbent assay (ELISA) and positive detections were confirmed

by reverse transcriptase polymerase chain reaction (RT-PCR). Four samples out of the 10,168 citrus samples that were tested and were identified as CTV-positive.

- Numerous workshops were held to train County Agriculture department staff in recognition of various important and high profile insects. These workshops were given throughout the year and included training in the identification of various moths, scales, and flies.
- A simplified PCR method for the identification of the most commonly found five species of root-knot nematodes in California was developed by Dr. Ke Dong. The PCR test involved five species-specific primer pairs in a multiplex PCR reaction for *Meloidogyne arenaria*, *M. chitwoodi*, *M. hapla*, *M. incognita*, and *M. javanica*. The nematode species were identified based on the size of PCR products. This new method greatly improved the efficiency and reliability of root-knot nematode species

diagnoses in CDFA nursery, quarantine, and survey programs with limited specimens in samples.

- Dr. Marc Epstein taught at the University of California at the Davis Adult Lepidoptera ID Workshop held on March 24<sup>th</sup> - 26<sup>th</sup> 2009.
- From February 2007 onwards, large numbers of avocados began entering California from Mexico. Many of the fruits arrived infested by live armored scale insects (Diaspididae). Senior Insect Biosystematist Dr. Gillian Watson recognized that one of the species was new to science; this species was described as *Abgrallaspis aguacatae* in an article in the January edition of *Zootaxa* (vol. 1991). The quarantine threat presented by this species and others found on imported avocados from Mexico was discussed in a Forum Article published in the September issue of the *Journal of Economic Entomology* (vol. 102).

# Sources of Diagnostic Samples

Samples typically arrive at the Plant Pest Diagnostics Center (PPDC) Laboratory from a multitude of sources for identification or diagnosis. These include, but are not limited to, the following sources:

- State, county, and federal agencies, as well as other municipal and public sources such as city arborists and parks departments.
- Samples submitted by the Fruit and Nut Tree and Grapevine Improvement Advisory Board (IAB Program) to be tested for virus diseases
- Grapevine samples submitted by the California Grapevine Registration and Certification Program for testing to detect the presence of grapevine fan-leaf and leaf roll viruses.
- The US Department of Homeland Security’s National Plant Diagnostic Network (NPDN).
- Seed samples destined for domestic or foreign markets, to determine phytosanitary seed health compliance prior to export, as well as domestic label compliance with regard to germination levels and purity of seed lots.
- Diagnosis and identification of miscellaneous plant samples, weeds, seeds, soil (for nematodes and pathogens) and arthropods submitted by individual homeowners, gardeners, and farmers; Pest control advisors; University of California cooperative extension agents; nurserymen; seed companies, arborists; private industry; educational institutions; and others.
- Diagnosis and identification of samples collected for various federal and state mandated and funded pest detection surveys for plant diseases, insects, nematodes, and weeds including Plum Pox Virus, Sudden Oak Death, Citrus Canker, Citrus Greening, Piece’s Disease of grapes, Rice Panicle Mite, Japanese Dodder, Light Brown Apple Moth, European Grapevine Moth, Africanized honeybees, Glassy Winged Sharpshooter (GWSS), imported fire ants, Asian Citrus Psyllid, Gypsy Moth, Potato Cyst nematode, and many others.
- Sample from CDFA Pest Exclusion sources such as Border Stations, seaports, airports (including those using Dog teams); postal and shipping companies.

Following is a table representing the number of samples and specimens submitted to the laboratory in 2009, compared with previous years. Most programs include special surveys or projects that generate additional samples than cannot be easily tracked by Pest and Damage Report numbers.

Note that sample numbers are not comparable among the different disciplines (labs/programs) as an accurate comparison of workload since the time and work required to diagnose or identify different types of samples varies widely from lab to lab and even sample to sample.

Labs/Programs	2003	2004	2005	2006	2007	2008	2009
<b>Botany<sup>1</sup></b>	3,284	1,008	1,000	1,474	1,029	1,682	1,167
<b>Entomology<sup>2</sup></b>	36,146	45,000+	50,000+	50,000+	65,000+	70,000+	80,000+
<b>Nematology<sup>3</sup></b>	4,782	3,874	4,923	7,912	8,648	5,870	7,864
<b>Plant Pathology<sup>4</sup></b>	88,233	109,398	103,451	87,434	78,872	90,531	92,218
<b>Seed<sup>5</sup></b>	3,067	6,923	3,166	5,791	2,427	1,843	3835
<b>Total</b>	<b>135,512</b>	<b>166,203</b>	<b>162,540</b>	<b>152,611</b>	<b>155,976</b>	<b>169,926</b>	<b>185,084</b>

<sup>1</sup>An additional 3000 botany specimens were examined & identified for herbarium curation in 2009

<sup>2</sup>Estimate of specimens examined.

<sup>3</sup> Figure includes Quarantine samples, Nursery Registration & Certification samples, USDA Survey Project samples, as well as Diagnostic samples.

<sup>4</sup>2009 Figure includes 50,363 samples tested for several target viruses as part of the California Deciduous Fruit Tree, Nut Tree, and Grapevine Improvement Advisory Board (IAB) program; 26,577 Sudden Oak Death (SOD) samples, 10,000 Asian Citrus Psyllids tested for Huanglongbung

(HLB) causal agent, and 2,169 plant samples tested for HLB causal agent.

<sup>5</sup> Quarantine, phytosanitary and noxious weed seed examinations require identification of 25,000 seeds per sample. Purity analyses require identification of 2,500 seeds per sample. In 2009 the total number of seeds or other propagules actually examined for identification exceeded 18,600,000.

Germination tests require the evaluation of 400 seedlings per sample; thus the total number of individual seedlings evaluated for germination tests was in excess of 440,000.

## Social Responsibility

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In addition to attempting to provide California's agriculture and nursery industries the best quality pest-diagnostics services possible, the Plant Pest Diagnostics Center staff also believe that as state employees, and therefore public servants, it is also our responsibility to reach out to serve human, social and community needs as well. For this reason the PPDC is also involved in providing training, tours, consultation and other services to the community. The Laboratory accomplishes this in various ways.

A good example of this outreach is the PPDC's relationship with a local elementary school. The Meadowview region of South Sacramento is an inner-city area of Sacramento that is known for gangs, violence, and poverty. It also happens to be the neighborhood where the California Department of Food and Agriculture's Plant Pest Diagnostic Center (PPDC) Laboratory is located. For the past several years the Laboratory staff have provided the gift of learning to Mark Hopkins Elementary School, a local inner city grammar school within walking distance of the Lab in which, according to Principal Laura Reed, 97% of the 400 plus students are from families at or below poverty level. As in previous years, the laboratory staff has reached out and given students from the 6<sup>th</sup> grade science classes of this school a hands-on learning experience of what real-world science is all about. Students are exposed to a 2 million specimen insect collection, the 2<sup>nd</sup> largest seed collection in the country, hands-on training in seed germination science, botany and plant identification, as well as insect identification and biology. In addition, they also get "up-close-and personal" with fungi, bacteria, viruses, and nematodes using professional grade microscopes, cultures, and specimens. These students are also reminded that in just 6 short years they will be college age, and are encouraged to consider taking some introduc-

tory science classes at the college level so that not only can they begin an advanced education that includes science as part of their base, they can also qualify to work in this very same laboratory within their community in which they just spent the morning learning.

Each May several PPDC scientists bring their specimens, microscopes, and other visual aids to share knowledge and experience with students at the annual California State Scientist's Day held each year on the grounds of the State Capitol. Hundreds of students from all over Northern California come in school busses and vans to learn about the various fields of science in which the state of California employs professional scientists.

In addition, various scout troops, local Master Gardener groups, local college science classes, and others have benefited from various specialized and general training and presentations both on-site and off-site. The Laboratory assists local municipal arborists in such cities as Sacramento and Roseville by providing free sample diagnosis and consultation. The City of Sacramento, for example, which is known as the City of Trees, has struggled to keep pace with the spread of Dutch Elm Disease (DED) in its urban forest. To help in this effort, the Laboratory has tested and diagnosed hundreds of elm trees for DED over the years. In 2009 PPDC staff also provided pest management training for the Sacramento Tree Foundation, a volunteer organization committed to a reforestation project called "Green Print" which provides for the planting of five million new trees in the Sacramento region over the next 25 years. In addition, in 2009 PPDC Plant Taxonomist, Dr. Dean Kelch identified numerous trees for an update of the map of the public arboretum surrounding Capitol Park in downtown Sacramento.



**Left:** Students examine fungal cultures under a microscope in the Plant Disease Laboratory. **Center:** Students met insects found in their back yard and from around the world at the Entomology booth at State Scientists' Day.; **Right:** Students learn about seeds, large and small, in the Seed Science Laboratory using the 2nd largest seed herbarium in the United States as a classroom.

## Seminar Series

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The Plant Pest Diagnostics Center seminar series began in 2004 to enable scientists to present research data and discuss ongoing research and pest issues of general importance. The series continued in 2009 with presentations by speakers from CDFA, USDA, and the University of California, Davis. Dr. Gillian Watson, Senior Insect Biosystematist, coordinates the series. Twelve stimulating and enjoyable seminars were held during 2009, listed below.

- **Dr Stephen Gaimari** (CDFA/PPDB Entomology) “A dipterist’s trek through Western Australia”  
22 January
- **Dr Elaine Backus** (USDA/ARS Research Entomologist) “Transmission mechanisms of *Xylella fastidiosa* by the Glassy-Winged Sharpshooter, and implications for disease epidemiology”  
26 February
- **Dr Gillian Watson** (CDFA/PPDB Entomology) “Scales and whiteflies: the challenges of a sedentary lifestyle”  
19 March
- **Dr Barry Hill** (CDFA/PPDB Plant Pathology) “Recent discoveries in the epidemiology of Pierce’s Disease”  
16 April
- **Dr Richard Hoenisch** (WPDN/ UC Davis Plant Pathology) “The NPDN First Detector Network and pest awareness”  
14 May
- **Dr Kris Godfrey** (CDFA Integrated Pest Control) “An update on Asian Citrus Psyllid and Huanglong-bing in North America and California”  
18 June
- **Steven Koike** (Plant Pathology Farm Advisor, U.C. Cooperative Extension) “Research update on the ecology of *E. coli* in Salinas Valley fields”  
16 July
- **Dr Martin Hauser** (CDFA/PPDB Entomology) “The hoverfly genus *Eumerus* in Australia - amazing flies from down under”  
20 August
- **Dr Martin Hauser** (CDFA/PPDB Entomology) “When vinegar flies go bad – the case of the Spotted Winged *Drosophila*”  
10 September
- **Dr Dale Woods** (CDFA/PPDB Integrated Pest Control) “Yellow Starthistle Rust: use of a plant pathogen as a weed biological control”  
15 October
- **Dr Alessandra Rung** (CDFA/PPDB Entomology) “Something about Brazil and aulacigastrids”  
12 November
- **Dr Rosser Garrison** (CDFA/PPDB Entomology) “Research on the Neotropical Odonata: current results and challenges ahead.”  
10 December

# NPDN Activities

The Mission of the National Plant Diagnostic Network (NPDN) (an arm of the US Department of Homeland Security) is to enhance national agricultural security by quickly detecting introduced pests and pathogens. The NPDN functions as a nationwide network of public agricultural institutions with a cohesive distributed system to quickly detect high consequence, biological pests and pathogens deliberately or inadvertently introduced into our agricultural and natural ecosystems. This is done by providing a means of quick determinations and establishing protocols for immediate

responders and decision-makers. The NPDN provides a way for university diagnosticians, state regulatory scientists and personnel, and others to efficiently communicate information, including pest and disease images and maps throughout the system in a timely manner.

As the “Hub” Laboratory for the Western Plant Diagnostic Network (WPDN), representing the Western Region’s ten states & 2 US territories, the PPDC Laboratory’s NPDN activities included the following service and accomplishments:

Figure 1. Diagnostics Course poster presented at NPDN National Meeting at Miami, FL in December 2009. Blomquist, C.L., Rooney-Latham, S. and T. Tidwell. 2009. “Graduate Level Diagnostics Course taught by NPDN Diagnosticians.” Second National Meeting of the National Plant Diagnostic Network. Dec. 6-10, 2009. Miami, FL.



## Graduate Level Diagnostics Course taught by NPDN Diagnosticians

Cheryl L. Blomquist, Suzanne Rooney-Latham and Tim Tidwell,  
California Department of Food and Agriculture, Sacramento 95832



**Why design a new course?** Diagnostic training is not always available in current Plant Pathology curricula and most graduate students are not able to add an additional full-time course to their schedules. In response to the requests of graduate students interested in disease diagnosis, we designed a 1 hour per week seminar class. The main objective of the course was to give students a practical hands-on experience in the diagnosis of diseases and other plant problems.

**Instructors:**

Name	Crop expertise
Suzanne Rooney-Latham	Grapevines, ornamentals, trees
Cheryl Blomquist	Ornamentals, trees
Doug Gubler	Fruits, nuts, vines
Mike Davis	Vegetables, field crops

**Who were the students?** Course participants included registered graduate students, graduate students on filing fee status, undergraduates, post-doctoral researchers, junior researchers and other staff members in the department and related departments




**Course Breakdown:** The class met for one hour each week during the spring 2009 quarter. Individuals were graded on a Pass/No Pass system, based solely on participation. Each week a different topic was presented to the students. An introduction and short lecture, including useful handouts, was typically presented during the first 10-20 minutes of each class. The remainder of the class time was spent on “unknown” disease samples that pertained to the weekly topic (or previous topics). Students were allowed to work independently or in small groups to try and diagnose each sample. Appropriate resources were made available to the students each week and included literature and reference manuals (i.e. compendia), compound and stereomicroscopes and necessary supplies for preparing specimens on slides. A group discussion for each plant sample was held toward the end of the class.

**Course topics:**

- Introduction:** Signs and symptoms, types of pathogens, important information needed for diagnostics, looking at samples with a compound and stereomicroscope, how to prepare slides for microscope viewing.




- Resources:** Books, lists, websites. (Handout)




- Root and crown diseases:** Below and aboveground plant symptoms of root rot, culturing from roots, sampling for an ELISA based assay for *Phytophthora* spp.
- Sequence Analysis data:** benefits, limitations, genes used in fungal identification, how to interpret sequence data and perform BLAST searches.
- Powdery and Downy mildews:** how to distinguish between them, morphological characters of each group, how to make scotch tape mounts (Handout)
- Rusts:** Common genera, urediniospore and teliospore morphology (Handout).

	Powdery Mildews	Downy Mildews
<b>Classification</b>	True fungi (Ascomycota)	Oomycetes (Stramenopiles)
<b>Characteristics</b>	White, powdery growth on upper and lower leaf surfaces	Yellowish-brown lesions on lower leaf surfaces
<b>Pathogen</b>	Ascomycetes	Oomycetes
<b>Diagnosis</b>	Microscopic examination of spores	Microscopic examination of spores
<b>Control</b>	Resistant varieties, fungicides	Resistant varieties, fungicides
<b>Damage</b>	Chlorotic, necrotic lesions	Chlorotic, necrotic lesions
<b>Overwintering</b>	Ascomycetes	Oomycetes
<b>Overwintering</b>	Ascomycetes	Oomycetes

**Rust Hierarchy:**  
Etiological Agents:

- Sporidia (S):** Produced by minute sporangium, which one-celled hyaline spores with no diagnostic value. Characteristic ornamentation.
- Aeciospores (A):** Non-repeating spores produced as a result of cleistothecium formation. Produced in cleistothecia. Characteristic ornamentation that permits to form the germ pore.
- Urediniospores (U):** Produced in cleistothecium from sporidia and they reproduce in the cleistothecium. Produced in cleistothecia in the cycles. Urediniospores typically globose, echinate, often with germ pores.
- Teliospores (T):** Typically the resting spore stage. Very resistant to desiccation and to high temperatures. Usually with thick walls, typically flattened. Produced in telia that can be found either in the cleistothecium, within the epidermal cells, the subcuticular layer, amongst cuticle or as thin-like columns.
- Basidiospores (B):** Produced on basidia following germination of teliospores. Very resistant and large but with no diagnostic value.



**7. Quarantine:** Discussion about pathogens of quarantine significance in California and what steps you need to take if you find a new pathogen/disease (Guest lecturer)

**8. Phytophthora diseases:** Using morphological, immunological and molecular detection methods.

**9. Virus detection:** virus symptoms, detection methods, challenges associated with viral diseases (Guest lecturer).

**10. Wilts and Canker Diseases:** Symptoms associated with vascular wilts, how to culture from vascular tissue, important vascular wilt diseases in California, class wrap up and course evaluations

**References:**

Blomquist, C.L., Rooney-Latham, S., and Tidwell, T. 2009. Graduate Level Diagnostics Course taught by NPDN Diagnosticians. California Department of Food and Agriculture, Sacramento, CA. 100 pages.

Blomquist, C.L., Rooney-Latham, S., and Tidwell, T. 2009. Graduate Level Diagnostics Course taught by NPDN Diagnosticians. California Department of Food and Agriculture, Sacramento, CA. 100 pages.

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Blomquist, C.L., Rooney-Latham, S., and Tidwell, T. 2009. Graduate Level Diagnostics Course taught by NPDN Diagnosticians. California Department of Food and Agriculture, Sacramento, CA. 100 pages.

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2009 Plant Pest Diagnostics Center Annual Report

## TRAINING

PPDB Lab scientists participated in various meetings, workshops, and training sessions with USDA to learn protocols and techniques to diagnose NPDN-identified high profile pathogens and plant pests:

- Two pathologists received training in the updated CPHST/USDA Diagnostics protocol for *Phytophthora ramorum* (Sudden Oak Death pathogen), as well as in the diagnostics for *Phytophthora kernoviae*, a pathogen very similar to *P. ramorum* currently known in Europe.

## PROVISIONAL ACCREDITATION

- Four PPDB diagnostic staff successfully performed and passed provisional laboratory tests as part of the APHIS Provisional Laboratory Accreditation process for *Phytophthora ramorum* diagnostics.
- Three PPDB diagnostic staff successfully performed and passed provisional laboratory tests as part of the APHIS Provisional Laboratory Accreditation process for Huanglangbing (HLB) diagnostics.

Figure 2. Palm Wilt poster presented at NPDN National Meeting in Miami, FL December 2009  
Rooney-Latham, S and C.L. Blomquist. 2009. "Palm wilt and other fungi associated with palm dieback in California."  
"Second National Meeting of the National Plant Diagnostic Network. Dec. 6-10, 2009. Miami, FL.



# Palm wilt and other fungi associated with palm dieback in California

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### Introduction:

Palm wilt is a lethal vascular wilt disease caused by the fungus *Fusarium oxysporum* f. sp. *canariensis*. It was first documented in 1970 in France and has since been reported in Italy, Australia, Greece, Japan and the U.S. (Florida and California). Worldwide, the most susceptible host is Canary Island Date Palm (*Phoenix canariensis*). The disease has also been reported on *Phoenix dactylifera*, *P. reclinata*, *P. sylvestris*, and *Washingtonia filifera* (3).



Figure 1: Palm wilt symptoms including one-sided dieback on mature trees in San Diego Co., CA (left) and San Francisco Co., CA (right).



Figure 3: Petiole discoloration (left) and leaflet dieback (right) of two fronds infected with palm wilt.

### Objective:

Determine the distribution and extent of palm wilt in California on various *Phoenix* species using the *Fusarium oxysporum* f. sp. *canariensis*-specific PCR assay.

### Survey Details:

**Sample collection:** Between April 2007 and November 2009, 460 palm samples were collected from 15 different counties throughout the state (Fig. 6). Symptomatic samples were taken from nurseries, businesses, parks and residences (Fig. 4). Samples were primarily *P. canariensis*, but *P. roebelii*, *P. dactylifera* and *P. reclinata* were also represented. Samples were collected and submitted to our lab by trained palm samplers (CDFA and county agricultural employees, private arborists and farm advisors)



Figure 4: The palm wilt survey included container and field grown trees in nurseries (left) and landscape trees (right).

### Results:

Disease and/or Fungus	No. samples	No. counties
<b>Palm wilt</b>		
<i>F. oxysporum</i> f. sp. <i>canariensis</i>	223 (49%)	14
<b>Pink rot</b>		
<i>Nalanthamala vermosenii</i>	81 (18%)	8
<b>Botryosphaeriaceae group:</b>	32 (7%)	10
<i>Neodeightonia phoenicum</i>	10	
<i>Neofusicoccum australe</i>	8	
<i>Neofusicoccum luteum</i>	7	
<i>Diplodia mutila</i>	2	
<b>Other fungi:</b>	24 (5%)	8
<i>Phaeoacremonium</i> spp.	8	
<i>Phaeomoniella</i> sp.	1	
<i>Phomopsis</i> sp.	14	
<i>Cytospora eucalypticola</i>	1	
<i>Exserohilum rostratum</i> (leaf spot)	1	



Figure 5: Typical dark vascular discoloration at the base of a petiole from an infected tree (left). Pathogenic strain of *Fusarium oxysporum* f. sp. *canariensis* on APDA (right).

### Summary:

**Palm wilt** appears to be widespread in California. In samples collected in 2007-2009, it was confirmed in 14 of the 15 surveyed counties. The weather in these counties ranged from cool-coastal to dry-valley to hot-desert. Palm wilt was only detected in *P. canariensis* and *P. reclinata* palm species. Interestingly, the palm wilt PCR did not detect 13 of the 223 (3%) *Fusarium oxysporum* f. sp. *canariensis* isolates. Final identification of these isolates was made by comparing the sequence of the TEF gene of the unknown isolate with known *F. oxysporum* f. sp. *canariensis* sequences. These PCR-negative isolates originated only from trees in Southern California counties (Riverside, San Diego and Ventura Co.). Variation may exist within *Fusarium oxysporum* f. sp. *canariensis* that was not evident when the assay was originally developed. **Pink rot** caused by *Nalanthamala vermosenii* was also common in our survey, especially among trees infected with *F. oxysporum* f. sp. *canariensis*.

Many species within the **Botryosphaeriaceae** were also confirmed from samples showing branch dieback and vascular discoloration symptoms. Although many of the species we encountered have not previously been reported on palms in California, they are probably associated with the "petiole or rachis blight" disorder described on *Phoenix* spp. *Neofusicoccum australe* has been reported on *Phoenix* sp. in Australia, but has only been reported on grapevine and avocado in the U.S. Worldwide, there are no reports of *N. luteum* on palm. *Neodeightonia phoenicum* has been documented on *P. dactylifera* in the U.S., but not *P. canariensis*.

Species of *Phaeoacremonium* and an undescribed species of *Phaeomoniella* were also detected in this survey. These two genera are most commonly associated with grapevine declines worldwide. *Cytospora eucalypticola*, which was encountered once in our survey, causes seedling and tree cankers on *Eucalyptus* spp. in Australia and South Africa. The role of these fungi in palm dieback is unknown. Pathogenicity experiments on *P. canariensis* plants with these fungi are forthcoming and this survey is ongoing.

### References:

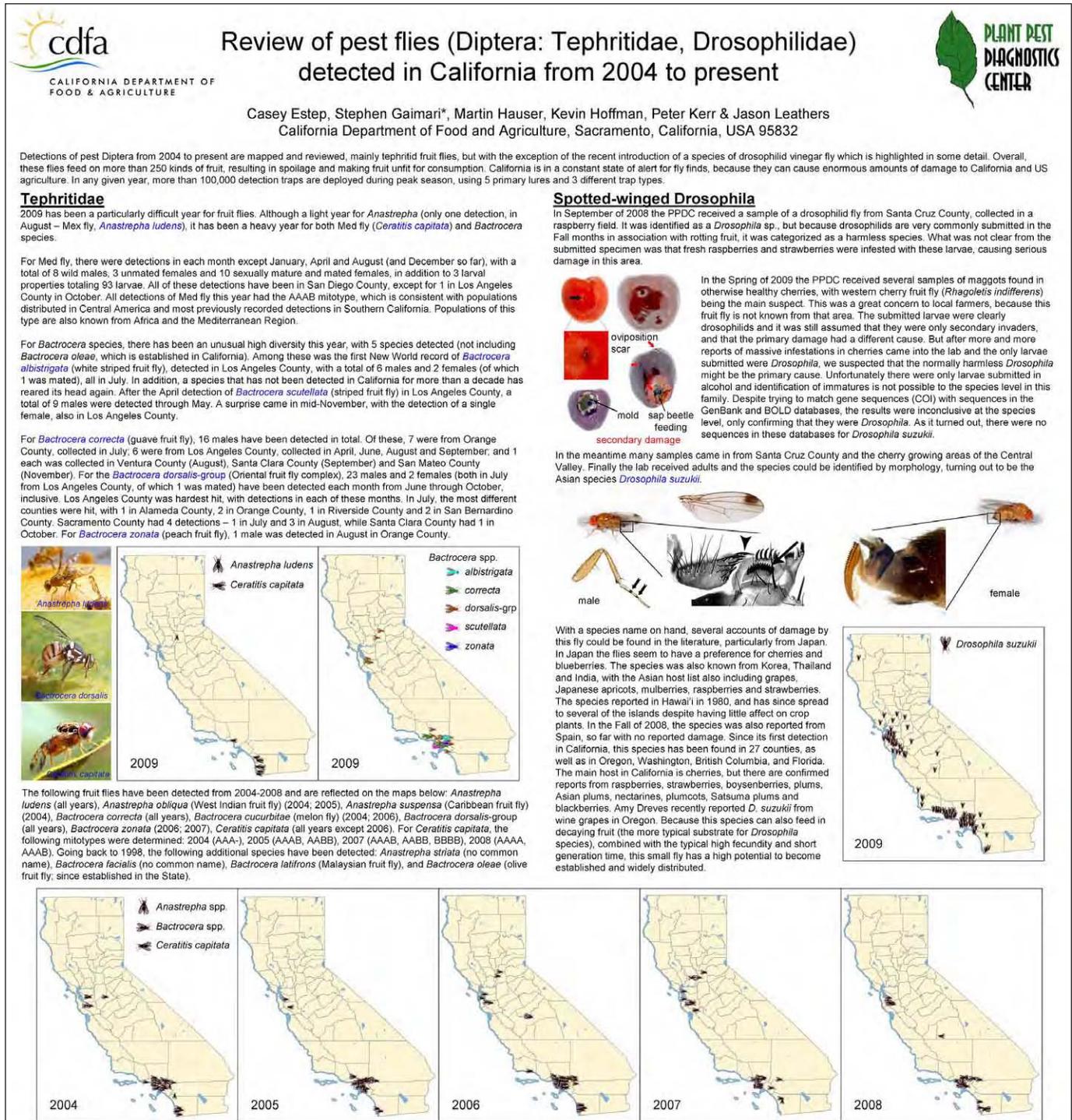
1. Davel, C. M. et al. 2009. FUSARIUMID v. 1.0: A DNA Resource Database for Identifying *Fusarium*. *European Journal of Plant Pathology*, 110:473-479.
2. Papp, T.R., Spauld, G.W., Runkholz, C. and H.C. Scales. 1999. Rapid detection of the Fusarium oxysporum f. sp. canariensis on the Canary Island Date Palm with pathogen. *Phytopathology*, 89:807-812.
3. Sorens, G.W. and Casler, G. 1998. Fusarium Wilt of Canary Island Date Palms in Florida. *Plant Pathology Path Brief* PP-48. University of Florida, Cooperative Extension Service, Gainesville, FL.

## MEETING PARTICIPATION

Four PPDC scientists participated in the 2009 NPDN National Meetings at Miami, FL. in December 2009. At the National Meeting three poster presentations were given by

PPDB staff and other collaborators. Two of the posters are on previous pages, the 3rd follows on the current page.

Figure 3. Pest flies detected in California poster presented at NPDN National Meeting in Miami, FL December 2009. Estep, C., S. Gaimari, M. Hauser, K. Hoffman, P. Kerr and J. Leathers. "Review of pest flies (Diptera: Tephritidae, Drosophilidae) detected in California from 2004 to present." Second National Meeting of the National Plant Diagnostic Network. Dec. 6-10, 2009. Miami, FL.



# California State Collection of Arthropods Report

The California State Collection of Arthropods (CSCA) is a scientific resource for the local, federal and international community for research and identification of various groups of arthropods, especially insects. The collection is maintained by the Entomology Lab of the Plant Pest Diagnostics Center. Two curators, a collection manager, and the entire scientific staff directly supervise the care, use, growth and development of CSCA by encouraging the use of this collection for research on the taxonomy and systematics of arthropod taxa. The web page for the collection is located at the following website: <http://www.cdfa.ca.gov/phpps/ppd/csc.html>.

As far as specimen usage, the California State Collection of Arthropods issued 24 loans in 2009 representing nearly 3,000 specimens, and hosted more than 20 visitors from the local, national and international communities to study the collections on site. Visitors came from several North American institutions, including the Smithsonian Institution, the Canadian National Collection of Insects, the California Academy of Sciences, the Field Museum, and the Royal Alberta Museum.

The total number of prepared specimens is over 2 million (databasing is not complete), with approximately 100,000 prepared specimens accessioned in 2009. With the CSCA's blanket permit to collect arthropods in California's State Park system, several seasonal survey efforts were undertaken in 2009, including Indian Grinding Rock Historical, Calaveras Big Trees and Prairie Creek State Parks, as well as Redwoods National Park. In addition, the CSCA organized the 2009 North American Dipterists Society field meeting, based in Crescent City. CSCA's frozen tissue collection continues to grow. At least 12 holotypes and numerous paratypes were deposited in CSCA in 2009, and the collection has been recognized as an important repository for certain groups of arthropods. While personal examination of types may always be necessary, there are plans to add multiple-view close-up digital images to the CSCA Web page for each species held. The inventory of the entire collection is nearly complete with more than 40,000 species so far.

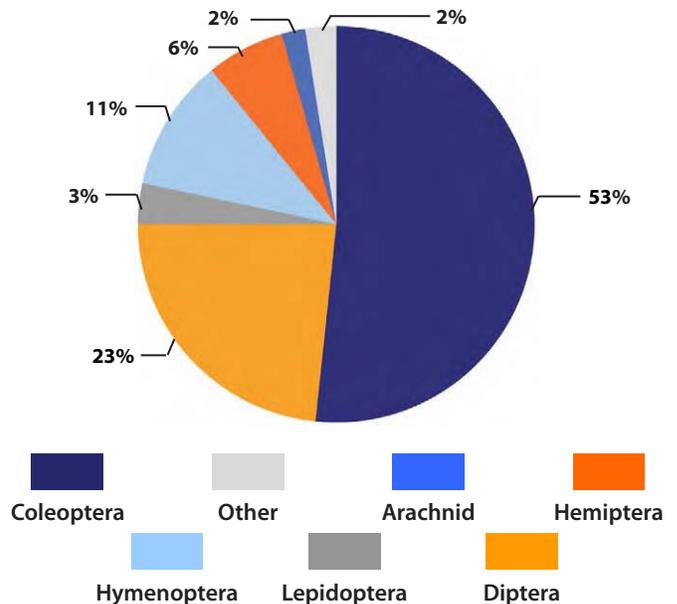
To accommodate interested vocational and avocational entomologists locally, regionally, and worldwide the CSCA has a Research Associate program. Through the associate program, PPDC encourages the use of the collection, the growth of the collection through their respective donations and allows associates to cite their status, if necessary, to provide an institutional address for publications or grants. Several additional scientists have applied to our program in

2009 and have been awarded this courtesy appointment. The Research Associates can be found on the branch website at: <http://www.cdfa.ca.gov/phpps/ppd/csc.html#associates>

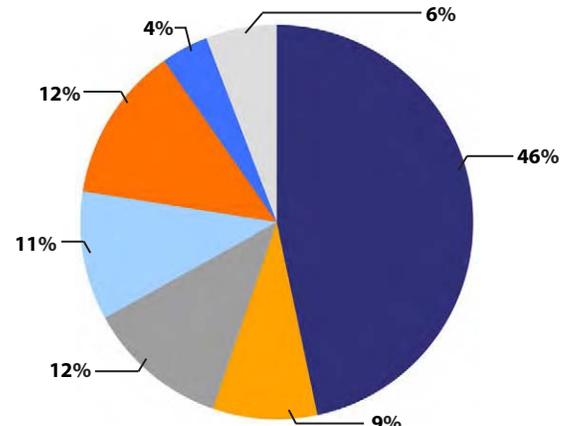
## Current Specimens Databased in the CSCA

Order	Total Specimens	Total Species
<b>Coleoptera</b>	781,047	19,134
<b>Diptera</b>	349,029	3,535
<b>Lepidoptera</b>	50,548	4,762
<b>Hymenoptera</b>	163,953	4,314
<b>Hemiptera</b>	96,528	5,320
<b>Arachnid</b>	31,126	1,551
<b>Other</b>	36,691	23,90
<b>Total</b>	1,508,922	41,006

## Current Specimens Databased in the CSCA



## Current Species Databased in the CSCA



## STAFFING CHANGES



From left to right: Jennifer Haynes demonstrating her pipetting expertise, Robert Price with one of his prize specimens, and Lani Yakabe hard at work in the Plant Pathology Laboratory..

### Arrivals

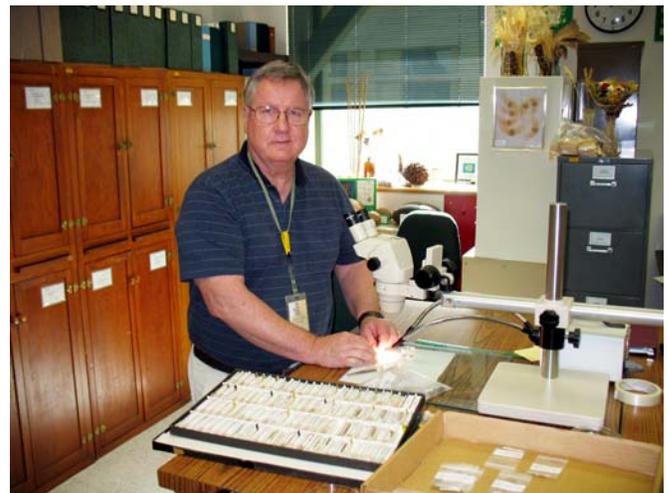
**Jennifer Haynes** joined the Plant Pathology laboratory as an Agricultural Biological Technician in March 2009, after serving as a Scientific Aide in the Nematology laboratory. Jennifer graduated from the University of California, Davis with a Master of Science in Plant Pathology in 2009. With her skills in molecular and classical diagnostic methods, as well as her knowledge of plant pathology, Jennifer has been a great addition to the Plant Pathology laboratory, particularly in the areas of molecular diagnostics of *Phytophthora ramorum* (Sudden Oak Death, or “SOD” pathogen) and Citrus Greening Disease (Huanglongbing, or “HLB”), as well as the day to day diagnostics of plant pathogens.

**Dr. Robert Price** joined the Seed Science laboratory as an Associate Seed Botanist in September, 2009. He has most recently worked in the Bay Area as a technical editor and as a consultant to a worldwide photographic atlas of conifers. He has also taught and conducted research in plant systematics at the University of Georgia with a specialization in the gymnosperms and the Brassicaceae. He received his Ph.D. in Botany at the University of California, Berkeley in 1987.

**Dr. Lani Yakabe** joined the Plant Pathology laboratory in November, 2009. Dr. Yakabe received her Ph.D. degree in Plant Pathology from the University of California, Davis in 2007. While a graduate student, she worked on *Phytophthora ramorum* research with Dr. Cheryl Blomquist of the PPDC. More recently, her research has focused on the Crown Gall pathogen on woody perennials. Her current diagnostic responsibilities include diagnostics of Huanglongbing (HLB) and other bacterial pathogens.

### Departures

Senior Seed Botanist, **Donald Joley**, retired after 33 years of state service at both the Plant Pest Diagnostics Center Seed Science Laboratory and the Integrated Pest Control Branch Biological Control Unit. Prior to professional service, Don also worked intermittently with CDFA for several years while completing a Masters Thesis on herbicide control of rush skeletonweed. Mr. Joley is an accomplished scientist in both the field and the laboratory, having worked for many years identifying noxious weeds by their seeds and other propagules, as well as doing field research on the biological control of noxious weeds using various arthropods and pathogens. He is particularly well known in CDFA for his extensive research on the biological control of Yellowstar thistle.



Donald Joley examining specimens in the the Seed Science Laboratory.

# BOTANY LABORATORY REPORT

2009 BOTANY LABORATORY STAFF

## PLANT SYSTEMATISTS

Fred Hrusa  
Dean Kelch

## TECHNICAL STAFF

Patrick Woods

## SCIENTIFIC AIDES

Matthew Beyer  
Mary Jo Colletti  
Yoshiko Kinmonth

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The Botany Laboratory provides plant identification services, noxious weed distribution information, and biological support data to the County Agricultural Commissioners' offices, the general public, CDFA programs, and various other State and Federal agencies. These activities function to help prevent the introduction and spread of serious weed pests and to identify host plants of insects, plant diseases, and plant parasitic nematodes. Plant identification is an integral part of weed pest exclusion, detection, control, and eradication. It is also important to other units of the Department, such as the Animal Health & Food Safety Services, Inspection Services and to county departments of agriculture, which require prompt and accurate botanical information in pursuit of their missions.

The Botany Laboratory herbarium (known internationally as The Herbarium of the California Department of Agriculture, or simply the "CDA,") currently contains more than 55,000 specimens and has an active specimen exchange program with state, national and international herbaria. These specimens form the basis for ensuring accurate identification of plants new to or currently growing in California. Field investigations are also an essential part of the program; not only to collect specimens, duplicates of which form the nucleus of the exchange program and populate the collection itself, but also to evaluate such things as the environmental conditions influencing the presence of new or existing plant populations. Seventy-five percent of the counties submit 90% or more of their plant specimens to the Botany Laboratory/Herbarium CDA for identification or confirmation. The ability of the laboratory to assist field programs promptly and ac-

curately has aided in pinpointing the distribution of the major weed pests in the state. The Botany Lab has begun a long-term project to database the entire herbarium collection and make the data available on the web as part of the Consortium of California Herbaria, which provides plant specimen data from 18 different California herbaria. One-stop shopping for botanical information will revolutionize the ability of scientists to understand plant distribution and systematics in California. This outreach to other botanical institutions is an example of forming alliances with other organizations and increasing the use and relevance of the CDA Herbarium to the California community.

In 2009, the Plant Pest Diagnostics Botany Lab received 1167 samples for identification along with Pest and Damage Report (PDR). Of those, 124 (10.6%) were identified as 'A'-rated weeds, 131 were 'B'-rated (11.2%), and 30 (2.6%) were 'Q'-rated. In 2009, approximately 2,475 new specimens were identified, cataloged, and added to the CDA Herbarium, expanding the collection to more than 55,000 mounted specimens. The Botany Laboratory's participation in an exchange program with other herbaria from around the country and the world continues to increase taxonomic diversity within the collection. Through this program approximately 975 new specimens were obtained, identified, and mounted in 2009. During the year, DNA analysis confirmed the morphological identifications of 38 *Cuscuta* specimens. 20 *Cuscuta* cf. *japonica* specimens were molecularly confirmed to be *Cuscuta japonica* (Japanese Dodder) and 18 morphologically indeterminate specimens were confirmed as various native California species of *Cuscuta*.

# Jepson Manual Taxonomic Treatments

F. Hursa

Dr. Hursa completed and submitted treatments for the below five genera belonging to the plant family Chenopodiaceae (pigweeds, goosefoots etc.). Most are California weeds. These treatments will be included in the upcoming Jepson Manual Ed. 2, due to be published in hard copy by 2011. Online access for these and other completed treatments are available at:

[http://ucjeps.berkeley.edu/tjm2/review/treatments/chenopodiaceae-gp-goldman\\_inc.html](http://ucjeps.berkeley.edu/tjm2/review/treatments/chenopodiaceae-gp-goldman_inc.html)

## BASSIA

Ann, gen hairy. **ST:** axis gen erect; branches ascending to erect. **LF:** linear to lanceolate, reduced distally on st. **INFL:** spike; bracts lf-like; fls 1–few per axil. **FL:** gen bisexual; calyx lobes 5, incurved, hooked-spiny in fr; stamens gen 5; stigmas gen 2. **FR:** ± depressed-spheric. **SEED:** horizontal. ± 10 spp.: warm temp Eurasia, Afr. (Ferdinando Bassi, Italian botanist, 1710–1774) [Chu & Sanderson 2008 Madroño 55:251–256; Mosyakin 2004 FNANM 4:309–310] *Kochia scoparia* alternatively treated here.

## *B. hyssopifolia* (Pall.) Kuntze

### NATURALIZED

Pl gen < 1.5 m. **LF:** lower 5–60 mm, 1–3.5 mm wide, flat, gen withered in age. **INFL:** 5–50 mm; bracts 2–5 mm, ± oblong. **FL:** calyx densely tan-woolly, base leathery in fr, spines ± 1 mm. **FR:** 1–1.5 mm diam. **SEED:** dark brown. Disturbed sites, fields, roadsides, ditches; < 1200 m. CA (exc NW, SNH; common in s CA); widespread N.Am; native to Eurasia. Occ confused with *Kochia scoparia*.

## CORISPERMUM

### BUGSEED

Ann, gen erect, branched, glabrous to sparsely long-hairy, gen glabrous in age. **ST:** branches 0–few, spreading to ascending. **LF:** gen linear. **INFL:** spike, terminal; bracts lf-like, reduced distally. **FL:** bisexual; perianth parts 0–5, scarious; stamens 1–3(5); ovary superior, chamber 1, stigmas 2. **FR:** 1.6–5.2 mm, elliptic to obovate. **SEED:** vertical, wings 0 to narrow. ±65 spp.: n temp. (Latin & Greek: leathery seed) [Mosyakin 2004 FNANM 4:313–321; Betancourt et al 1984 Nature 311:653–655]

## *C. americanum* (Nutt.) Nutt. var. *americanum*

### AMERICAN BUGSEED

#### NATIVE

Pl well-branched, 3–15 cm; glabrous. **LF:** 9–25 mm, 1–2.5 mm wide. **INFL:** 1–4 cm, narrow; bracts in fr 3–20

mm, gen covering fr, margin scarious. **FL:** perianth parts 1, stamens gen 3. **FR:** body 2.0–3.5 mm, ± obovate, ± yellow-green to brown, gen red-spotted or warty, convex abaxially, flat to ± convex adaxially; wing ± opaque, 0–0.2 mm, entire or ± cut, if ± 0 gen with remnant style-base < 0.1 mm beyond summit. Sandy soils, dunes; 900–1200 m. n DMoj (Eureka Valley); N.Am exc se, n Mex. [*Corispermum hyssopifolium* L., misappl.; *Corispermum hyssopifolium* var. *americanum* Nutt.]. CA apparently rare, seldom collected. California material ± atypical, more study needed. *Corispermum americanum* var. *rydbergii* Mosyakin in SW N.Am, Mex; May.

## CYCLOLOMA

### WINGED PIGWEED

1 sp. (Greek: circular wing, from calyx in fr) [Mosyakin 2004 FNANM 4:264–265]

## *C. atriplicifolium* (Spreng.) J.M. Coult.

### NATURALIZED

Ann 12–75 cm, many-branched, rounded. **ST:** spreading, slender, striate, finely long-shaggy-hairy to tomentose, gen glabrous in age. **LF:** gradually reduced distally; petiole 0–12 mm; blade 5–65 mm, lanceolate to ovate, wavy-dentate; densely to sparsely long-shaggy-hairy, gen glabrous in age. **INFL:** panicle-like, terminal, open in fr; bracts 0; fls sessile. **FL:** bisexual or pistillate; calyx enclosing fr, 2–3 mm diam in fr, round-winged, lobes 5, ± keeled; stamens 5; ovary densely, finely tomentose, style deeply 2–3-lobed. **FR:** ± 2 mm diam. **SEED:** 1.5–2 mm diam, lens-shaped, horizontal, dull black, long-shaggy-hairy.  $2n=36$ . Fields, disturbed areas, gen sandy; < 1250 m. GV, s SCo, w PR, DMoj; Can to N Mex; native to c N.Am. [*Salsola atriplicifolia* Spreng.]



*Cycloloma atriplicifolium*, Packer Island, Glenn Co., CA  
Photo by D.W. Taylor, PhD



*Kochia scoparia*, Lassen Co., CA; Photo by G.D. Barbe (CDA)

## KOCHIA

Ann to subshrub, gen erect, glabrous to tomentose. **LF:** alternate or lower  $\pm$  opposite,  $\pm$  threadlike to lanceolate, flat to cylindrical, fleshy or not. **INFL:** spikes, simple or branched; bracts lf-like; fls 1–7 per axil. **FL:** bisexual or pistillate, sessile; calyx lobes 5, incurved, keeled; tubercled, winged or not in fr; stamens 5; stigmas 2–3. **FR:**  $\pm$  compressed-spheric. **SEED:** horizontal.  $\pm$  15 spp.: w N.Am, Eurasia. (Wilhelm D. Koch, German physician & botanist, 1771–1849) [Chu & Sanderson 2008 *Madroño* 55:251–256] Native spp. alternatively treated in *Neokochia*, *Kochia scoparia* in *Bassia*.

1. Ann; lower cauline lvs narrowed to base or short-petioled, gen 3–5-veined below middle. ....  
*K. scoparia* subsp. *scoparia*

1' Per or subshrub; lvs sessile, vein 1 or obscure

2. Sts many from base, gen simple, glabrous to finely white-tomentose; lvs gen overlapping .....  
*K. americana*

2' Sts 1–few from base, gen branched throughout, gray- to brown-puberulent; lvs not overlapping .....*K. californica*

### *K. americana* S. Watson

#### NATIVE

Subshrub 8–40 cm, root-sprouting. **ST:** many from base, gen simple, ascending to erect, gen finely white-tomentose, occ glabrous in age. **LF:** 5–20 mm, 1–2 mm wide, gen overlapping,  $\pm$  cylindrical to flat,  $\pm$  fleshy, glabrous to spreading-long-hairy; vein obscure or 1. **INFL:** fls 1–3 per axil; bracts 4–15 mm, 0.5–1 mm wide, gen ascending, spreading in age.

**FL:** calyx lobes gen white-tomentose, wings fan-shaped, in fr < 2 mm. **FR:** < 4 mm wide. Alkaline soils, flats, dry lake margins; 600–2200 m. GB, DMoj; to WA, MT, TX; [*Kochia americana* var. *vestita* S. Watson; *Kochia vestita* (S. Watson) Rydb.; *Neokochia americana* (S. Watson) G.L. Chu & S.C. Sand.]. May–Aug

### *K. californica* S. Watson

#### NATIVE

Per or subshrub 20–60 cm, root-sprouting. **ST:** 1–few from base, erect, gen branched throughout, densely gray- or brown-puberulent to long-spreading-hairy. **LF:** 3–12 mm, 1–3 mm wide, gen well spaced, gen flat,  $\pm$  fleshy,  $\pm$  appressed silky-hairy; vein obscure or 1. **INFL:** fls 1–2(5) per axil, bracts gen spreading. **FL:** calyx lobes densely short-hairy, wings in fr  $\pm$  1–2 mm. **FR:** < 3 mm wide. Alkaline soils, flats; < 1000 m. s SnJV, DMoj; s NV. [*Kochia americana* var. *californica* (S. Watson) M.E. Jones; *Neokochia californica* (S. Watson) G.L. Chu & S.C. Sand.]. May–Sep

### *K. scoparia* (L.) Schrad. subsp. *scoparia*

#### NATURALIZED

Ann 20–120 cm. **ST:** simple to much-branched, glabrous to spreading-hairy. **LF:** 8–50 mm, 1–6 mm wide, flat, glabrous to appressed-hairy, gen 3–5-veined below middle. **INFL:** branched spike, short- to densely long-hairy, hairs < to > fls; fls 1–7 per axil; hairs gen hiding fls in immature infl. **FL:** calyx glabrous to thinly appressed-hairy, lobe margins gen bristly (glabrous); bisexual fls with tubercles or wings < 2 mm in fr. Disturbed places, fields, roadsides; < 2300 m. CaR, SN, GV, n SnFrB, SCo, SnBr, GB, D; to e US; native to Eurasia. [*Bassia scoparia* (L.) A.J. Scott; *Bassia scoparia* var. *culta* Voss; *Bassia scoparia* subsp. *culta* (Voss) Nebot, De la Torre, Mateo & Alcaraz; *Kochia iranica* Bornm., misappl.; *Kochia scoparia* subsp. *culta* (Voss) O. Bolòs & Vigo; *Kochia scoparia* var. *subvillosa* Moq.; *Kochia scoparia* forma *trichophylla* (Voss) Schinz & Thell; *Kochia trichophylla* Voss.]. Immature pls much like *Bassia hyssopifolia* (Pall.) Kuntze. A cult form, with linear to thread-like lvs, short internodes, infl hairs < fls, has been called *Kochia scoparia* subsp. *culta* (Voss) O. Bolòs & Vigo, is a rare escape in SnJV, SCo, and expected elsewhere. Other subsp. in Eurasia. Aug–Nov.

## SALSOLA

### G. F. Hrusa

Ann to shrub. **ST:** simple to many-branched. **LF:** gen reduced distally along st, thread-like to  $\pm$  cylindrical, spine-tipped, in age gen thick, rigid. **INFL:** axillary; bracts 1–2; fls gen 1 per axil. **FL:** bisexual; sepals 4–5, thickened in fr, persistent, gen tubercled to winged; stamens gen 5, exserted, style branches gen 2, exserted. **FR:** spheric to obovoid; tip

± depressed. **SEED:** gen horizontal. ± 100 spp.: ± world-wide. (Latin: salty, from habitats) [Mosyakin 2003 FNANM 4:398–403; Hrusa & Gaskin 2008 Madroño 55:113–131] As treated here, *Salsola* is paraphyletic. An alternative, monophyletic, treatment as separate genera *Kali* (*Salsola australis*, *Salsola gobicola*, *Salsola paulsenii*, *Salsola ryanii*, *Salsola tragus*), *Caroxylon* (*Salsola damascena*), and *Salsola* (*Salsola soda*) has been proposed (Akhani et al. 2007 Int J Plant Sci 168:931–956).

1. Shrub; lvs 3–9 mm, not reduced upward, oblong to ovate, gen puberulent .....*S. damascena*

1' Ann; lvs 5–55 mm, gen reduced upward, thread-like to lanceolate, glabrous to hairy or papillate.

2. Pl strongly fleshy in fr; sepal wings in fr ± tubercled, thickened, rudimentary; lf, bract narrowed abruptly to short-pointed tip; st glabrous .....*S. soda*

2' Pl not or ± fleshy in fr; sepal wings in fr thin, membranous, well-developed on at least some frs; lf, bract tips narrowed gradually to sharp spine; st glabrous to bristly, papillate-hairy, or with mixed hair types

3. St papillate-hairy or with mixed hair types

4. Sepals 5, gen all winged, tips in fr soft to spiny; st hairs mixed bristly- and papillate-hairy, or papillate-hairy only; bract wing 0.3–0.6 mm --> *S. gobicola*(2)

4' Sepals 5, 3 segments gen winged, 2 rudimentary to ± narrowly winged, tips in fr hardened into sharp 3–5-parted spine; st hairs papillate; bract wing gen < 0.3 mm or 0 .....*S. paulsenii*

3' St glabrous to bristly, bristles occ few or short

5. Smallest 2 sepal wings deltoid to broadly obovate, length 1–2 × width; anthers ≤ 0.7 mm .....*S. australis*

5' Smallest 2 sepal wings oblong, spoon-shaped, lanceolate, linear, or rudimentary, gen not ± fan-shaped, length > 3 × width; anthers ≥ 0.6 mm

6. Bract wing narrow, 0.3–0.6 mm, opaque-white to ± translucent, base not surrounding fr; sepal wings ± translucent, smallest 2 narrowly oblanceolate to linear, or 1 (both) rudimentary --> *S. gobicola*(2)

6' Bract wing broad, gen > 0.4 mm, ± translucent, base surrounding fr; sepal wings opaque to translucent, smallest 2 narrowly winged

7. Smallest 2 sepal wings narrower at base, broadened gradually or sharply to gen rounded

tips; st hairs sparse, short; anthers 0.6–0.9 mm .....*S. ryanii*

7' Smallest 2 sepal wings with ± parallel sides, tip unevenly lobed, or wing linear and tip ± truncate; st glabrous to bristly; anthers 0.6–1.3 mm .....*S. tragus*

### ***S. australis* R. Br.**

#### **NATURALIZED**

Ann < 2 m, branched, not readily breaking at base, glabrous to ± minutely scabrous (short-bristly). **ST:** brittle, blue-glaucous to green, occ red-striped. **LF:** opposite or alternate below, alternate above, 8–52 mm, blade ± deciduous, base broader in age, margin broad, translucent, tip sharp-pointed to spiny. **INFL:** open to dense, prickly, gen not rigid; bract not surrounding fr, subcylindric, weakly spiny, narrowly wing-margined in age, lower margin ± translucent. **FL:** sepals 2.5–3 mm, lobes soft in fr; anthers 0.5–0.7 mm. **FR:** deciduous in age; 4.8–7.9 mm diam incl wings; developed wings 5, opaque, veins few, gen dark, margin gen smooth, smallest wings deltoid to broadly obovate.  $2n=18$ . Disturbed places, road banks, open slopes, railroad tracks, shorelines; < 700 m. GV, CW, SCo, D (rare in DMoj); sw N.Am, Mex, Afr; possibly native to Australia. [*Kali australis* (R. Br.) Akhani & Roalson; *Salsola kali* L. subsp. *pontica* (Pall.) Mosyakin, misappl.; *Salsola kali* L. var. *tenuifolia* Tausch, misappl.; *Salsola tragus* L., misappl.]. Mar–Jan.

### ***S. damascena* Botsch.**

#### **NATURALIZED**

Shrub 60–100+ cm, gen puberulent. **ST:** branched ± throughout, branches ascending to erect, not ribbed longitudinally, not red-striped. **LF:** alternate, 3–9 mm, lower oblong, upper ovate, gen puberulent, tip obtuse to acute. **INFL:** bracts ovate, lf-like, narrowly wing-margined. **FL:** sepals 2–3 mm, wing ± 2 mm **FR:** 7–11 mm diam incl wings; de-



*Salsola australis*, San Joaquin Vallet, nr. Shafter, Kern Co., CA; Photos by P. Akers, CDFA



*Salsola gobicola*, Victorville, San Bernardino Co., CA  
Photo by P. Akers, CDFA

veloped wings 5, opaque, veins numerous. Clay soils, flats; ± 1000 m. se SCoRI (Temblor Range); native to Medit, sw Asia. [*Salsola vermiculata* L., in part; *Caroxylon vermiculatum* (L.) Akhani & Roalson, in part]

### ***S. gobicola*** Iljin

#### **NATURALIZED**

Ann < 1.5 m, branched from base, papillate to short-stiff-hairy (± glabrous). **ST:** spreading to ascending, longitudinally ribbed, occ red-striped. **LF:** opposite to alternate below, alternate above, 8–52 mm, gray-green to yellow-green, blade deciduous; in age rigid, thick, broad, leathery, tip sharp-pointed or -spined. **INFL:** bract not surrounding fr, ± cylindric, spiny, bract wing 0.3–0.6 mm, opaque-white to ± translucent. **FL:** sepals 2.5–3 mm, soft to partially spiny in fr; anthers 0.7–0.9 mm. **FR:** deciduous in age; 5.4–11.1 mm diam incl wings, developed wings 5, ± translucent, veins few, gen pale, margin smooth to uneven, base gen with yellow or pink spot or both, smallest 2 wings narrowly oblanceolate to linear or 1 (both) rudimentary. Common. Disturbed, sandy, places; 120–2200 m. s SnJV, n WTR, SNE, DMOj; to UT, Mex, apparently native to Eurasia. [*Salsola paulsenii* Litv. misappl., *Salsola tragus* L., misappl.] Hybridizes with *Salsola tragus*, *Salsola paulsenii*. Relationship between papillate and non-papillate or ±glabrous forms warrants further study. Jul–Oct. = *Salsola* × *gobicola*

### ***S. paulsenii*** Litv.

#### **BARBWIRE RUSSIAN THISTLE**

#### **NATURALIZED**

Ann, gen < 1.5 m, ± conic, gen densely papillate. **ST:** branched from base, longitudinally ribbed, occ red-striped. **LF:** opposite to alternate below, alternate above, 5–32 mm; in age gen yellow-green, leathery, base wider. **INFL:** bract not surrounding fr, ± cylindric, spiny, margin narrow, white to ± translucent. **FL:** sepals 2.5–3.5 mm; anthers 0.4–0.7 mm. **FR:** deciduous in age; 6.6–10.7 mm diam incl wings; developed wings 3–5, translucent, veins few, gen pale, mar-



*Salsola paulsenii*, Mojave River nr. Atton Canyon, San Bernardino Co., CA; Photo by P. Akers CDFA



gin gen smooth, base yellow- to pink-spotted, in fr smallest 2 wings rudimentary or 1(2) narrowly linear; sepal tips spiny. Common. Sandy, disturbed places; < 1000 m. n WTR (se Cuyama Valley), D; to UT; native to se Eur, c Asia. [*Kali paulsenii* (Litv.) Akhani & Roalson]. Hybridizes with *Salsola tragus*. Jul–Oct.

### ***S. ryanii*** Hrusa & Gaskin

#### **NATURALIZED**

Ann < 2 m, ± rounded, loosely branched from base, glabrous to sparsely short-bristly. **ST:** branched from base, longitudinally ribbed, occ red-striped. **LF:** opposite to alternate below, deciduous, alternate above, 5–55 mm, in age upper rigid, bases wider, leathery, margin translucent, tip sharp-pointed to spiny. **INFL:** bract ± cylindric, spiny, in age broad, thick, lower margin ± translucent. **FL:** sepals 2.5–3 mm; anthers 0.6–0.9 mm. **FR:** persistent or not; 4.6–8.1 mm diam incl wings; developed wings in fr 5, gen opaque, veins few, dark to pale, margin smooth to unevenly scalloped, smallest wings spoon-shaped. 2n=54. Uncommon. Disturbed places; < 350 (800) m. ScV, s SnJV, SCoRI. Hexaploid derivative of tetraploid *Salsola tragus*, diploid *Salsola australis*.



*Salsola ryanii*, Maricopa, Kern Co., USA  
Photo by P. Akers, CDFA

Not known outside CA. Occ pls of hexaploid *Salsola tragus* may key here, these gen more robust, hairy than *Salsola ryanii*. Jun–Oct

### *S. soda* L.

#### NATURALIZED

Ann 15–45 cm, branched from base, fleshy, glabrous. **ST**: branched from near base, not longitudinally ribbed, not red-stripped. **LF**: opposite below, alternate above, 6–55 mm, base widened, translucent-margined, tip rigid, short, pointed, not spined. **INFL**: bracts ± alternate, free, lanceolate to ovate, ± keeled, base broad, margin wing translucent, tip abruptly narrowed, short-pointed **FL**: sepals 3.5–6 mm, fleshy, glabrous, wingless or with rudimentary appendages in age. **FR**: 3–6 mm diam, appendages 0–1.6 mm.  $2n=18$ . Uppermost intertidal zone, saline or muddy flats, open areas in salt marshes; < 40 m. ScV (Delevan Wildlife Refuge), n CCo (San Francisco Bay); native to S. Eur. Jul–Oct.

### *S. tragus* L.

#### RUSSIAN THISTLE, TUMBLEWEED

#### NATURALIZED

Ann < 1.5 m, glabrous to bristly; when dead readily breaking at base, gen tumbling. **ST**: branched from base, branches wiry, longitudinally ribbed, gen red-stripped. **LF**: opposite to alternate below, deciduous, alternate above, 8–52 mm; in age leathery, upper lf bases widening, base margin translucent, tip sharp-pointed to spiny, fused with opposite bract or not. **INFL**: bract surrounding fr, ± cylindric, spiny, in age broad, thick, lower margin wing ± 0.5 mm, translucent. **FL**: sepals 2–5 mm, tips not stiff; anthers 0.6–1.3 mm. **FR**: gen persistent; 2.9–8.4 mm diam incl wings; wings 5, opaque, veins dark to pale, margins minutely toothed to unevenly scalloped (smooth), largest gen centrally notched, smallest linear to blunt-elliptic, sides ± parallel.  $2n=36(54)$ . Common. Disturbed places; < 2800 m. CA-FP, GB, D; to e N.Am, Mex; native to Eurasia. [*Salsola iberica* (Sennen & Pau) Botsch.; *Salsola kali* L. var. *tenuifolia* Tausch; *Salsola*



*Salsola tragus*, Bishop, Inyo Co., CA. Photo by P. Akers, CDFA.



*Salsola tragus*, Wasco, San Joaquin Co., CA;  
Photo by P. Akers, CDFA

*pestifer* A. Nelson]

Extremely variable in habit, coloration, sepal wing shape, etc. Hybridizes with *Salsola paulsenii*. Most common in GV, CW, MP, SW, SNE, D; uncommon or rare elsewhere, gen as a waif. Jul–Oct

This and other completed treatments  
[are available online](#)

## Significant Finds

### *Orobanche ramosa* (branched broomrape)

F. Hursa

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Branched broomrape, an achlorophyllous parasitic annual plant species known to use more than 300 other plant species as its host, was discovered in San Benito County in 2009. This is the first find of branched broomrape in California since 1983, and significantly the same site was the location for that infestation. Many of the parasitized species are crop plants or their wild or weedy relatives, with the most severely attacked being tomato (*Lycopersicon esculentum*), hemp, both European and Chinese (*Cannabis sativa* L. and *Cannabis indica* Lam. respectively) and tobacco (*Nicotiana tabacum*), three of the world's most important crops, although only the first is a major crop in California. Hemp is not a crop in California. Despite the use of its scientific name, *Cannabis sativa*, for cultivated marijuana; the intoxicating species is *Cannabis indica* (Hillig & Mahlberg 2004). *Cannabis indica* is also bred and grown for seed and fiber (and thus as hemp) in eastern Asia, particularly China, and *Orobanche ramosa* is a parasite of Chinese hemp and therefore *Cannabis indica*. In fact, the original introduction of branched broomrape to North America was through import of Chinese hemp seed (McPartland et al. 2000). At that time these Chinese hemp varieties were thought to be *Cannabis sativa*, but are now known to be conspecific with the intoxicant species *C. indica* and are not the industrial non-intoxicant *C. sativa* (Hillig & Mahlberg op cit.). Thus it is a parasite or potentially serious parasite of two of California's largest crops, even if one is only unofficially the largest in the state (*Cannabis*). This is particularly pertinent at this time as *Cannabis indica* could soon become one of, if not the largest, legal agricultural crop in California.

#### History

*Orobanche ramosa* may have first been recognized by the ancient Greeks who described plants attached to the roots of legumes. However, it is not known if they were referencing *Orobanche ramosa* or other species such as *O. cruenta* that preferentially parasitize legumes. It was definitely described by herbalists of the 16<sup>th</sup>-17<sup>th</sup> centuries, who, despite not knowing its biology, were aware of its requirement for a specific companion crop (Wilhelm 1962). These names and descriptions have no nomenclatural bearing, and the current name of *Orobanche ramosa* L. dates from Linnaeus' Species Plantarum of 1753.

Its indigenous region is thought to be the Caucasus of southern Russia (Wilhelm 1962.). The earliest reports of branched broomrape did not mention hosts, and it is unclear what it parasitizes in the indigenous non-agricultural setting.

It was introduced to Europe at an early date, apparently as a contaminant in hemp seed, and it is likely that it came to North America via the same host (Wilhelm op. cit; McPartland et al. 2000). When and how it first arrived in California is not known but the first report from the state was in Butte County in 1903. The host was not specified, but the specimen label stated "a very destructive root parasite on hemp, Gridley", suggesting that hemp was being cultivated then in the northern Sacramento Valley, and contaminants in hemp seed could have thus been the source of the first California branched broomrape infestations. Later, in 1928 (reported to CDFA in 1929) it was found on tomatoes growing in the Centerville region of Alameda County, a location where it persisted at least until the 1970s. The original find stated that only about 1.5 (one and one-half) acres were infested, with a second small infestation about 500 yards distant. These fields were abandoned, but in 1934 they were replanted to tomato and the parasite recurred. Again abandoned, there were subsequent flood events that washed over the local region apparently spreading seed downstream. In 1942 a local infestation was found, but not reported at the time. In 1949-52 it was found on at least 100 acres in the flooded zone, plus in smaller patches upstream of the original 1929 find. These upstream sites were farmed by the same family who farmed the original find (Stout and Wagon, 1953). It is not known whether hemp was cultivated in that region prior to 1929, and thus how the seed first arrived in Alameda County is unknown.

In 1959 it was found in two regions in and about the Sacramento Delta. In both locations it was parasitizing tomato. Surveys continued from then until the middle 1970s with finds continuing over all those years. Wilhelm et al. (1965) suggested that these infestations, described as in "heavy concentrations" on Grand and Roberts Islands in the mid-1960s had been present for a long period, perhaps many decades. Again, it is not known if hemp had ever been grown on Grand or Roberts Islands.

In 1976 it appeared in San Benito County near Frazier Lake and Shore Rds, just south of the State Hwy 152 and State Hwy 256 intersection. In 1982 a second infestation was discovered in the adjacent township and comprised almost 60 acres of a larger field. This location was found continuously infested for two years (1982 and 1983), then was put out of cultivation. Until 2009, this was the last known active location in California. In September of 2009 a specimen from



**Branched Broomrape, *Orobanche ramosa*, an A-rated, non-native parasite. Photo by D. Keltch**

San Benito County was received from the same township and range as previous, but a different section was reported. It later was confirmed that the 1983 and 2009 sites were the exact same locality and that the site had been fallow since 1983 (observed records are not available to confirm that no agricultural enterprise had subsequently occurred on the land, but it had not grown tomatoes). In 2009, following a request from the tomato industry for additional acreage, the 60 acres known infested in 1983 were planted to tomatoes. The result was an exact replication of the 1983 infestation, including almost the exact same boundaries.

### **Biology**

Plants of the genus *Orobanche* are non-photosynthesizing annual root parasites. Seeds in the soil germinate when triggered by root exudate from a compatible host. The root tips force themselves into the host root stele where they establish a vascular connection. The parasite then grows above the soil, flowers, sets and disperses seed. Seed is actually dispersed both before and at the time of senescence. Depending on the crop, the yellow-colored parasite with white or blue flowers may be readily visible or hidden beneath dense foliage. Although the plants are not typically self-pollinated, in California fertility ranges around 10% (Wilhelm 1962) suggesting that most of its seeds are the result of self-fertilization, and that an effective pollinator is likely not present. The effective pollinators in its indigenous range are not known. The seeds are small - - they have been compared to grains of ground pepper and each fully fertile flower produces several hundred with vigorous single plants producing up to at least 50,000 (Wilhelm et al. 1965). They are generally spread abiotically (soil, water, wind), but human assistance in both

these natural processes and via anthropogenic mechanisms such as harvesting and cultivation equipment have been responsible for its long-distance dispersal. The seeds are long-lived. Considering their small size, this is somewhat surprising, but literature sources citing anecdotal evidence, reveal that known infestations remain viable in the absence of the living parasite for at least 13 years (Wilhelm op cit.; Wilhelm et al. 1965 ). It is not known if a host was present in the 2009 infested area between 1983 and 2009, but in 2004 a tomato patch was planted and tended by Agricultural Commissioners staff in San Benito Co. on the site where in 1983 boots that had been worn during broomrape surveys were cleaned of mud (pers. comm. R. Ross, San Benito Co. Ag. Comm. office) . These tomatoes were attacked by *Orobanche ramosa*, proving that the seeds are viable for at least 21 years. Seed has been observed to germinate at highest frequency in the top 3-6 inches of soil (Wilhelm op cit.) suggesting the possibility of physical control through burial of the top soil layers. This proved ineffective however (Wilhelm op cit.). Branched broomrape has an affinity for clay soils in California, and deliberate infestations have been uneven in their establishment, often diminishing over time (Wilhelm 1979). How these observations can be applied in a control protocol is not yet clear.

### **The Future of Branched Broomrape in California**

Branched broomrape is considered a serious pest of its three main hosts. In California at present we are concerned strictly with tomatoes. It has been reported to cause up to 50% crop loss on tomatoes in particular fields or parts of them (Stout and Wagnon, 1955). Effective control involves soil fumigation with methyl bromide. Because of costs and generally incomplete control even with methyl bromide, the most efficacious management method to date has been to abandon infested fields. Even alternative, non-host crops are problematic due to the potential for seed bank seed dissemination in the absence of the living parasite. Host crops partially resistant to several herbicides or combinations thereof, have been used as a “trap crop” to stimulate germination and then kill the parasite with the systemic herbicide applied to the at least partially resistant host crop (Haidar et al. 2005). Moreover, the advent of genetically engineered, and specifically, “roundup-ready” crops, could make the use of glyphosate as a general application over the resistant crop, potentially useful.

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## Botanical Outreach

### F. Hursa

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In 2009 Dr. Hursa reviewed and edited the following 66 taxonomic treatments for the Flora of North America project. Dr. Hursa has been a reviewer for FNA since 1993.

Family names in parentheses have not yet been submitted for review:

Apodanthaceae  
Calophyllaceae  
Comandraceae  
Cistaceae: *Cistus*, *Tuberaria*  
Clusiaceae  
(Euphorbiaceae): *Acalypha*  
Datisceae: *Datisca*  
Elatinaceae: *Elatine*  
Fabaceae: *Aeschynomene*, *Arachis*, *Cicer*, *Hoffmanseggia*, *Marina*, *Nissolia*, *Pomaria*, *Psorothamnus*, *Diphysa*, *Amorpha*, *Ceratonia*; *Colutea*; *Coronilla*; *Eysenhardtia*; *Lotus*; *Onobrychis*; *Ornithopsis*; *Pickeringia*; *Securigera*  
Frankeniaceae: *Frankenia*  
Gunneraceae; *Gunnera*  
Hypericaceae: *Hypericum*

(Lamiaceae) *Clinopodium*; *Lamiastrum*  
Malvaceae: *Abelmoschus*, *Alcea*, *Althaea*, *Eremalche*; *Iliamna*; *Lagunaria*; *Malacothamnus*; *Malva*; *Malvastrum*; *Sidalcea*; *Trigonella*; *Ulex*; *Urena*; *Waltheria*; *Lavatera*.  
(Rafflesiaceae) *Pilostyles*  
Rosaceae: *Sanguisorba*; *Poterium*; *Poteridium*; *Rubus*;  
*Spiraea*  
Thymeleaceae: *Dirca*  
Viscaceae

# SEED LABORATORY REPORT

## 2009 SEED LABORATORY STAFF

### SEED BOTANISTS

Riad Baalbaki  
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The Seed Laboratory's responsibilities include the following:

- Provide identification and quality assessments of agricultural, vegetable, flower, native and weed seed.
- Substantiate label information on seed lots in the marketplace.
- Prevent introduction and dissemination of noxious weed pests via contaminated seed lots moving into and through California.
- Provide required seed quality assessment and phytosanitary testing for seed export.
- Serve as a repository for seed and fruit specimens and associated literature used for morphological identification.
- Serve as a resource of scientific expertise in seed identification, seed physiology and seed quality assessment for the Department and the seed industry.

### Background

The scientists in the Seed Science Laboratory identify seed and other plant disseminules, as well as evaluate seed viability and seedling growth potential from samples submitted by Department representatives (primarily through the Pest Exclusion Branch), seed producers and distributors, commercial and private laboratories, other state, county, and federal agencies, academic institutions, and private citizens. The laboratory is regarded by the seed industry as an impartial authority and the information provided is often utilized in resolving contract disputes among seed trade parties.

The Seed Science Laboratory consists of two sections (Seed Taxonomy and Seed Physiology) and the majority of the samples received require processing through both sections of the laboratory for comprehensive analysis. In the Seed Taxonomy Laboratory, scientists identify seed, fruit and other plant disseminules; examine quarantine and border station samples for noxious weed pest disseminules; evaluate the quality of seed lots for labeling and planting purposes;

examine seed lots in the marketplace for purity label integrity; and inspect feed mill samples for weed seed contaminants. The Seed Physiology Laboratory scientists perform germination and viability evaluations of seed lots for labeling and planting purposes; examine commercial seed lots for germination label integrity; determine viability of weed seed contaminants for feed mill certification; and perform biochemical and seed vigor assessment procedures to detect structural damage of the seed that may result in seedling abnormalities indicating the potential for crop failure in the field.

The scientists conduct research, either individually or in cooperation with scientists from other laboratories, to improve methods for laboratory seed testing. Many of the methods used throughout North America today are the result of such work.

In addition to required academic degrees, scientists in the Seed Science Laboratory have obtained professional certifications in the field of seed technology from the following organizations: Association of Official Seed Analysts (AOSA) and the Society of Commercial Seed Technologists (SCST).

### Sample Workload

The Seed Laboratory sample workload is segregated into seven general categories: (1) identification of unknown seeds and fruits submitted from a variety of sources, including federal, state, county, university, and private entities; (2) mill approval inspection for viable weed seeds in livestock feed; (3) phytosanitary inspection in support of federal certification to meet export requirements; (4) quarantine noxious weed seed examination in support of both interior and exterior quarantine inspection programs; (5) referee, investigation, and proficiency testing; (6) regulatory label compliance and seed quality assessment testing in support of the seed regulatory program; and (7) fee-based seed quality assessment testing as a service to the seed industry. A summary of the Seed Laboratory sample workload for 2009 is given in Figure 1.

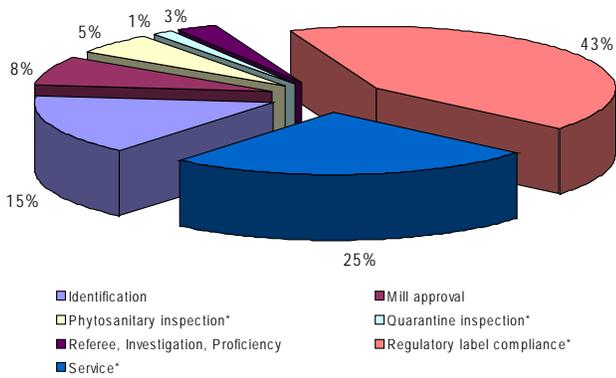


Figure 1. Seed Laboratory sample workload for 2009.  
 \* Note: Quarantine, phytosanitary and noxious weed seed examinations require identification of 25,000 seeds per sample. Purity analyses require identification of 2,500 seeds per sample. Total numbers of seed identifications are in excess of 17,000,000. Germination tests require the evaluation of 400 seedlings per sample; the total number of seedlings evaluated is in excess of 428,000.

## What Does “Seed Quality Assessment Testing” Mean?

*The purpose of seed quality assessment is to determine the value of the seed for planting.*

The assessment is performed on representative samples drawn from seed lots in the marketplace or from seed lots being prepared for the marketplace. In general, the assessment involves the inspection of the seed sample to verify the identification of the kind of seed and examination for contaminants such as inert matter and disseminules of other plant species, including species designated as noxious weeds. Such tests require microscopic examination of thousands of seeds within each sample. High quality seed lots contain few contaminants; low quality seed lots contain a higher percentage of contaminants. The assessment also evaluates the ability of the seed to produce well-developed seedlings. Hundreds of seedlings from each sample are individually evaluated to determine if the structures essential to produce normal plants under favorable conditions are present. High quality seed lots produce high germination percentages in the laboratory and this can usually translate to high germination potential in the field. The tests used to assess seed quality are based on standardize protocols used by all seed laboratories worldwide. Examples of some seed quality problems encountered in laboratory testing are shown in Figures 2 through 4.



Figure 2. Pelleted beet sample with the bottom row showing pellets as received for testing. Removal of pelleting material revealed beet fruits (top row), contaminated with disseminules of the weed *Gallium* or bedstraw (middle row).



Figure 3. Left: Oat sample contaminated with the noxious weed jointed goatgrass. Right: Corn sample with insect damaged seed. This sample had a high percentage of pure seed, but because of the insect damage the germination percentage was low.

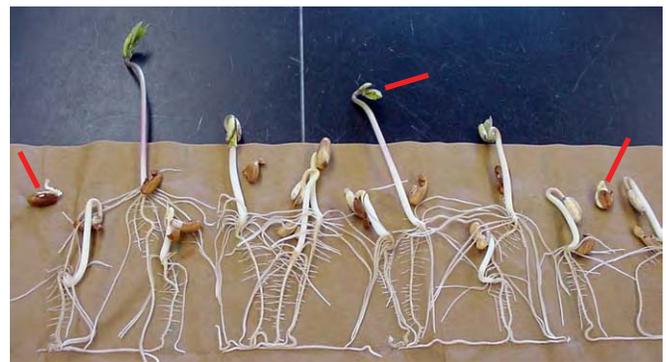


Figure 4. Bean seedlings in a germination test demonstrating some types of abnormalities encountered including broken seed unable to produce a seedling (left), abnormally shaped primary leaves (center), and broken cotyledons (right).

## Seed Identification

The Seed Laboratory receives specimens of seeds, fruits, and other plant disseminules for identification from a variety of sources including county agricultural inspectors, border inspection stations, private seed testing laboratories, seed companies, government seed laboratories from other states, archaeologists, environmental consultants, veterinarians, university researchers and private citizens. The need to know the identity of a seed specimen varies considerably from one source to another and is not always related to agriculture. Whether the specimen is taken from a seed lot, is found in or on agricultural commodities, farm equipment, heavy equipment, recreational vehicles, or self movers, is found stuck to the side of a house or a landscape plant, is found in the stomach of a dead animal, is retrieved from the site of an ancient civilization, or is found in the excrement of an animal, we will attempt to identify it because the information is important to the person that submitted the specimen.

One of the more interesting projects the scientists are involved in is cooperative work with ethnobotanist Dr. Kat Anderson, USDA, Natural Resource Conservation Service (NRCS), National Plant Data Center, and the Phoebe A. Hearst Museum of Anthropology, UC Berkeley. The project involves identification of seed, fruit, and plant fragment samples collected from tribal members of California's indigenous people. The samples were collected in the early part of the twentieth century and have been stored, untouched, at the Phoebe Hearst Museum. The study is to determine what plant species were collected and used for food, fiber, and medicine by the various tribes. In the first year of the project scientists in the Seed Taxonomy Laboratory examined 105 samples and identified nearly 156,000 seeds, fruits, and vegetative materials representing 174 plant species. More specimens from the museum are due to arrive in early 2010 and the complete project report should be available in the latter part of 2010. (Figure 5).



Figure 5. A. nutlets of *Salvia carduacea*, thistle sage, Lamiaceae or mint family; B. achenes of *Madia elegans*, common madia, Asteraceae or sunflower family; C. Nutlets of *Plagiobothrys* sp., popcorn-flower, Boraginaceae or borage family; D. tubers of *Perideridia* sp., yampah; Apiaceae or carrot family; E. tubers of *Cyperus esculentus*, yellow nutsedge.

## Special Testing

Pelleted seeds are seeds that have been covered with layers of materials that obscure the original shape and size of the seed. The pellets are designed to improve plantability of the seeds by transforming irregularly shaped seeds into nearly spherical objects. Often, other value added enhancements are included in the pellets, such as plant hormones, fungicides and fertilizers. Each year the laboratory tests a number of pelleted seed lots for label compliance under the California State Seed Law. This year the laboratory tested a variety of pelleted sugar beet lots at the request of some California sugar beet growers. The growers were concerned that poor plant performance in the field was directly related to low quality seed. The laboratory performed a series of tests on each of the questionable seed lots to determine potential planting quality. The first test performed was a purity analysis to determine the physical composition of the sample. In this test the pelleting material is removed for verification of the kind of seed and determination of the percentage of pelleting material, and pure seed (Figure 6). In addition, contaminants such as other crop seeds, weed seeds, and inert matter are identified and quantified.

Following purity analysis, a set of germination tests were conducted on pelleted and de-pelleted (naked) sugar beet seed to assess their potential to produce normal plants. Naked and pelleted seed are germinated under ideal conditions of temperature, moisture and light and each seedling is evaluated for the essential structures that indicate its ability to produce a normal plant under favorable field conditions (Figure 7).

After the germination tests were completed, vigor of the different pelleted seed lots was assessed based on a vigor index. Unlike germination tests that evaluate emergence potential under ideal field conditions, vigor tests are designed to assess emergence and field establishment potential under a wide range of favorable and unfavorable field conditions. With the aid of a newly acquired bi-directional thermo gradient germination table, different seed lots were simultaneously germinated at temperatures ranging from 18 to 34°C (Figure 8). Speed of germination under different temperature regimes was also recorded daily. Germination performance at different temperature was combined with speed of germination resulting in a single vigor index. Seed lots with a high vigor index were those that exhibited the ability to germinate and develop into normal seedlings under a wide range of temperatures in the shortest possible time. Under actual field conditions, planting seed lots with a high vigor index should result in higher emergence rates and better field establishment.



Figure 6. A. Pelleted seed and de-pelleted seed; B. De-pelleting process; C. Pelleted sugar beet seed (top) and de-pelleted sugar beet seed (bottom).

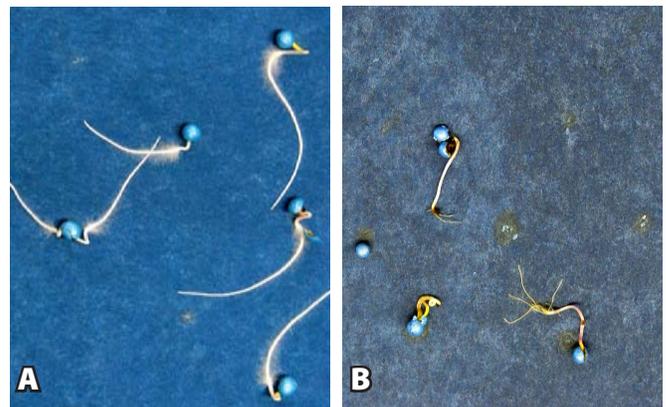


Figure 7. Left: Normal seedling growth from pellets; Right: Abnormal seedling growth from pellets.

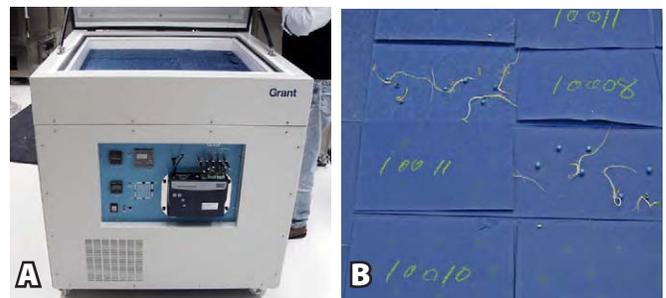


Figure 8. A. Bidirectional thermo gradient germination table; B. Pelleted sugar beet seedling vigor evaluation.

# New Edition of AOSA's Seed Vigor Testing Handbook

The Association of Official Seed Analysts (AOSA) has recently published a new edition of the *Seed Vigor Testing Handbook*<sup>1</sup>. The handbook was developed by Riad Baalbaki (Senior Seed Botanist-Plant pest Diagnostics Branch, CDFA), Sabry Elias (Seed Laboratory-Oregon Sate University), Julio Marcos-Filho (Crop Science Department-University of Sao Paulo, Brazil) and Miller McDonald (Department of Horticulture and Crop Science-Ohio State University).

The new handbook is a comprehensive revision of the 1983 and 2002 versions that set the standard for vigor testing. As a methodical and detailed resource, the handbook will be of value to seed technologists, scientists, students, and industry personnel interested in the fascinating subject of seed vigor, and will serve as an important reference resource for seed analysts involved in seed quality control around the world. The *Seed Vigor Testing Handbook* has been internationally recognized as an important tool for all aspects of vigor testing, and the new edition represents the definitive authority on the theory, standardization, applications and methods of seed vigor testing.

The handbook is divided into four parts, each covering a different aspect of vigor testing. Part One focuses on explaining the importance of vigor testing, its rich history, basic vigor concepts and definition of seed vigor. Part Two emphasizes important issues related to the standardization of vigor tests such as use of standards, control samples, tolerances, sampling techniques, etc., general procedures for controlling variation, as well as presentation and interpretation of vigor test results. In parts Three and Four, the authors have taken a new approach to classifying seed vigor tests by dividing them into categories according to Aging, Cold, Conductivity, Seedling Performance, and Tetrazolium tests. Part Three focuses on the principles of each vigor test, while Part Four presents detailed descriptions of test procedures. Considerable research in vigor testing has been reported since 1983 for specific crops. This information is compiled in an Appendix that lists more than 50 major crops and the vigor tests that have been successfully used to test them.

Vigor testing is an important diagnostic tool that complements other seed quality assessments, with a majority of North American seed testing laboratories conducting vigor tests on regular basis. The new *Seed Vigor Testing Handbook* is an important demonstration of the Seed Laboratory's commitment to the refinement and modification of the rules and

procedures for seed testing, ensuring that testing procedures are standardized between analysts and among laboratories.

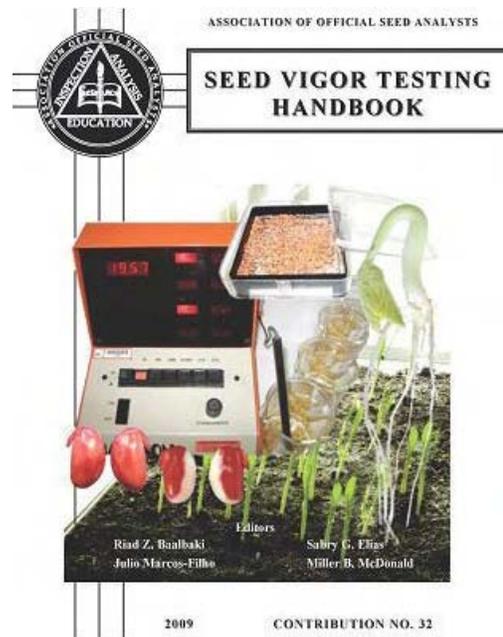


Figure 9. The new edition of the AOSA's Seed Vigor Testing Handbook (top), Cold test for corn (middle) and cool test for cotton (bottom), two common vigor tests.

<sup>1</sup> Baalbaki, R., S. Elias, J. Marcos-Filho, and M. B. McDonald. 2009. Seed Vigor Testing Handbook. Contribution 32, *Handbook on Seed Testing*. Assoc. Off. Seed Anal., Ithaca, NY, 341 pps.

## Cooperative Studies

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The Seed Science Laboratory participated in a variety of cooperative studies with other seed labs. In one such study the seed lab conducted a referee ring testing among seed laboratories for validation of proposed purity and germination testing methods of a new type of coated grass seed product. This particular type of coating material, when applied to grass seed helps to retain moisture around the seed during the early stages of germination thus reducing the amount of water required when establishing a field stand. Unfortunately, the material also obscures the identifying characters of the grass species involved and interferes with standard purity testing procedures, including the identification of possible

noxious weed contaminants. Because of the moisture retention nature of the material removal during laboratory testing is difficult and removal must be done in a way that will not damage the germination potential of the seed. An AOSA Rules change proposal co-authored by Dr. Riad Baalbaki and Deborah Meyer (CDFA), Dr. Sabry Elias, Oregon State University, and Sharon Davidson and Jane Penrose (Agri Seed Testing) was submitted the Association of Official Seed Analysts and Society of Commercial Seed Technologists for consideration and possible adoption as an official method. Voting on the proposal will take place in June 2010.

## Service to Professional Organizations

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### Jim Effenberger

- Member – Purity Testing Research Subcommittee, Association of Official Seed Analysts (AOSA) (1994 – present)
- Member – AOSA/SCST Task Force studying the feasibility of merging the two organizations into one North American Seed Testing Organization (2006 – present).

### Riad Baalbaki

- Chairperson – Germination and Dormancy Research Subcommittee, AOSA (2006 – present)
- Co-chairperson – Vigor Evaluation Research Subcommittee, AOSA (2007 - present)
- Associate Editor – *Seed Technology*, 2007 – present

### Deborah Meyer

- Associate Editor – *Seed Technology*, 2001 – present
- Chairperson – Rules Issues and Review Committee, AOSA (2006 – present)
- Chairperson – Purity Testing Research Subcommittee, AOSA (1994 – present)
- Member – Purity Committee, International Seed Testing Association (ISTA) (1995 – present)
- Member – Registered Seed Technologist Board of Examiners, SCST (2002 – present)
- Member – Community Advisory Council of the College of Natural Sciences and Mathematics, California State University, Sacramento (2005 – present)
- National Plant Board Representative – National Seed Health System – Seed Testing Working Group (2000 – present)
- Member – AOSA/SCST Task Force studying the feasibility of merging the two organizations into one North American Seed Testing Organization (2006 – present).

# 2009 ANNUAL REPORT OF THE ENTOMOLOGY LABORATORY

## 2009 ENTOMOLOGY LABORATORY STAFF

### INSECT BIOSYSTEMATISTS

Charles Bellamy  
Andrew Cline  
Marc Epstein  
Stephen Gaimari  
Rosser Garrison  
Martin Hauser  
Peter Kerr  
Alessandra Rung  
John Sorensen  
Gillian Watson

### TECHNICAL STAFF

Donna Imes  
Scott Kinnee  
Jacqueline Kishmirian  
Thomas Manos  
Megan O'Donnell  
Ramona Randolph  
Obie Sage

### SCIENTIFIC AIDES

Mia Bellante  
Robert Copsey  
Rabbit Corbin  
Kandis Demeo  
Dennis Ho  
Caleb Marion  
Dominique Orozco  
Zella Redus  
Kirk Sorensen  
Abel Unzueta  
Natalia von Ellenrieder  
Sara West

The primary objectives of the Entomology Laboratory are to:

- Provide identification services to the Division's pest prevention programs, other government agencies, universities, industry, and the public in an accurate and timely fashion.
- Act as a reference repository (California State Collection of Arthropods) for specimens and any associated data available for arthropods and mollusks of the State and region, and worldwide.
- Conduct research in biosystematics.
- Assist personnel in other agencies with problems related to insects and other arthropods and mollusks.

The laboratory evaluates and identifies insects and related arthropods and mollusks submitted by a variety of agency representatives. The most frequent clients are county agricultural commissioners, other Branches of CDFG, agricultural Extension representatives, industry, universities, other state and federal agencies, and the public. Communication with scientists worldwide is essential to ensure a cooperative exchange of information and services. Identifications under routine conditions are usually made within two and one-half days of receipt and processing. Samples submitted as "RUSH" are normally processed in less than four hours.

During periods when large numbers of samples are being processed, priority is given to samples that involve quarantine shipments likely to be held for inspection, or critical extensions in the delimitations of pests under eradication. This laboratory is the primary support unit for the state's eradication, control, survey, and biological programs involving injurious pests, including (but not limited to): exotic fruit

flies; leafmining and other flies; Glassy-winged sharpshooter and other leafhoppers; Asian citrus psyllid; Africanized honey bee; Red imported fire ant; Asian longhorn beetle and other wood boring beetles; Japanese beetle; *Diaprepes* root weevil and other weevils and leaf beetles; European and Asian gypsy moths; light brown apple moth, European grapevine moth and various other moths; numerous scales, whiteflies and mealybugs; fleas, ticks, mites, spiders and other arachnids; Zebra, Quagga, and other mussels and mollusks; as well as many other domestic and exotic pests.

Identifications and services to agencies other than the county and state include: universities; other state departments of agriculture; USDA-ARS, USDA-APHIS, the USDA Forest Service, the US Fish and Wildlife Service and other federal agencies; museums; faunal inventories and surveys; private industry and the general public.



Asian longhorn beetle, *Anoplophera glabripennis*, a wood boring pest that attacks maple, horsechestnut, poplar, and other trees in the urban and suburban areas.

## Editorial Responsibilities & Scientific Service

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PPDB entomologists serve in an editorial capacity for several scientific journals, and provided other service to professional societies, as follows:

### Chuck Bellamy

- English Language Editor: *Folia Heyrovskyana* (2002 – present)
- Subject Editor (Coleoptera: Buprestoidea): *Zootaxa* (2001 – 2004, 2007 – present)
- Subject Editor (Coleoptera: Cleroidea): *Zootaxa* (2009)
- Editor: *The Coleopterists Society Vaurie Monograph Series* (2009 – present)
- Manuscript Referee: *The Coleopterists Bulletin*, *Folia Heyrovskyana*, *Zootaxa*
- Webmaster: Pacific Coast Entomological Society (<http://www.pcentsoc.org>)

### Andrew Cline

- Treasurer and Membership Secretary – The Coleopterists Society
- Subject Editor (Coleoptera: Bostrichiformia, Cucujiformia - Lymexyloidea, Cucujoidea): *Zootaxa*
- Manuscript Referee: *Insecta Mundi*, *Journal of the Acadian Entomological Society*, *Systematic Entomology*, and *Zootaxa*
- Grant Reviewer – National Science Foundation
- Grant Panel Committee Member – National Science Foundation

### Marc Epstein

- Lepidoptera Subject Editor: *Pan Pacific Entomologist* (2004 – present)

### Stephen Gaimari

- Editorial Advisory Board: *African Invertebrates* (2008-present)
- Organizing Committee: 7<sup>th</sup> International Congress of Dipterology (2008-present)
- Editor: *Fly Times*, North American Dipterists Society (2007-present)
- Editor: *California Plant Pest and Disease Report* (2005-present)
- Diagnostics Committee: National Plant Diagnostics Network (2007-present)

- Subject Editor (Diptera): *Annals of the Entomological Society of America* (2002-present)
- Ad hoc Reviewer: National Research Foundation of South Africa
- Ad hoc Reviewer: National Science Foundation
- Manuscript Referee: *African Entomology*, *African Invertebrates*, *Annales Zoologici*, *Biological Control*, *Bulletin of Insectology*, *Contributions in Science*, *Insect Systematics & Evolution*, *Proceedings of the Entomological Society of Washington*, *Systematic Entomology*, *Vestnik Zoologii*, and *Zootaxa*

### Rosser Garrison

- Subject Editor (Odonata): *Pan-Pacific Entomologist* (2005 – present)
- Editor: *Odonatologica* (1998 – present)
- Subject Editor (Odonata): *Zootaxa* (2005 – present)

### Martin Hauser

- Subject Editor (Diptera): *Pan Pacific Entomologist* (2007 – present)
- Subject Editor (Diptera): *Proceedings of the Entomological Society of Washington* (2008 – present)
- Subject Editor (Diptera): *Studia Dipterologica* (2006 – present)
- Subject Editor (Diptera): *ZooKeys* (2007– present)
- Manuscript Referee: *Annals of the Entomological Society of America*, *Cladistics*, *Insect Systematics & Evolution*, *Zoology in the Middle East*, *Zootaxa*, and *ZooKeys*

### Peter Kerr

- Subject Editor (Diptera: Sciaroidea): *Zootaxa* (2008—present)
- Subject Editor (Molecular Systematics): *Pan Pacific Entomologist* (2005—present)
- Manuscript Referee: *Zootaxa*, *Molecular Phylogenetics and Evolution*

### Alessandra Rung

- Manuscript Referee: *African Entomology*, *Entomological News*, *Insect Science*, *Insect Systematics and Evolution*, *Zootaxa*, and *Zoologia*

# Taxonomy and Systematics of Coleoptera Progress Report

A.R. Cline

Several research projects were undertaken and/or completed in 2009. One of my previous papers from 2008, "Revision of the Sap Beetle Genus *Pocadius* Erichson, 1843 (Coleoptera: Nitidulidae: Nitidulinae)", was awarded the Lacordaire Prize by The Coleopterists Society.

Research projects in 2009 spanned different biological disciplines; however, most were focused on the taxonomy and systematics of the Cucujoidea family Nitidulidae. Below is an outline of the major projects completed in 2009.

The description of new taxa within the nitidulid subfamily Nitidulinae remains a focal point of my research. This subfamily contains ~75% of the generic diversity within Nitidulidae. This year I described a new genus, *Neohebascus*, from the Neotropics and discussed its placement within the *Pocadius* generic complex in Nitidulinae. These beetles have a spectacular egg-laying apparatus that has undoubtedly evolved to penetrate the tough lignicolous fungi which are host to the developing larvae (Figure 1B). This is also the first nitidulid from the New World that is known to possess lamellate antennae in both male and female sexes.<sup>1</sup>

A major revisionary treatment of the sap beetle subfamily Meligethinae was completed by an international group of investigators. This revision was the first ever attempt to systematically evaluate generic level concepts on a global basis within Meligethinae. As a result of this effort, twenty-three new genera were formalized and a natural classification for all constituent taxa proposed.<sup>2</sup>

The southern African genus *Anthystrix* was revised in collaboration with several Italian colleagues. This genus has been a historical dumping ground for unrelated nitidulid taxa from South Africa. The genus was revised, with several new species described, and others transferred or synonymized. The following publication was derived from this research.<sup>3</sup>

<sup>1</sup> Cline, A.R. 2009. A new sap beetle (Nitidulidae: Nitidulinae) genus from the Neotropics, with commentary on the *Pocadius* generic complex. *Zootaxa* 2237:34-42.

<sup>2</sup> Audisio, P., A.R. Cline, A. De Biase, G. Antonini, E. Mancini, M. Trizzino, L. Costantini, S. Strika, F. Lamanna, and P. Ceretti. 2009. Preliminary re-examination of genus-level taxonomy of the pollen beetle subfamily Meligethinae (Coleoptera: Nitidulidae). *Acta Entomologica Musei Nationalis Pragae* 49(2):341-504.

<sup>3</sup> Audisio, P., Cline, A.R., Lamanna, F., Trizzino, M., Antonini, G., Mancini, E., & DeBiase, A. 2009. Revision of the Southern African Pollen Beetle Genus *Anthystrix* (Coleoptera: Nitidulidae: Meligethinae). *Annals of the Entomological Society of America* 102(6):998-1012.

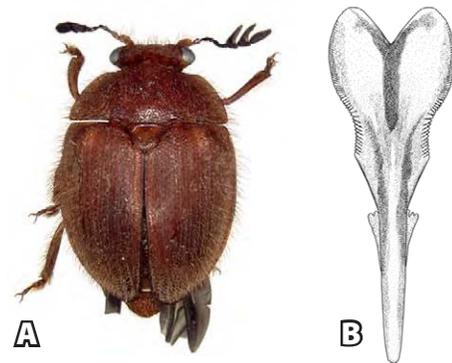


Figure 1. *Neohebascus tishechkini* Cline. A. Dorsal image; B. Ovipositor (egg-laying apparatus), note serrated lateral margins for slicing into hard fungi.

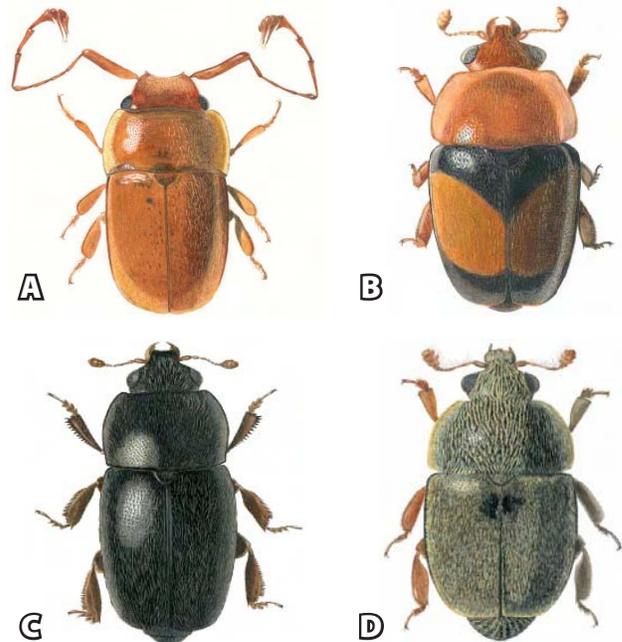


Figure 2. Members of the subfamily Meligethinae; A. *Lucanopria* Audisio & Cline, B. *Tarchonanthogethes* Audisio & Cline, C. *Afrogethes* Audisio & Cline, D. *Xenostromylogethes* Audisio & Cline.



Figure 3. *Anthystrix megalocera* Audisio & Cline

Web-based publications are an alternative method of product dissemination. In collaboration with researchers at the University of Georgia, a multi-phase project was begun to complete web-pages for all Cucujoidea families for the Tree of Life Web Project. To this end, I coauthored the Discolomatidae web page.<sup>4</sup>

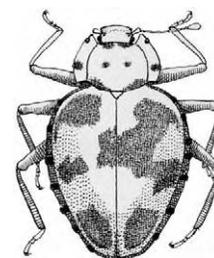


Figure 4. *Pachyplacus* sp., a discolomatid beetle.

<sup>4</sup> Shockley, F.W. & A.R. Cline. 2009. Discolomatidae Horn 1878. Discolomatid beetles, Discolomid beetles, Mexican hat beetles. Version 21 September 2009. <http://tolweb.org/Discolomatidae/9168/2009.09.21>, In The Tree of Life Web Project, <http://tolweb.org>.

The description of beetle diversity is an ongoing research pursuit, and typically includes revisionary and/or monographic works. Below are the new taxa described in 2009.

### New Genera

*Afrogethes* Audisio & Cline  
*Aristogethes* Audisio & Cline  
*Asterogethes* Audisio & Cline  
*Bolbocerogethes* Audisio & Cline  
*Boragogethes* Audisio & Cline  
*Brassicogethes* Audisio & Cline  
*Fabogethes* Audisio & Cline  
*Genistogethes* Audisio & Cline  
*Indogethes* Audisio & Cline  
*Jelinekigethes* Audisio & Cline  
*Lamiogethes* Audisio & Cline  
*Lucanopria* Audisio & Cline  
*Neolariopsis* Audisio & Cline  
*Odontholariopsis* Audisio & Cline  
*Paleogethes* Audisio & Cline  
*Rubiogethes* Audisio & Cline  
*Sagittogethes* Audisio & Cline  
*Stachygethes* Audisio & Cline  
*Tarchonanthogethes* Audisio & Cline  
*Thymogethes* Audisio & Cline  
*Xenostromylogethes* Audisio & Cline  
*Xerogethes* Audisio & Cline  
*Neohebascus* Cline

### New Species

*Anthystrix endroedyi* Audisio & Cline  
*Anthystrix flabellicornis* Audisio & Cline  
*Anthystrix megalocera* Audisio & Cline  
*Lucanopria wagneri* Audisio & Cline  
*Neohebascus tischeckini* Cline

### 2009 Field Research

St. Lucia

# Systematics of the Buprestoidea Leach, 1815 (Coleoptera)

C. L. Bellamy

As detailed in the 2008 PPDC annual report, my research on jewel beetles (Coleoptera: Buprestidae) continues in several of the main themes:

## The Madagascan Coraebini

([www.fond4beetles.com/Buprestidae/MadCor/intro.html](http://www.fond4beetles.com/Buprestidae/MadCor/intro.html))

Viette, P., C. L. Bellamy & H.-P. Aberlenc. 2009. Catalogue of Madagascan and adjacent islands Buprestidae (Bellamy 2006): Addenda & Corrigenda. *Zootaxa* 2197:64-68.

## The Buprestidae of the Philippines

Bellamy, C. L. & S. Ohmomo. 2009. Three new species of Coraebini Bedel, 1921 (Coleoptera: Buprestidae: Agrilinae) from the Leyte Island, Philippines. *Zootaxa* 2292:57-64.

## The World Catalogue of Buprestoidea

([www.fond4beetles.com/Buprestidae/worldcatalogue.html](http://www.fond4beetles.com/Buprestidae/worldcatalogue.html))

The final volume (of five) was published by Pensoft Publishers in February, 2009.<sup>1</sup>

The International Commission of Zoological Nomenclature in 2009 published Opinion 2228 ruling on Case 3393 (Bellamy & Moore 2007).<sup>2</sup>

## The Buprestidae of Fiji

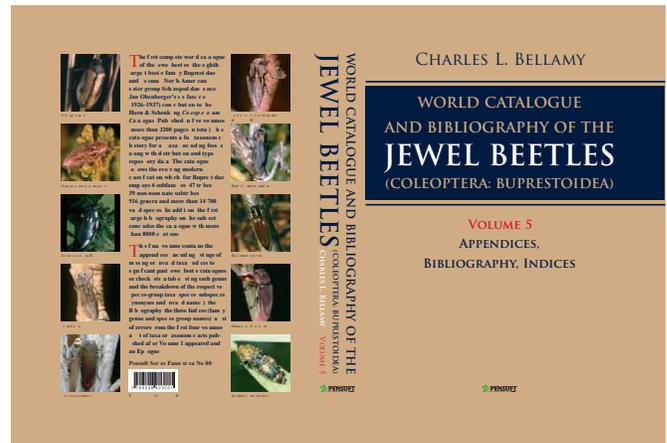
Bellamy, C. L. 2009. A new species of *Chrysobothris* Eschscholtz, 1829, the first from Fiji (Coleoptera: Buprestidae). *Zootaxa* 2261:63-65.

## Miscellaneous Publication

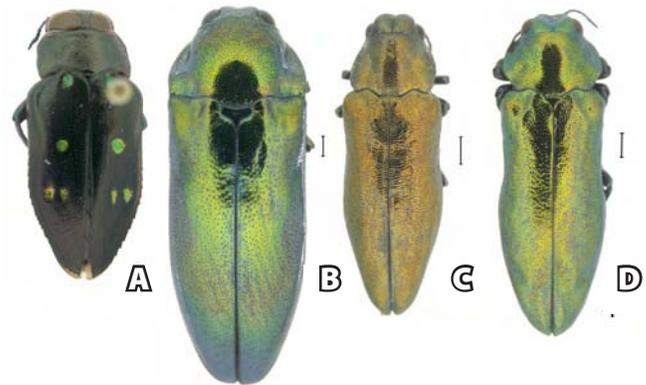
Bellamy, C. L. 2009. Review of: U. Nylander. 2008. A review of the genera *Calodema* and *Metaxymorpha* (Coleoptera: Buprestidae: Stigmoderini). *The Coleopterists Bulletin* 63(2):237-238.

## New taxa (species) proposed during 2009

As illustrated on the right.



The cover wrap for volume five of The World Catalogue of Buprestoidea published in 2009.



## New Buprestidae from Fiji and the Philippines

- A. *Chrysobothris fiji* Bellamy, 2009 – Fiji;
- B. *Coraebosoma viridis* Bellamy & Ohmomo, 2009 – Philippines;
- C. *Lumawigia leytenensis* Bellamy & Ohmomo, 2009 – Philippines;
- D. *Philippscelus gracilis* Bellamy & Ohmomo, 2009 – Philippines

<sup>1</sup> Bellamy, C.L. 2009. *A World Catalogue and Bibliography of the Jewel Beetles* (Coleoptera: Buprestoidea), Volume 5: Appendices, Bibliography, Indices, Pensoft Series Faunistica No. 80, pp. 2685-3264, Pensoft Publishers, Sofia–Moscow.

<sup>2</sup> ICZN. 2009. Opinion 2228 (Case 3393). *Dactylozodes* Chevrolat, 1838 (Insecta, Coleoptera): name not conserved. *Bulletin of Zoological Nomenclature* 66(2):201-202.

Bellamy, C. L. & T. Moore. 2007. Case 3393. *Dactylozodes* Chevrolat, 1838 (Insecta, Coleoptera): proposed conservation of usage. *Bulletin of Zoological Nomenclature* 64(1):43-44.

# Mealybug, Scale & Whitefly Research

G. Watson

## Identifications

Identification on cut flowers from Hawaii of Pacific mealybug (*Planococcus minor*) in May and June, and a mealybug (*Delottococcus confusus*, specific to Proteaceae) in June and July, resulted in traceback detections of both species in Hawaiian nurseries. Eradicatory action resulted from these detections.

Some invasive mealybugs of New World origin (e.g. *Nipaecoccus nipae* and *Paracoccus marginatus* (pictured below), *Phenacoccus solenopsis*, *Ph. madeirensis* and *Ph. manihoti*) are spreading in countries around the Indian Ocean. Several countries sent samples to Dr. Watson in 2009 for authoritative identification, prior to initiating biological control programs. Identification of some scale insect samples sent by the Malaysian Agricultural Research and Development Institute (MARDI) added useful reference material of Old World species to the California State Collection of Arthropods. Authoritatively identified reference material will be returned to all these countries in due course, to support scale insect identification within the region in the future.

## Training provided

Mr. Josh Vlach, Entomologist at Oregon Department of Agriculture (ODA), visited PPDB 24-26 March for training with Dr. Watson in scale insect preparation and identification, and Dr. Bob Dowell to learn about CDFA's LBAM eradication program. Josh brought ODA scale insect reference slides with him, to have the identifications authoritatively checked.

Mr. Ramón A. Dones, a USDA APHIS PPQ identifier at the port of Miami, Florida, received advanced training in the

identification of mealybugs and scale insects with Dr. Watson on July 22.

Mr. Ghulam Abbas, a Ph.D. student from University of Faisalabad, Pakistan, studied the identification of mealybugs and scale insects with Dr. Watson between 2 September and 22 October. Collaborative work on identification keys for the mealybugs of Pakistan, including the introduced alien species that are spreading in Asia, was initiated.

## Research

The ongoing spread of the pest mealybug on cotton in Asia, *Phenacoccus solenopsis*, continues to cause international concern. Collaborative work with Yanping Wang and Dr Runzhi Zhang (both of the Institute of Zoology, Chinese Academy of Sciences, and the State Key Laboratory of Integrated Management of Pest Insects and Rodents in Agriculture, Beijing, China) resulted in completion of a CLIMEX analysis of the potential global distribution of this mealybug. The analysis indicated that it has the potential to spread and impact cotton and other crops in many more countries; this work is now in press.

Work continued with Dr. Alessandra Rung (CDFA-PPDB) to accumulate and analyze DNA samples of *Phenacoccus solenopsis*. Molecular information from these samples will help determine the number of species in this complex, and develop morphological diagnoses for the taxa.

Dr. Watson is a participant in a three-year research project that is being funded by USDA-CREES Agriculture and Food Research Initiative. The project, "Molecular Identification



Figure 1. *Delottococcus confusus* on Proteaceae; Left: young adult female; Right: mature females with ovisacs and crawlers.



Figure 2. Left: *Paracoccus marginatus* on papaya in Indonesia (photo by A. Rauf); Right: *Nipaecoccus nipae*, adult female.

and Cryptic Diversity of Armored Scale Insects Intercepted in Plant Quarantine”, is headed by Prof. Benjamin Normark (University of Massachusetts). It brings together key personnel who identify armored scale insects in state and federal agencies, with the leading molecular laboratory devoted to studying armored scale diversity (U. Massachusetts). The objectives are: (1) improved accuracy of species-level identifi-

cation at plant quarantine inspection; (2) discovery of cryptic species complexes that are invasive; and (3) discovery of geographic sources of genetic diversity within invasive species. Three gene loci will be sequenced. The review committee classed the proposal as outstanding, and the work plan was praised as a likely model for monitoring other potential propagules of introduced species.

## Advances in Mealybug Molecular Identifications, Leafhoppers, & Psyllids

A. Rung

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### Research on molecular identification of mealybugs

The first paper on Dr. Rung’s research on molecular identification of mealybugs has been published (with a brief comment).<sup>1</sup> The paper details methods that can be used to distinguish three species of mealybugs that are difficult to identify based on morphological characteristics (*P. citri*, *P. minor*, and a genetically distinct group that is morphologically identical to *P. citri*, from Hawaii). She continues her cooperation with PPDC scientist Dr. Watson and others in expanding this research into new groups.

### Research on Psylloidea

The psyllids of California and their hosts have been databased in a 3i database, a Microsoft Excel searchable database created by Dmitry A. Dmitriev for storage and retrieval of taxonomic information. The Californian psyllid database will be deployed online in 2010 and will facilitate updated pest information retrieval such as hosts, current distribution, bibliography, synonyms and illustrations for easy identification. An example of a pest information sheet generated by the web version is shown in Figure 1 on the next page.

<sup>1</sup> Rung, A., D. Miller and S.J. Scheffer. 2009. Polymerase Chain Reaction-Restriction Fragment Length Polymorphism method to distinguish three mealybug groups within the *Planococcus citri*-*P. minor* species complex (Hemiptera: Coccoidea: Pseudococcidae). *Journal of Economic Entomology* 102(1):8-12.



Ligurian leafhopper, *Eupteryx decemnotata*, feeding.

### Research on Leafhoppers

A paper detailing the Ligurian leafhopper, a new leafhopper pest of plants in the mint family, was published (with a brief comment) this year. So far, this European species has only been detected in California and Florida. Diagnostic characters for species identification, summary of hosts, damage, and U.S. known distribution are given.<sup>2</sup> The complete abstract can be found on page 48.

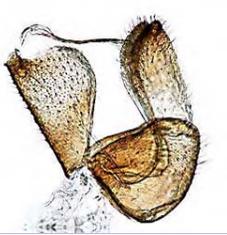
<sup>2</sup> Rung, A., S. Halbert, D.C. Ziesk, and R. Gill. 2009. A leafhopper pest of plants in the mint family, *Eupteryx decemnotata* Rey (Hemiptera: Auchenorrhyncha: Cicadellidae), Ligurian leafhopper, new to North America. *Insecta Mundi* 88:1-4.

Figure 1. An example of a pest information sheet of the tipu psyllid, *Platycorypha nigrivirga*, generated by the web version of 3i.

**Platycorypha nigrivirga** Burckhardt, 1987
3i | [Home page](#)

[Platycorypha nigrivirga](#) Burckhardt, 1987 194

**Images**




**Distribution**

[Argentina](#), [Bolivia](#), [Brazil](#), [Uruguay](#), [USA \(introduced\)](#).



No Map Legend    Best Fit Map

Save map preferences

**Host Plants**

[Fabaceae](#) [Tipuana tipu](#) ([Benth.](#)).

Plants	Number of Specimens Collected	(Localities)
<a href="#">Tipuana tipu</a> ( <a href="#">Benth.</a> )	12 (10)	100%
<b>Total</b>	<b>12 (10)</b>	

**Studied Material**

**Holotype** [Argentina](#) Buenos Aires, Ramos Mejia, 34°39'17" S 58°33'13" W, 5 XII 1961 (G. Topa), ([Reference](#)). Buenos Aires, San Fernando, 34°26'35" S 58°33'28" W, ([Reference](#)). Chaco, Resistencia, 26°35'8" S 60°57'14" W, ([Reference](#)). Salta, Pampa Grande, La Vina, 25°30' S 65°33' W, ([Reference](#)). Tucuman, 26°56'48" S 55°16'9" W, ([Reference](#)). [Bolivia](#) Cochabamba, Villa Montes, 17°24'43" S 68°8'46" W, ([Reference](#)). [Brazil](#) Parana, Colombo, 25°17'35" S 49°13'24" W, on [Tipuana tipu](#) ([Benth.](#)), ([Reference](#)). Parana, Curitiba, 25°25'42" S 49°16'24" W, on [Tipuana tipu](#) ([Benth.](#)), ([Reference](#)). Parana, Guarapuava, 25°23'37" S 51°27'22" W, ([Reference](#)). [Spain](#) Island of Ma lorca, 39°41'43" N 3°12'4" W, ([Reference](#)). [Andalucia](#), 37°33'35" N 4°43'33" W, on [Tipuana tipu](#) ([Benth.](#)), ([Reference](#)). [Andalucia](#), Benalmádena, 36°35'43" N 4°34'24" W, on [Tipuana tipu](#) ([Benth.](#)), ([Reference](#)). [Andalucia](#), Cádiz, Jerez de la Frontera, 36°41'11" N 6°9' W, on [Tipuana tipu](#) ([Benth.](#)), ([Reference](#)). [Andalucia](#), Sevilla, 37°23'22" N 5°59'47" W, on [Tipuana tipu](#) ([Benth.](#)), ([Reference](#)). [Uruguay](#) Montevideo, 34°55' S 56°15'4" W, on [Tipuana tipu](#) ([Benth.](#)), ([Reference](#)). [USA](#) 3m, 4f, California, Los Angeles Co., West Hollywood, 34°53'33" N 118°20'46" W, on [Tipuana tipu](#) ([Benth.](#)), 11 II 2009 (G. Akadelian), (CSCA). California, Orange Co., Anaheim, 33°50'10" N 117°53'23" W, on [Tipuana tipu](#) ([Benth.](#)), 26 VI 2009 (Rob Gomes), (CSCA). 2m, 3f, California, San Diego Co., Encinitas, 354 Santa Fe Drive, 33°2'11" N 117°17'2" W, on [Tipuana tipu](#) ([Benth.](#)), 31 III 2009 (T. Ellis, D.Kellum, C.Duffy), (CSCA).

**Museum Abbreviations**

Abbreviation	Museum	Location
CSCA	California State Collection of Arthropods	USA, California, Sacramento

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Rung, A., Arakelian, G., Gill, R. and Nisson, N., 2009. *Platycorypha nigrivirga* Burckhardt (Hemiptera: Sternorrhyncha: Psylliodes), Tipu Psyllid, New to North America. *Insecta Mundi*. 0097 1-5 (records, hosts).

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[Platycorypha](#) Tuthill, 1945

# The Spotted Wing Drosophila, a New Extremely Rapidly Spreading Pest

M. Hauser & S. Gaimari

In September of 2008 the CDFA lab in Sacramento received a sample of a drosophilid fly from Santa Cruz County, California, collected by farm advisor Mark Bolda in a raspberry field. It was identified as *Drosophila* sp. But because drosophilids are not rare especially in the fall near fruit, it was categorized as a harmless species which did not require any regulatory action by the state. What was not clear from the submitted specimen was that the raspberries and in a lesser degree strawberries were infected with drosophilid larvae, which caused serious damage to the crop in some areas.

In the spring of 2009 the CDFA lab received several records of maggots found in otherwise healthy cherries, and the western cherry fruit fly (*Rhagoletis indifferens*) was the main suspect. This was a great concern for the local farmers, because this pest was not known in the region. But the submitted larvae were clearly drosophilids and it was still assumed that they are only secondary invaders and that the primary damage was caused by a different cause. But after more and more reports of massive infestations in cherries came into the lab and the only larvae submitted were *Drosophila*, the suspicion was raised that the normally harmless *Drosophila* might be the primary cause. It was clear that a species identification was needed. Unfortunately there were only larvae conserved in alcohol on hand and it is nearly impossible to identify larvae to species level. The genetic identification with the barcode CO1 gene (comparing with sequences in genebank and the BOLD database) confirmed that it is a *Drosophila* but the results were inconclusive for the species level. As it turned out there was no CO1 sequence submitted for this species, but this gap is now closed by the submitted sequence from the CDFA lab.

In the meantime many samples came in from Santa Cruz County and the cherry growing areas in the central valley, like Merced Co, Stanislaus Co, and San Joaquin Co. Finally the lab received some adults from the Watsonville area and the species could be identified the old fashioned way as *Drosophila suzukii*.

The females are characterized by an unusually large ovipositor, with which they could penetrate thin skinned fruit. With a species name on hand, several accounts of damage by this fly could be found in Japanese literature, indicating that the flies seem to have a preference for cherries and blueberries (Kanzawa, 1936, 1939).



Figure 1. Male *Drosophila suzukii* (photo by John Davis)

The species was described by Matsumura in 1931 from Japan and that a few years later reports of damage by this species were published (Kanzawa 1936, 1939). The earliest records of this species from Japan are from 1916 (Kanzawa 1936) and there is the possibility that the species was not always endemic to Japan, but has been introduced at the turn of the century into Japan. The species is also recorded from Korea, Thailand and India (Kashmir region).

There is no doubt that this species has a high potential to disperse. In 1980 the species was collected for the first time from Oahu, HI (Kaneshiro, 1983) and it was subsequently reported from several Hawaiian Islands without any reports of it causing damage (Nishida 1997, Breadsley & Perreira 1999, O'Grady & Perreira 2002). The species spread in 2009 into more than 20 counties in California from San Diego Co in the south to Humboldt Co in the north. It was also found in Oregon, Washington, and British Columbia (Canada), as well as in Florida (Steck et al. 2009). It is very likely that the fly spread through shipments of infested crop and that in 2010 many Midwestern and East coast states will report this pest.

There are also reports from Europe, where *D. suzukii* was found in October 2008 in Spain (150km from Barcelona by G. Calabriain) and several reports from the Italian Alps, where the fly might be established by now.

There were no further reports from Spain, which could be explained by the dry Mediterranean climate, which is not the preferred condition for *D. suzukii* according to ecological simulations run by Martin Damus (pers. communication). If the fly spread to the more humid central Europe it could develop into a serious pest for the agriculture there.

The main host in California are cherries, but there have been confirmed reports from raspberries, strawberries, nectarines, boysenberries, Asian plums, plums, plumcots, Satsyma plums and blackberries. In the literature are reports of infestations in healthy blueberries, grapes, mulberries and Japanese apricots as well as reports in damaged or dropped fruits of apples, peaches, persimmons and tomatoes. Amy Dreves reported *D. suzukii* from wine grapes in Oregon (Dreves 2008).

The wide variety of host fruit as well as the ability to use fresh and healthy fruit and also decaying fruit, which is the more typical substrate for drosophilids, combined with the typical high fecundity and short generation time, make this small fly a serious danger for (global) agriculture in the next years. All records of this fly are of great interest for future studies and are welcome

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Figure 2. Cherry with oviposition scars

# The Striped Fruit Fly, a Potential Pest of Cucurbits & Eggplant

J. Leathers, M. Hauser & S. Gaimari



A male *Bactrocera scutellata*, Striped Fruit Fly, trapped early in 2010 in San Pedro, California. Lateral (Left), and dorsal (right).

Over the past three years the Palos Verdes Peninsula of southern Los Angeles County has been a hot-spot for the introduction of exotic tephritid fruit flies to California. The hilly peninsula is composed largely of affluent single-family homes interlaced with rugged canyons containing natural areas. The ports of Long Beach and Los Angeles are located immediately to the east of the area. Since 2007, the Mediterranean Fruit Fly (*Ceratitidis capitata*), Oriental Fruit Fly (*Bactrocera dorsalis* complex), Guava Fruit Fly (*B. correcta*), and Striped Fruit Fly (*B. scutellata*) have all been collected in detection traps on the peninsula. All of these invaders have been successfully eradicated except for the Striped Fruit Fly.

The first Striped Fruit Fly of 2009 was found April 7<sup>th</sup> in a Cue lure trap in a community garden located just across the highway (about 200m) from the Port of Los Angeles. A second fly was trapped the following day in a cue lure trap about 3km to the northwest. By May 26<sup>th</sup> seven additional striped fruit flies were trapped in the area. They were all males in cue lure traps. An extensive larval survey was conducted of potential host material in the area and no larvae were found. No additional Striped Fruit Flies were trapped until November 17<sup>th</sup>, when a single immature female fly was collected in a McPhail trap just over a kilometer south of the original find site. Then on March 29, 2010 two male Striped Fruit Flies were trapped in Cue lure traps.

Although this is the first time a population of Striped Fruit Flies has been detected in California, four individual flies were collected before. Two of these were trapped in the wild in the vicinity of present finds. In 1987 one male Striped Fruit Fly was trapped in a Cue lure trap in Rancho Palos

Verdes, the same area where flies have been trapped recently. And in 1999, a female Striped Fruit Fly was trapped in a McPhail trap in Wilmington, only 4-5km to the east of the present find sites. Two other flies were caught in buildings. In 1990 a male was collected in a maintenance hangar at Los Angeles International Airport, 20km to the north of the present detection area. And finally, in 1992, a female was hand collected in a building in Santa Ana, 35km to the east.

The striped fruit fly is native to China, Taiwan, Japan (Shiraki 1968, White & Elson-Harris 1992), Malaysia, and Thailand (White & Hancock 2001) where it is primarily associated with male flower buds and the galls of midges on stems and flowers of plants in the family Cucurbitaceae. The larvae have been found in ungalled male flower buds of pumpkin (*Cucurbita pepo*), butternut squash (*C. moschata*) (Shiraki 1968), the Chinese herb guālóu (*Trichosanthes kirilowii*), and gourds (*T. laceribracteata*, *T. miyagii*, *T. multiloba*, and *T. ovigera*) (Miyatake et al. 2000, Suguru et al. 2006). They have also been found in the galls of midges on the flowers and stems of gourds (*T. cucumeroides* (Tanaka 1936), *T. ovigera*, *Diplocyclos palmatus* (Miyatake et al. 2000), and *Zehneria liukuensis* (Sugimoto et al. 1988, Miyatake et al. 2000). The only fruit that Striped Fruit Fly larvae have been found in are cucumber (*Cucumis sativus*) (Ohno et al. 2006), eggplant (*Solanum melongena* (Solanaceae) (Kanmiya 1986)), and guālóu (*T. kirilowii*). There is also a doubtful record of larvae found in pear (*Pyrus communis* (Rosaceae) (Yang 1988)).

The Striped Fruit Fly is a colorful fly characterized by three parallel yellow to white stripes on the dorsal side of the

thorax between the wings, a scutellum that is yellow basally with a black apex, and three black “T” marks on the abdomen. There are two black spots on the face of the fly. The wings have a black band along the front that is expanded at the wing tip. Males are attracted to Cue lure (Melon Fly) traps.

Although the Striped Fruit Fly has a rather limited host range, it does have the potential to damage crops worth \$77 million annually in California (USDA NASS 2008). The fly has the potential to build up very large populations; it is

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## Outreach

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### North American Dipterist's Society Field Meeting

P. Kerr, M. Hauser, S. Gaimari

CDFA dipterists organized and hosted the North American Dipterist's Society Field Meeting June 1-4 in Crescent City. Forty of the top fly specialists in the world participated, including the Agriculture Canada Diptera diagnostics team. High quality formal presentations on various aspects of Diptera systematics and biology were given by Wayne Mathis and Chris Thompson (Smithsonian Institution), Greg Courtney (Iowa State University), Gary Dodson (Ball State University), Gregory Curler (University of Tennessee), Riley Nelson and Paul Frandsen (Brigham Young University), Matthew Van Dam (UC Berkeley), Isaac Winkler (North Carolina State University), and Torsten Dikow (Field Museum of Natural History). The meeting also involved field collecting and laboratory identification workshops.

### Pacific Coast Entomological Society

M. Hauser

The November 2009 meeting of the Pacific Coast Entomological Society was organized and moderated by Martin Hauser, and held at CDFA.



Attendees of the North American Dipterist's Society Field Meeting, 2009. Kneeling (left to right): Peter Kerr, Terry Wheeler, Ken Collins, Joel Gibson, Terry Whitworth, Riley Nelson, Vanessa Christensen, Margarita Chase, Julia Mlynarek, Adrienne Burke. Standing (l to r): Greg Curler, Jeff Cumming, Matthew Van Dam, Owen Lonsdale, Shelah Morita, Gary Dodson, Isaac Winkler, Brian Wiegmann, Torsten Dikow, Keith Bayless, Faye Whitworth, Martin Hauser, Brad Sinclair, Wayne Mathis, Scott Brooks, Dianne Mathis, Jim O'Hara, Marjolaine Giroux, Eric Fisher, Paul Frandsen, Stephanie Boucher, Steve Gaimari, Jim Hogue, Daniela Ramirez, Chris Thompson, Betty Thompson. Not pictured: Steve Marshall, Steve Marshall, Jr., Greg Courtney, Kevin Barber.

## Featured Entomological Abstracts of Work Published This Year

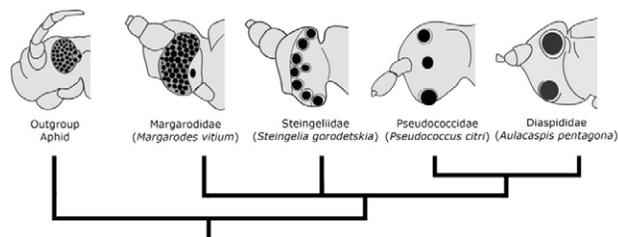
Brown, J.W, **Epstein, M.E.**, Gilligan, T.M, Passoa, S.C. & Powell J. A. Biology, Identification, and History of the Light Brown Apple Moth, *Epiphyas postvittana* (Walker) (Lepidoptera: Tortricidae: Archipini) in California: An Example of the Importance of Local Faunal Surveys to Document the Establishment of Exotic Insects. *American Entomologist*, Volume 56, Number 1, Spring 2010, pp. 34-43(10).

**Abstract.** The light brown apple moth (LBAM), *Epiphyas postvittana* (Walker), is a polyphagous species that is an important pest of apple, citrus, and grapes in Australia and New Zealand. The potential threat of LBAM to U.S. agriculture was recognized formally in 1957 when this species was included in the pest alert series "Insects Not Known to Occur in the United States" of the Cooperative Economic Insect Report. Although LBAM was excluded from a list of the top 100 most dangerous exotic pests of concern to the United States in 1973, most regulatory entomologists have continued to cite this species in risk assessments. LBAM was first discovered in the United States at Berkeley, CA, in 2006. Pheromone trapping efforts in 2007-2009 by the California Department of Food and Agriculture and the U.S. Department of Agriculture revealed its presence in Alameda, Contra Costa, Los Angeles, Marin, Monterey, Napa, San Benito, San Francisco, San Joaquin, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Solano, Sonoma, Ventura, and Yolo counties, California. Previous surveys in California over the past 40 years, for LBAM in particular and for Lepidoptera in general, covering a variety of habitats including most of the known geographical range of LBAM, failed to detect this species. These negative data provide circumstantial evidence that LBAM arrived in California only recently. We provide descriptions and illustrations to help identify this newly arrived pest, along with a history of its discovery.



Buschbeck, E.K. & **M. Hauser** (2009): The visual system of male scale insects. *Naturwissenschaften* **96**: 365-374

**Abstract.** Animal eyes generally fall into two categories: (1) their photoreceptive array is convex, as is typical for camera eyes, including the human eye, or (2) their photoreceptive array is concave, as is typical for the compound eye of insects. There are a few rare examples of the latter eye type having secondarily evolved into the former one. When viewed in a phylogenetic framework, the head morphology of a variety of male scale insects suggests that this group could be one



Illustrated evolution of the visual system of male scale insects

such example. In the Margarodidae (Hemiptera, Coccoidea), males have been described as having compound eyes, while males of some more derived groups only have two single-chamber eyes on each side of the head. Those eyes are situated in the place occupied by the compound eye of other insects. Since male scale insects tend to be rare, little is known about how their visual systems are organized, and what anatomical traits are associated with this evolutionary transition. In adult male Margarodidae, one single-chamber eye (stemmateran ocellus) is present in addition to a compound eye-like region. Our histological investigation reveals that the stemmateran ocellus has an extended retina which is formed by concrete clusters of receptor cells that connect to its own first-order neuropil. In addition, we find that the ommatidia of the compound eyes also share several anatomical characteristics with simple camera eyes. These include shallow units with extended retinas, each of which is connected by its own small nerve to the lamina. These anatomical changes suggest that the margarodid compound eye represents a transitional form to the giant unicornal eyes that have been described in more derived species.



Evans, G.A., **Watson, G.W.** & Miller, D.R. (2009) A new species of armored scale (Hemiptera: Coccoidea: Diaspididae) found on avocado fruit from Mexico. *Zootaxa*, 1991: 57-68.

**Abstract.** A new species of armored scale, *Abgrallaspis aguacatae* Evans, Watson, and Miller spec. nov. is described and illustrated from specimens collected on avocado fruit from Mexico. This species has caused considerable concern as a quarantine issue in the United States. A key to the armored scale species known to feed on avocado worldwide is provided.





A Therevid fly, *Henicomysia* from Guatemala.

Lambkin, C.L., J.W.H. Trueman, D.K. Yeates, K.C. Holston, D.W. Webb, M. Hauser, M.A. Metz, H.N. Hill, J.H. Skevington, L. Yang, M.E. Irwin, & B.M. Wiegmann (2009): Supertrees and the Tree of Life: generating a metaphylogeny for a diverse invertebrate family (Insecta : Diptera : Therevidae) using constraint trees and the parsimony ratchet to overcome low taxon overlap. *Invertebrate Systematics* 23: 171–191.

**Abstract.** The dipteran family Therevidae (stiletto flies) is cosmopolitan and has been the focus of many taxonomic and phylogenetic studies over the last 25 years. Despite this work, questions remain concerning the relationships between subfamilies, genera and generic groups and membership of those groups. We use the supertree method to produce an inclusive phylogeny for the family Therevidae from 24 phylogenetic studies using matrix representation with parsimony (MRP) analysis. The supertree method, one of the most common approaches to calculating globally inclusive phylogenies from smaller more exclusive analyses, produced the therevid metaphylogeny despite only 34% of the terminal taxa being found in more than one source tree. We describe a method for handling low taxon overlap in supertree analyses, in combination with the parsimony ratchet and constraint tree techniques. The supertree presented here is an overarching phylogenetic hypothesis of the Therevidae, incorporating extensive sampling of major lineages and summarising past phylogenetic work on the family. The inclusive metaphylogeny for 362 therevid taxa robustly retrieves the subfamilies Agapophytinae, Phycinae, Therevinae and Xestomyzinae, and the tribes Cyclotelini and Therevini. The Phycinae and Xestomyzinae form a clade, sister to the remaining Therevidae. The Australasian and South American *Taenogera* Kröber genus-group is monophyletic and sister to a clade of Therevinae and the Australian endemic Agapophytinae. The Therevinae consists of the *Anabarhynchus* Macquart genus-group of Australian, South American, New Caledonian and New Zealand taxa as sister to the non-Australasian ‘higher Therevinae’, which contains the tribes Cyclotelini



*Odontomyia annulata* female feeding on a flower of *Thapsia* sp. (Sardinia, Buddusò). Photo by F. Mason

and Therevini. The Therevini includes the *Hoplosathe* Lyneborg & Zaitzev, *Litolinga* Irwin & Lyneborg, *Baryphora* Loew, *Pandivirilia* Irwin & Lyneborg and *Thereva* Latreille generic-groups. MRP supertree methods can be used to produce inclusive metaphylogenies in situations where source trees have poor data overlap and low taxon overlap, and are therefore valuable in species-rich groups such as arthropods. These methods may be necessary for constructing the ‘Tree of Life’, representing phylogenetic relationships among the millions of known species. However, our analyses show that in situations of source tree conflict, MRP supertree analyses present only the majority signal. We also show that conflict between source trees can be hidden in MRP supertrees, thus our results emphasise the need to evaluate the resulting clades with reference to the source trees.



Mason, F., R. Rozkosny & M. Hauser (2009) A review of the soldier flies (Diptera: Stratiomyidae) of Sardinia. *Zootaxa* 2318: 507-530. [In: Cerretti, P., F. Mason, A. Minelli, G. Nardi & D. Whitmore (Eds.), Research on the Terrestrial Arthropods of Sardinia (Italy). *Zootaxa* 2318: 1-602.]

**Abstract.** All published records on Stratiomyidae from Sardinia were critically evaluated and extensive, recently collected material (more than 500 specimens) was identified. The present review of the soldier flies from Sardinia includes 27 species. *Nemotelus niloticus* Olivier, 1811 is newly recorded from Europe and Italy, and *Lasiopa pseudovillosa* Rozkošný, 1983 and *Zabrachia tenella* (Jaenicke, 1866) are newly recorded from Sardinia. *Nemotelus brachystomus* Loew, 1846 and *N. leucorhynchus* Costa, 1884 are proposed as new synonyms of *N. notatus* Zetterstedt, 1842. *Beris hyaliniventris* Costa, 1857, the types of which could not be found, is removed from synonymy with *Chorisops tibialis* (Meigen, 1820) and declared as species *incertae sedis*. Brief comments are made on the zoogeography of Sardinian soldier flies.

Morse, J.G., Rugman-Jones, P.F., **Watson, G.W.**, Robinson, L.J., Bi, J.L. & Stouthamer, R. (2009) High levels of exotic armored scales on imported avocados raise concerns regarding USDA-APHIS' phytosanitary risk assessment. Forum Article, *Journal of Economic Entomology* 102(3): 855-867.

**Abstract.** Between 1914 and 2007, a quarantine protected California avocado, *Persea Americana* Mill., groves from pests that might be introduced into the state along with fresh, imported avocados. Soon after Mexican avocados were first allowed entry on 1 February 2007, live specimens of several species of armored scales (Hemiptera: Diaspididae) not believed to be present in California were

detected on 'Hass' avocados entering the state from Mexico. Initially, the California Department of Food and Agriculture (CDFA) prevented avocados infested with these scales from entering the state or required that they be fumigated with an approved treatment such as methyl bromide. After a Science Advisory Panel meeting in May 2007, U.S. Department of Agriculture Animal and Plant Health Inspection Service (USDAAPHIS) reaffirmed its position that armored scales on shipments of fruit for consumption (including avocados) pose a "low risk" for pest establishment. In compliance with APHIS protocols, as of 18 July 2007, CDFA altered its policy to allow shipments of scale-infested avocados into the state without treatment. Here, we report on sampling Mexican avocados over an 8-mo period, September 2007 - April 2008. An estimated 67 million Mexican Hass avocados entered California over this period. Based on samples from 140 trucks containing  $\approx 15.6\%$  of this volume of fruit, we estimate that  $\approx 47.6$  million live, sessile armored scales and an additional 20.1 million live eggs and

crawlers were imported. We found eight probable species of armored scales in the samples, seven of these are not believed to occur in California; 89.3% of the live scales were *Abgrallaspis aguacatae* Evans, Watson and Miller, a recently described species. In contrast to the USDAAPHIS opinion, we believe the volume of shipments and levels of live scales they contain present a significant risk to California's US\$300 million avocado industry and to other crops that might become infested by one or more of these exotic species.



**Figure 4.** A typical species of the genus *Ptecticus*.

Muniappan, R., Shepard, B.M., **Watson, G.W.**, Carner, G.R., Sartiami, D., Rauf, A. & Hammig, M.D. (2009) First report of the papaya mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae), in Indonesia and India. *Journal of Agricultural and Urban Entomology* 25(1): 37-40.

**Abstract.** The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae), is recorded from the Oriental Region for the first time, where it was found in Indonesia (Java) and India (Tamil Nadu) in 2008. Papaya mealybug is a polyphagous pest that damages many tropical crops. A native of Central America, it spread to the Caribbean region and South America in the 1990s; since then it has been accidentally introduced to some islands in the Pacific region. The distribution, host range and characteristics of the mealybug are summarized.



Rozkošný, R. & **M. Hauser** (2009): Species groups of Oriental *Ptecticus* Loew including descriptions of ten new species with a revised identification key to the Oriental species (Diptera: Stratiomyidae). *Zootaxa* 2034: 1–30.

**Abstract.** The species of Oriental *Ptecticus* are reviewed and ten species are described: *P. artocarpophilus* **sp. nov.** from the Philippines; *P. bannapensis* **sp. nov.**, *P. kubani* **sp. nov.** and *P. subaurifer* **sp. nov.** from Laos; *P. elegans* **sp. nov.** and *P. semimetallicus* **sp. nov.** from Nepal; *P. fukienensis* **sp. nov.** from southern China; *P. indicus* **sp. nov.** from India; and *P. infuscatus* **sp. nov.** and *P. sarawakensis* **sp. nov.** from Borneo. Five new synonymies are proposed: *P. minimus* Rozkošný & Kovac, 1997 is a junior synonym of *P. shirakii* Nagatomi, 1975; *P. okinawae* James, 1950 is a junior synonym of *P. aurifer* (Walker, 1854); *P. tenebrifer* (Walker, 1849) is a junior synonym of *P. japonicus* (Thunberg, 1789); *P. wulprii* Brunetti, 1907 is a junior synonym of *P. melanurus* (Walker, 1848), and *P. zhejiangensis* D. Yang & C. Yang, 1995 is a junior synonym of *P. kerteszi* de Meijere, 1924.

Eight species groups for the Oriental *Ptecticus* species are defined: *aurifer* group (6 spp.), *australis* group (9 spp.), *cingulatus* group (11 spp.), *histrion* group (7 spp.), *longipennis* group (6 spp.), *shirakii* group (1 sp.), *japonicus* group (4 spp.), *tricolor* group (3 spp.) and 5 species remain unplaced. A new identification key to the Oriental *Ptecticus* species, including references to the published figures of distinguishing characters and basic distributional data, is given.



**Rung, A.,** S. Halbert, D.C. Ziesk, and R. Gill. 2009. A leafhopper pest of plants in the mint family, *Eupteryx decemnotata* Rey (Hemiptera: Auchenorrhyncha: Cicadellidae), Ligurian leafhopper, new to North America. *Insecta Mundi* 88: 1-4.

**Abstract.** The Ligurian leafhopper, *Eupteryx decemnotata* Rey (Hemiptera: Auchenorrhyncha: Cicadellidae), is reported for the first time in North America (USA: Florida and California). Diagnostic characters for species identification, summary of hosts and damage, and U.S. known distribution are given.



**Rung, A.,** D. Miller and S.J. Scheffer. 2009. Polymerase Chain Reaction- Restriction Fragment Length Polymorphism method to distinguish three mealybug groups within the *Planococcus citri*-*P. minor* species complex (Hemiptera: Coccoidea: Pseudococcidae). *Journal of Economic Entomology* 102(1): 8-12.

**Abstract.** The mealybug species *Planococcus citri* (Risso) and *Planococcus minor* (Maskell) (Hemiptera: Coccoidea: Pseudococcidae) have special significance to U.S. quarantine and U.S. agriculture and difficult to identify based on morphological characters. This paper presents a molecular method for distinguishing *P. citri*, *P. minor*, and a genetically distinct group that is morphologically identical to *P. citri*, from Hawaii. This method uses polymerase chain reaction (PCR) followed by restriction fragment polymorphism analysis (RFLP) using the restriction enzymes BspH1, BsmH1, and HpaH1. The resulting band patterns can be visualized in a 2% agarose gel and are sufficient to differentiate between the three entities mentioned above.



**Rung, A.,** G. Arakelian, **R. Gill** and N. Nisson. 2009. *Platycorypha nigrivirga* Burckhardt (Hemiptera: Sternorrhyncha: Psylloidea), Tipu Psyllid, New to North America. *Insecta Mundi* 97: 1-5.

**Abstract.** The tipu psyllid, *Platycorypha nigrivirga* Burckhardt (Hemiptera: Sternorrhyncha: Psylloidea), is reported for the first time in North America (USA: California). Diagnostic characters for identification of adults and nymphs, host and damage data, and known distribution are given.



Sformo, T., F. Kohl, J. McIntyre, **P.H. Kerr**, J.G. Duman, B.M. Barnes (2009) Simultaneous freeze tolerance and avoidance in individual fungus gnats, *Exechia nugatoria*. *Journal of Comparative Physiology B*, 179: 897-902.

**Abstract.** Freeze tolerance and freeze avoidance are typically described as mutually exclusive strategies for overwintering in animals. Here we show an insect species that combines both strategies. Individual fungus gnats, collected in Fairbanks, Alaska, display two freezing events when experimentally cooled and different rates of survival after each event (mean  $\pm$  SEM:  $-31.5 \pm 0.2^\circ\text{C}$ , 70% survival and  $-50.7 \pm 0.4^\circ\text{C}$ , 0% survival). To determine which body compartments froze at each event, we dissected the abdomen from the head/thorax and cooled each part separately. There was a significant difference between temperature levels of abdominal freezing ( $-30.1 \pm 1.1^\circ\text{C}$ ) and head/thorax freezing ( $-48.7 \pm 1.3^\circ\text{C}$ ). We suggest that freezing is initially restricted to one body compartment by regional dehydration in the head/thorax that prevents inoculative freezing between the freeze-tolerant abdomen ( $71.0 \pm 0.8\%$  water) and the supercooled, freeze-sensitive head/thorax ( $46.6 \pm 0.8\%$  water).



Shi, L., D. Yang, & **S.D. Gaimari** (2009) Species of the genus *Cestrotus* Loew from China (Diptera: Lauxaniidae). *Zootaxa* 2009: 41-68.

**Abstract.** The Chinese fauna of the genus *Cestrotus* Loew (Diptera: Lauxaniidae) is revised, including the five new species *Cestrotus acuticurvus* **sp. nov.**, *Cestrotus heteropterus* **sp. nov.**, *Cestrotus liui* **sp. nov.**, *Cestrotus longinudus* **sp. nov.** and *Cestrotus obtusus* **sp. nov.**, and the two previously described species *Cestrotus apicalis* (Hendel) and *Cestrotus flavoscutellatus* de Meijere. Extralimital records are also given for *Cestrotus flavoscutellatus* and *Cestrotus heteropterus*, including paratypes of the latter species from Thailand. A key to the species of *Cestrotus* from China is presented, and a list of all described species of *Cestrotus* is provided,



**Figure 5.** A species of *Cestrotus* from Thailand (photo by Nikita Vikhrev).

with information on type locality, primary type specimen(s) and depository, synonymy, and distribution.



**Watson, G.W.** & El-Serwy S.A. (2009) Aspects of the biology, ecology and parasitism of *Acanthomytilus sacchari* (Hall) (Hemiptera: Diaspididae) on sugarcane in Egypt. Pp. 159-167 *In*: Branco M., Franco J.C. & Hodgson C. (eds) Proceedings of the XI International Symposium on Scale Insect Studies, Oeiras, 24-27 September 2007. ISA Press, Lisbon, Portugal. 322 pp.

**Abstract.** The armoured scale, *Acanthomytilus sacchari* (Hall) (Hemiptera: Diaspididae), attacks sugarcane, *Saccharum officinarum* L., in Egypt. A diagnosis and taxonomic illustration are provided to aid identification of this insect, and its host range and distribution are given. The biology was studied in an untreated sugarcane field at Al-Aiat (Giza governorate) in 2000. Scales appeared in early May; by the end of July, 72% of the leaves bore 5024 scales each. By late August, every leaf was infested, each with an average of about 25 scales. Scale numbers peaked at an average of about 40 per leaf in the third week of September. Significantly more scales were found on the upper leaf surface than the lower, and on the middle third of the leaf rather than at either end. In late July, the average number of eggs and first-instar larvae found under a female's scale was 39; reproduction peaked at an average of 48 eggs and larvae per female in early September. In the outdoor insectary, four generations (egg to egg) occurred between late July and mid-December. The shortest generation time (27 days), oviposition period (7 days), and highest fecundity (6.86 eggs/day) occurred at an average temperature of 29.0°C and relative humidity (RH) of 62.2% in August. The longest generation time (48 days), oviposition period (16 days) and lowest fecundity (3.69

eggs/day) occurred in December at an average temperature of 22.6°C and RH of 67.4%. Reproductive capacity ranged between 25-67 (average 50) eggs per female. The sex ration was about 1:1. Parasitism of *A. sacchari* by *Metaphycus flavus* (Howard) (Hymenoptera: Encyrtidae) was recorded for the first time. The average level of parasitism for July-September was 22%, with peaks recorded in late July, mid-August and late September (about 28, 39 and 25% respectively).



Winkler, I.S., **Rung, A.**, Scheffer S. J. Hennig's orphans revisited: Testing morphological hypotheses in the "Opomyzoidea" (Diptera: Schizophora). *Molecular Phylogenetics and Evolution*.

**Abstract.** The acalyprate fly superfamily Opomyzoidea, as currently recognized, is a poorly-known group of 14 families. The compositions of this group and relationships among included families have been controversial. Furthermore, the delimitation of two opomyzoid families, Aulacigastridae and Periscelididae, has been unstable with respect to placement of the genera *Stenomicro*, *Cyamops*, and *Planinasus*. To test the monophyly of Opomyzoidea, previously proposed relationships between families, and the position of the three problematic genera, we sequenced over 3300 bp of nucleotide sequence data from the 28S ribosomal DNA and CAD (rudimentary) genes from 29 taxa representing all opomyzoid families, as well as 13 outgroup taxa. Relationships recovered differed between analyses, and only branches supporting well-established monophyletic families were recovered with high support, with a few exceptions. Opomyzoidea and its included subgroup, Asteioinea, were found to be non-monophyletic. *Stenomicro*, *Cyamops*, and *Planinasus* group consistently with Aulacigastridae, contrary to recent classifications. Xenasteiidae and Australimyziidae, two small, monogeneric families placed in separate superfamilies, were strongly supported as sister groups.

# PLANT PATHOLOGY LABORATORY REPORT

2009 PLANT PATHOLOGY LABORATORY STAFF

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Diagnostic services provided by the Plant Pathology Laboratory include but are not limited to:

- Diagnosis of samples submitted by pest prevention programs by state, county, and federal agencies, as well as academic and public sources.
- Diagnosis of samples submitted by the Fruit and Nut Tree and Grapevine Improvement Advisory Board (IAB Program) to be tested for Prunus necrotic ringspot and prune dwarf viruses using enzyme-linked Immunosorbent assay (ELISA).
- Diagnosis of grapevine samples submitted by the Grapevine Registration and Certification Program for ELISA testing for the presence of grapevine fanleaf and leaf roll viruses.
- Diagnosis of plant samples specifically for Pierce's Disease, as part of the Statewide Glassy Wing Sharpshooter and Pierce's Disease Project.
- Diagnosis of samples as part of The US Department of Homeland Security's National Plant Diagnostic Network (NPDN).
- Diagnosis of Seed samples examined and tested to determine phytosanitary seed health compliance prior to export.
- Diagnosis of miscellaneous plant samples submitted by individual farmers, Pest control advisors, U.C. cooperative extension agents, nurserymen, arborists, homeowners, government municipalities, educational institutions, and others.
- Diagnosis of samples collected for various plant disease surveys including Plum Pox, Sudden Oak Death, Citrus Canker, Rice Diseases, and others.

Plant Disease Samples handled by the plant pathology laboratory include those caused by fungal pathogens, viral pathogens, phytoplasmas, Stramenopiles (Oomycetes such as *Phytophthora*, *Pythium*, the Downy mildews), bacterial pathogens, and other organisms. Some samples have plant disorders that have a physiological, chemical, or genetic cause. In addition, many samples have no detectable pathogen and require further sampling and/or investigation.

In 2009 more than 92,000 samples were processed and diagnosed in the Plant Pathology Laboratory. Highlights for 2009 included more than 50,000 samples tested for several target viruses as part of the California Deciduous Fruit Tree, Nut Tree, and Grapevine Improvement Advisory Board (IAB) program; and nearly 27,000 Sudden Oak Death (SOD) samples. Also included were over 10,000 Asian Citrus Psyllid samples and over 2000 Citrus samples that were tested for the Huanglongbung (HLB) pathogen. In addition, for the first time in this laboratory, more than 10,000 Citrus samples were tested for Tristeza Virus (Figure 1). Also noteworthy was the fact that over 500 Phytosanitary Certification (crops grown for seed) samples were examined for seed-borne pathogens, and more than 200 samples were diagnosed from the CDFA border stations.

## A and Q Rated Plant Pathology Pest Records for 2009

Pathogen	Rating	Common Name	Host	County
Citrus Tristeza virus	A	Citrus Tristeza virus	<i>Citrus spp.</i>	Tulare
<i>Fusarium oxysporum f.sp. canariensis</i>	A	Palm Wilt	<i>Phoenix canariensis</i>	Imperial, Marin, Orange, Riverside, Sacramento, San Diego, Santa Barbara, Stanisluas, Ventura
<i>Coccidiella sp.</i>	Q	Mycoparasite	<i>Aegle mameelos (Bilva tree)</i>	San Bernardino
<i>Coniothyrium sp.</i>	Q		<i>Tillandsia sp.</i>	Madera
<i>Diplodia corticola</i>	Q	Canker fungus	<i>Quercus chrysolepis</i>	Plumas
<i>Exserohilum rostratum</i>	Q	Leaf spot fungus	<i>Phoenix canariensis</i>	San Diego
<i>Fusarium oxysporum f.sp. dianthi</i>	Q	Root and crown rot	<i>Dianthus sp.</i>	San Luis Obispo
<i>Geosmithia sp. nov.</i>	Q	Walnut Thousand Cankers	<i>Juglans californica</i>	Sutter, Yolo
<i>Kutilakesa pironii</i>	Q	Stem gall	<i>Pittosporum variegata</i>	Sacramento
<i>Mycosphaerella buckinghamiae</i>	Q	Leaf spot fungus	<i>Arctostaphylos gabilanensis,</i> <i>A. pallida, A. imbricata,</i> <i>A. silvicola</i>	Contra Costa, Alameda
<i>Phaeomoniella sp.</i>	Q	Leaf spot fungus	<i>Olea europaea</i>	Santa Barbara
<i>Phytophthora porri</i>	Q	Leaf blight	<i>Schefflera actinophylla</i>	Los Angeles
<i>Phytophthora ramorum*</i>	Q	Sudden Oak Death (S.O.D)	Multiple hosts	Alameda, Contra Costa, Marin, Monterey, Placer, Sacramento, San Mateo
<i>Pseudocercospora liquidambaricola</i>	Q	Leaf spot fungus	<i>Loropetalum chinense</i>	Santa Barbara
<i>Ramularia didyma</i>	Q	Leaf spot fungus	<i>Ranunculus asiaticus</i>	San Mateo
<i>Septoria darrowii</i>	Q	Leaf and cane spot	<i>Rubus ursinus var. loganobaccus</i>	Madera
<i>Therrya fuckelii**</i>	Q	Fungus from pine bark	<i>Pinus sp.</i>	Redwood Highway Insp. Sta.
Tomato leaf curl virus	Q	Tomato leaf curl virus	<i>Lycopersicon esculentum</i>	Riverside
<i>Uromyces transversalis*</i>	Q	Gladiolus rust	<i>Gladiolus sp.</i>	Alameda, Contra Costa, San Francisco, San Mateo, Santa Barbara, Santa Clara, Santa Cruz

\*S.O.D. and Gladiolus Rust detailed statistics are presented in individual tables; \*\*Intercepted pest.

Table Prepared by J. White

# Karnal Bunt

T.E. Tidwell & Y. Zhang

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Following is a summary of the Karnal Bunt wheat-testing activities of the CDFA Plant Pest Diagnostics Branch for the 2009 Calendar Year in partial fulfillment of the Karnal Bunt Contract with the USDA APHIS. During the 2009 wheat-growing season a limited number of wheat fields were planted in the Palo Verde Valley, near Blythe, CA, which is still under federal quarantine and therefore monitored and tested locally for the presence of the pathogen before any wheat is permitted to leave the region. Thus, a total of thirty were tested for the Karnal Bunt pathogen in the USDA/CDFA laboratory located at Blythe, CA. For the fifth consecutive year, the Karnal Bunt pathogen, *Tilletia indica*, was not detected in any of the Blythe wheat samples. As in previous testing seasons, we examined all wheat samples for bunted wheat kernels using a highly efficient seed examination machine, and we examined each wheat sample using a highly sensitive laboratory seed wash screening test<sup>1</sup> that detects even minute levels of teliospores in the wheat samples. In addition, the success of this project is largely attributable to the outstanding on-site project management of USDA biologist Michael Hennessey and CDFA border station/field biologist Ben Mays, who, over the course of several seasons, have consistently enforced the biologically sound policy of permitting harvesting or sampling equipment to proceed

<sup>1</sup> Peterson, G. L., M.R. Bonde and J.G. Phillips. 2000. Size-selective sieving for detecting teliospores of *Tilletia indica* in wheat seed samples. Plant Disease 84:999-1007.

from field to field *only* after wheat samples from the field in question have tested negative for the pathogen by laboratory testing. Harvesting equipment which collects wheat samples that test positive for the Karnal Bunt Pathogen are required to be disinfested before being allowed to proceed to a new field for sampling or harvesting. Implementing this practice for several seasons has been highly effective in preventing the inadvertent spread of the pathogen to other wheat fields via contaminated harvesting equipment.

National Karnal Bunt Survey activities and sample numbers were consistent with those of previous years. A total of fifty-three samples from California were tested for the Karnal Bunt pathogen as part of the annual National Karnal Bunt Survey. The Karnal Bunt pathogen was not detected in any of the National KB wheat samples. In addition, three samples were tested as part of the seed health testing program for seed being exported to Canada from the Imperial County region of California. The pathogen was not detected in any of those samples.

On the following page the 2009 Calendar Year National Survey samples are listed by County, as well as CDFA Pest and Damage Report number (Table 1).

**Table. 1** Wheat samples diagnosed for the Karnal Bunt National Survey in 2009, grouped by county.

County	Samples tested	PDR#	Determination
<b>Colusa</b>	2	1552006	Negative
		1552050	Negative
<b>Contra Costa</b>	1	1504340	Negative
<b>Fresno</b>	5	1338652	Negative
		1338654	Negative
		1338653	Negative
		1338655	Negative
		1338651	Negative
<b>Glenn</b>	1	1354777	Negative
<b>Imperial</b>	10	1263703	Negative
		1263704	Negative
		1263705	Negative
		1263706	Negative
		1263707	Negative
		1263708	Negative
		1263709	Negative
		1263710	Negative
		1263711	Negative
		1163712	Negative
<b>Kern</b>	3	1486851	Negative
		1486852	Negative
		1486853	Negative
<b>Kings</b>	5	1520681	Negative
		1520680	Negative
		1520679	Negative
		1520678	Negative
		1520677	Negative

County	Samples tested	PDR#	Determination
<b>Lassen</b>	1	1307866	Negative
<b>Madera</b>	1	1505856	Negative
<b>Merced</b>	1	1418384	Negative
<b>Monterey</b>	1	1693900	Negative
<b>Placer</b>	1	1379978	Negative
<b>Riverside</b>	2	1501775	Negative
		1501776	Negative
<b>Sacramento</b>	1	1423354	Negative
<b>Santa Barbara</b>	1	1555161	Negative
<b>Siskiyou</b>	1	1407361	Negative
<b>Solano</b>	2	1413740	Negative
		1413739	Negative
<b>Sonoma</b>	1	1537923	Negative
<b>Stanislaus</b>	1	1475339	Negative
<b>Sutter</b>	1	1306371	Negative
<b>Tehama</b>	1	1386531	Negative
<b>Tulare</b>	3	1411143	Negative
		1411144	Negative
		1411145	Negative
<b>Yolo</b>	6	1520104	Negative
		1520103	Negative
		1520102	Negative
		1520105	Negative
		1520106	Negative
<b>Yuba</b>	1	1520107	Negative
		1295395	Negative

**Total number of samples tested for the year: 53**

# Phytopathology

D. Opgenorth

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## Citrus Greening (Huanglangbing) (HLB) Survey

The CDFA Citrus Greening (Huanglangbing) (HLB) Survey took the majority of my time this year. Beginning in 2009 we were confident that our current survey of plant materials in San Diego and Imperial County was adequate. Funding was available for laboratory expansion and additional equipment was requested in anticipation of possible project escalation. Heating blocks, tissue macerators, centrifuges and thermo cyclers were ordered and put into service. The laboratory area for processing was expanded to include three new sites. A room on the first floor was repurposed to house all the Real Time Cepheid thermocyclers.

While equipment is necessary to perform the testing, the most critical need is for certified personnel to perform the approved assay in a timely way. This is a highly technical, precise and unforgiving procedure. The tedious nature of the test is a matter of concern; therefore, I am trying to work with USDA to find ways to partially alleviate these issues. We have generated data that causes us to believe that a multiplex PCR of both Liberobacteria species is possible without sacrificing sensitivity. This would reduce the amount of reagents, tubes and labor required to perform the assay on both bacterial species for which we are now testing.

In July and August the number of sites where Asian Citrus Psyllids (ACP) were trapped began to increase. Expressed concern from the Citrus Industry made the survey a higher priority and placed increased pressure on the diagnostic laboratory. Members of our technical staff were made available to process the increased numbers of plant and insect samples. Currently only two of our technical staff trained by USDA passed the proficiency panel for HLB. This number will be increased to comply with our needs; an increased number of samples will require more trained and certified staff.

Since August, the number of ACP sites has escalated to over three hundred. As these sites are chemically treated they will be eliminated. However, it is reasonable to expect just as many or more new sites when the weather warms next year. Thus, our laboratory needs to be adequately staffed and stocked to deal with the anticipated sample load.

There was an eight week period in 2009 where we had difficulty in keeping up with assay results. This problem involved our ability to order reagents, at least in part because of concerns over the passage of the annual State Budget. Only a hard frost will reset the clock on psyllid movement

and the number of sites that need to be monitored. This may occur in some areas away from the coast on the fringe of the Los Angeles basin, but I would not expect this to occur in the heart of the Los Angeles area where most of the finds have occurred. While HLB is of greatest concern we need to retain our vigilant observation of Citrus Canker symptoms while completing the HLB surveys.

There were two noteworthy, non-survey finds in 2009. One of the CDFA dog teams detected plant material in a backpack at the Fresno airport. Dead psyllids were found and tested positive for HLB. The origin was believed to be from Southeast Asia according to information provided by the owner. Another interesting shipment from India contained curry leaves with live psyllids. I informed Sacramento County to place the package in a freezer for at least a half hour to slow or kill the insects before further investigation. Fortunately, the curry and psyllids were not positive for the HLB bacteria. In this regard, I would like to commend the dog teams and the workers at our border stations for their vigilance in identifying materials that pose a significant threat from areas outside the United States.

*Other areas of concern for bacterial diseases did not take as much time as HLB, but also warrant some mention. While they continue to be significant issues, I will not be able to commit as much time to them next year if the HLB survey expands significantly.*

## Corn Stunt

During the past nine years my laboratory has provided diagnostic support to the University of California scientists at Parlier and Cooperative Extension agents in Tulare and Kings County. Corn samples were initially tested using ELISA, PCR and now with Real Time PCR. Corn and Leafhopper samples can be tested in one day with great sensitivity. This year the farm advisor in Tulare County, Carol Frate, was granted a sabbatical leave to work on the Corn Stunt problem. In a brief training session, emphasizing DNA extraction and Real Time PCR from corn embryo tissues, it was noticed that both Stunt Spiroplasma and Maize Bushy Stunt Phytoplasma were present in the samples. This would make the work more interesting and demanding since MBSP had not been previously reported in the San Joaquin Valley.

Carol was able to get continuing help from Charles Summers and staff at U C Parlier, and acquire the help of Ray Yokomi, and visiting scientist M. Saponari at the USDA

Research facility at Parlier. We have previously shown that the Spiroplasma is seed borne and I would hope that additional work would prove the Phytoplasma is also. This would be information that could change the strategy for control of these corn pathogens that have the potential to decrease the yield of forage by fifty percent. Following is a brief report concerning this work in progress.

### **Corn Stunt and Maize Bushy Stunt Research 2009**

*Carol Frate, Farm Advisor on Sabbatical Leave with support from Dr. Dan Opgenorth, CDFR; Dr. Ray Yokomi, USDA-ARS; Dr. Charlie Summers, UC Cooperative Extension*

Over 150 plants, from field locations and greenhouse, have been tested for Corn Stunt spiroplasma (CSS) and Maize Bushy Stunt phytoplasma (MBSP).

**Greenhouse:** Both CSS and MBSP were found in tips of corn kernels from ears sampled from a 2008 field trial evaluating seed treatments. With limited testing (due to priority given to field samples while there is corn in the field), it has not been confirmed that seedlings grown from kernels of infected plants have been infected with either organism. More emphasis will be on this work in the following months.

**Field:** Both CSS and MBSP have been identified in field samples. However, many plants with symptoms attributed to these pathogens have tested negative, a common problem that has faced researchers with these diseases in other parts of the world. The majority of plants testing positive have both CSS and MBSP.

**Insects:** The corn leafhopper populations built up more slowly this year than in recent years based on surveys by Dr. Summers. Many fewer insects than plants have been tested. At first the rapid technique developed by Dr. Opgenorth was used on insect samples but with later samples, CTAB extraction has been the main method in order to test not only for CSS but also MBSP. There were a few positives for CSS but most were weak and late curves with qPCR and, to date, none have tested positive for MBSP.

There have been a few samples that were negative for MBSP but that had a band in a nested PCR that is generic for many phytoplasmas. Dr. M. Saponari, Visiting Scientist with Dr. Yokomi, designed new primers that should be more inclusive for different strains of MBSP. These samples will be re-tested in the next 3 months to determine if they react with samples already positive for MBSP and the samples that had a band with the nested PCR.

Dr. Opgenorth has provided training on PCR techniques, especially the rapid technique in helped to develop, and the CSS probe for qPCR as well as advice and suggestions.



**Figure 1. Cherries infected with Cherry Buckskin Disease.**

### **Cherry Buckskin**

Over the last two years we have been sampling a cherry orchard in San Joaquin County which has classical symptoms of Cherry Buckskin Disease. The previous season we were only able to use classical PCR techniques because of budget restraints. However, this season we implemented a generic Real Time assay that made it possible to do additional testing. Our objective was to find a way to use the Real Time PCR Assay to prove the presence of the phytoplasma so appropriate measures could be taken to abate the orchard and prevent further spread of the disease. The assay was successful on symptomatic fruit, leaf petioles, leaf hopper vectors collected with a D-Vac and weed hosts collected from the orchard floor. The Buckskin Phytoplasma was confirmed in the symptomatic fruit pedicels by DNA sequencing and further work needs to be done to prove that the same phytoplasma was present in the hoppers and weeds. Hopefully, we can continue this project next year and get more information about the alternative hosts and vectors. Attached is a early year summary that was compiled at the request of the County for use in possible abatement.

### **Strawberry Angular Leaf Spot**

In 2007 a significant effort was made to upgrade the diagnostic ability of our laboratory for *Xanthomonas fragariae*. My seasonal scientific aide was able to show that a classical nested PCR was very sensitive, but also somewhat inconsistent in diagnosis. In 2008 we tried using a Real Time PCR packaged by the California Seed and plant Laboratory and later invested in our own reagents. This assay was even more sensitive, but suffers from issues of contamination and false positives. When plants having classical symptoms of the disease are collected, leaf lesions are oozing the bacteria and it becomes very difficult to prevent initial contamination when using an extremely sensitive assay. This year a new antibody assay was available and needed to be evaluated for its sensitivity and reliability. Usually, the detection of bacte-

rial pathogens using antibodies leaves much to be desired regarding sensitivity and specificity. In many cases the bacteria needs to be cultured so that bacterial suspensions can be attached to a ELISA plate. Since *Xanthomonas fragariae* is difficult to culture, this may be a problem. However, BIO-REBA has just marketed a dip stick antibody based assay that precludes the need for pure culture. The test seems to be sensitive and specific for many symptomatic and also asymptomatic plant parts. We are now confirming our results using classical and Real Time PCR on the same extracts used in the dip stick assay. The work on this project was somewhat postponed because of a large sample volume of HLB Psyllids beginning in October and continuing through the remainder of the year. I hope the quantitative nature of the Real Time assay will strongly reflect the results of the dip stick assay and provide validation for its use.

### **Cucumber Yellow Vine Disease (CYVD)**

In late October it was announced that Banana Squash samples had been sent to Oklahoma for confirmation of *Serratia marcescens*, which causes Cucumber Yellow Vine Disease (CYVD). This had caused a little excitement because the bacteria is a known human pathogen and has not been previously reported in California on cucurbits. However, the plant disease strain is significantly different than the human pathogen and this always needs to be emphasized when speaking to anyone in the news media. After contacting researchers in Oklahoma who received the samples from a California Farm Advisor, they acknowledged that isolations had been made and pure cultures used to inoculate plants in an effort to prove pathogenicity. We were interested in getting positive DNA from the California cultures so we could do our own investigation, however, these isolates have as yet to be confirmed using PCR. If these isolates prove to be positive, a field survey should be done next season around harvest time. A unique feature of this disease is that the bacteria can be carried by plant bugs feeding on the fruit. It is also reported that the bacteria overwinters with the insects. Verification of these reports would be valuable in development of a strategy for mitigation and control of the disease.

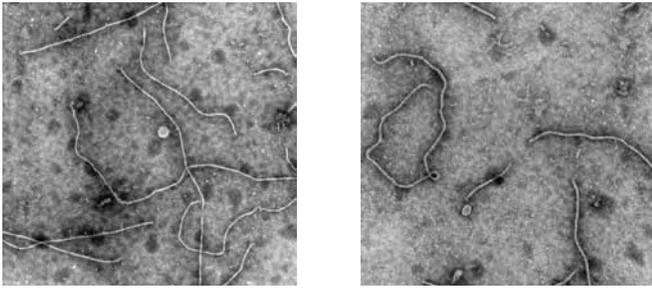
### **Crown Gall of Grape**

This spring we worked on grape samples from Tuolumne County that had overgrowths at the graft union. The grower was concerned that his new vineyard had contacted Crown Gall. Plants in pots were also obtained from the grower from the same group of materials that were planted. *Agrobacterium* species were isolated from overgrowths on the vineyard and the potted grapes and confirmed by an independent laboratory. At the request of the County I made a trip with our new Associate Plant Pathologist, Dr. Lani Yakabe, who has past experience with Bacterial Crown Gall. Additional samples were taken and isolations confirmed *Agrobacterium* but of a non-pathogenic strain. This information was forward to the County and hopefully the grower will have piece of mind concerning his new vineyard.

These projects could not be accomplished without the continuing technical help of Israfiel Mohammed, Terra Walber, Monica Negrete, and Jennifer Haynes.

# Citrus Tristeza Virus Testing

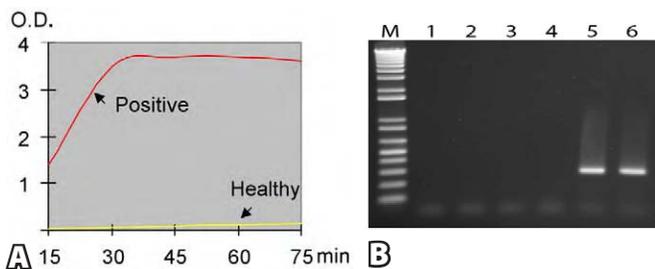
T. Tian & L. Rains



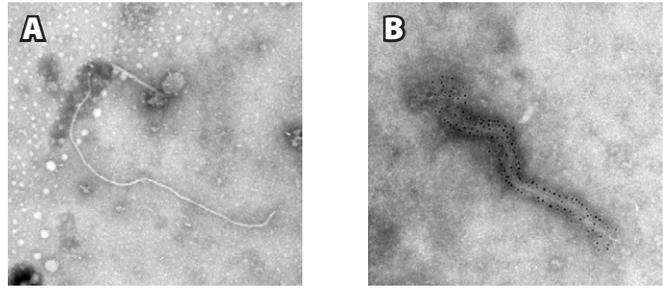
**Figure 1.** Electron micrographs of the virions of *Citrus tristeza virus*. Abundant virions were observed from CTV ELISA positive samples after a simple extraction.

*Citrus tristeza virus* (CTV), one of most important pathogens of citrus, infects all citrus species and is distributed in all citrus growing regions worldwide. Symptoms of the disease range from symptomless to stunting, fruit yield reduction, or quick decline. Different strains of CTV and susceptibility of citrus varieties cause the symptom variation. In California, only mild strains of CTV have been detected. Several aphid species can transmit CTV from infected trees to healthy trees in the field. However, the most important means of spreading the virus is by propagation of CTV infected trees. Therefore, testing citrus propagation sources and monitoring CTV in young citrus trees are very important.

Because of organizational changes within CDFA and CCTEA (Central California Tristeza Eradication Agency), citrus samples collected by our Nursery Program, Fresno and Tulare Counties were tested for CTV for the first time at the Plant Pest Diagnostics Center. We chose to use CTV ELISA reagents from Agdia Inc. as the primary method for CTV detection. ELISA protocol from Agdia was first evaluated using CTV positive and healthy citrus plants provided by CCTEA and critical steps, such as PNP substrate incubation time, under our lab conditions were determined (Figure 2



**Figure 2.** A. Evaluation of incubation time after addition of PNP Substrate for CTV ELISA test; B. RT-PCR using oligo primers specific for the CP region of CTV: M = 1 KB plus DNA size markers, lanes 1 to 4, healthy citrus plants; lanes 5 & 6, CTV infected plants.



**Figure 3.** A. Electron micrograph of CTV virion from purified preparation of Sample B described in Table 1; B. Immunogold labeling of the same virion preparation using antibodies against CTV.

A). In order to insure the accuracy of our detection, we also implemented RT-PCR to confirm all the CTV ELISA positive or questionable samples. We used RT-PCR procedures according to Rosa *et al.* 2007 and Huang *et al.* 2004. Figure 2 B shows an example of RT-PCR amplification of CTV coat protein coding region from CTV infected trees.

Between March 4<sup>th</sup> and June 15<sup>th</sup>, a total of 10,168 citrus samples were tested for CTV; 4,028 from the Nursery Program, 5,439 from Fresno County, and 700 from Tulare County. Only five trees tested positive for CTV by ELISA and were confirmed with RT-PCR. All were from our Nursery Program and identified as potential source trees for propagation. Among these five samples, two were further evaluated because of relatively weak ELISA readings (Table 1). In our first ELISA test, eight leaves from A and B were tested as composite samples following our standard protocol. Then we requested 8 shoots from each tree and tested each shoot individually. ELISA results showed extremely uneven distribution of CTV, as the O.D. reading varied from the level of healthy control (~0.06) to 30.6 and 7.5 times the healthy control, respectively.

During the process of confirmation, we also extracted CTV virions from both samples. We observed the presence of virions and labeled them with CTV antibodies (Figure 3 A & B).

One season of CTV testing allowed us to experience the complexity of CTV detection. Uneven CTV distribution within a tree and nucleotide sequence variation makes it difficult to rely on only one detection method. We believe that using both ELISA and RT-PCR enhanced the reliability of our testing. As we accumulate more experience with CTV work, we will be able to conduct detection assays more efficiently and accurately. This coming season, we will evaluate

Table 1. Uneven distribution of CTV for ELISA weak positive samples. Positive control was from a greenhouse at CCTEA. Samples A and B were collected from the fields for CTV testing.

	1st Test <sup>a</sup>	Leaves from each of 8 shoots of Samples A & B <sup>b</sup>							
Positive	3.146	3.508							
Healthy	0.081	0.063							
Sample A	<b>0.223</b>	<b>0.092</b>	<b>0.074</b>	<b>1.839</b>	<b>0.315</b>	<b>0.060</b>	<b>0.063</b>	<b>0.083</b>	<b>0.067</b>
Sample B	<b>0.538</b>	<b>0.089</b>	<b>0.066</b>	<b>0.343</b>	<b>0.074</b>	<b>0.099</b>	<b>0.450</b>	<b>0.069</b>	<b>0.094</b>

<sup>a</sup>O.D. reading of CTV ELISA test of the 8 leaves for each composite sample.

<sup>b</sup>O.D. reading of CTV ELISA test of individual shoot of samples A and B. Same positive and healthy controls for the 1st test were used.

more PCR primers and continue the procedures from the previous season to ensure the quality of CTV detection.

### ACKNOWLEDGEMENTS

We would like to thank Cindy Wallen, Paul Metheny of Central California Tristeza Eradication Agency for providing positive and healthy controls for this project, and Paul Metheny and MaryLou Polek of Citrus Research Board for helpful discussions on CTV detection assays. We would also like to thank Katie Posis and Matt Waters for participating this project.

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Figure 4. Citrus leaves are pulverized with buffer in ball-mill canisters of a KLEEKO tissue grinder in preparation for ELISA testing for the Citrus Tristeza Virus.



Figure 5. Liquefied leaf tissue is carefully pipetted into cuvettes laid out in the pattern of the wells of an ELISA plate, where it will be dispensed, allowed to react, and eventually read electronically for traces of the virus in the samples.

# Sudden Oak Death Diagnostics

S. Rooney-Latham, C. Blomquist, T. Irving-Walber, M. Negrete, J. Haynes, E. Lovig, M. Soriano, J. Estoque & A. Noguchi

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CDFA's Plant Pest Diagnostics Branch (PPDB) Laboratory continued its *Phytophthora ramorum* diagnostics and scientific support activities, which included the following:

- The lab processed a total of 26,577 samples from both California nurseries and forests.
- A total of 1,858 California nursery sites were inspected and tested for *P. ramorum* in 2009. Of those nurseries, 646 contained regulated material and were sampled at the compliance agreement level (minimum of 40 samples per location). 1,212 nursery sites surveyed did not contain any *P. ramorum* host material, but were still visually inspected for symptoms of *P. ramorum*. Of the 1,858 nursery sites surveyed, 4 were confirmed to have *P. ramorum* positive samples. Of those 4 sites, 2 were located in non-infested counties (i.e. regulated counties) and 2 were in known infested counties (quarantined counties). At the 4 positive sites, 4 plant and 0 soil samples tested positive for *P. ramorum* as follows:
  - Host: *Rhododendron sp.*
  - Host: *Leucothoe fontanesiana*
  - Host: *Sequoia sempervirens*
  - Host: *Camelia sp.*
- The Lab hired 9 seasonal scientific aides to process SOD samples.
- PPDB Lab scientists and technicians participated in various meetings, workshops, and training sessions with USDA to learn protocols and techniques for both *Phytophthora ramorum* and *Phytophthora kernoviae*

- The following samples were the result of a site that was initially determined positive in late 2008 and the investigation continued into early 2009 (this site and resulting samples are not included above) Total follow up samples determined in 2009: 9 plant and 4 soil samples.
  - Host: *Magnolia grandiflora*
  - Host: *Camelia sasanqua*
  - Host: *Rhododendron sp.*
  - Host: *Arbutus unedo*
  - Host: *Laurus nobilis*
  - Host: *Loropetalum chinense* (2 positive samples)
  - Host: *Cinnamomum camphora*
  - Host: *Pieris japonica*
- The Lab temporarily assigned 7 permanent employees to the SOD project, including three exclusively for molecular testing and one exclusively for ELISA testing.
- PPDB Lab staff was called upon routinely to consult with county staff on specific samples and nurseries, instructions for re-sampling, soil sampling, etc.
- Four PPDB Lab personnel successfully performed and passed provisional laboratory tests as part of the APHIS Provisional Laboratory Accreditation process for nested and quantitative PCR.
- Agriculture Biotechnician, Erin Lovig was promoted to Agriculture Biologist and is now a member of Pest Exclusion's *Phytophthora ramorum* group.



Scientific aides process SOD nursery samples by culturing plant material for *Phytophthora ramorum*, and by testing by immunoassay (ELISA) for the presence of *Phytophthora* spp. Samples tested positive by immunoassay are further tested for *P. ramorum* by Real Time

Research papers and projects in 2009 that were associated with SOD diagnostics included:

- Project with Frank Martin USDA, Mike Coffey UCR and others to test *Pr* PCR-based diagnostics using field samples.<sup>1</sup>
- Initial diagnosis of *Phytophthora siskiyouensis* causing a canker disease on alder in California. This species had only previously been associated with stream water in Oregon.<sup>2</sup>
- Collaboration with Mike Coffey and Deborah Mathews (UCR) to initially diagnose *Phytophthora siskiyouensis* on alder in southern California.
- Project with Enviroligix, Portland, ME to develop a new ELISA for detection of *Phytophthora ramorum* and other *Phytophthora* spp.
- Project with Agdia, Elkhardt, IN to develop a new ELISA for detection of *Phytophthora ramorum* and *Phytophthora kernoviae*, as well as an ELISA to replace their existing general *Phytophthora* ELISA test.
- Performed site visits to infested nurseries in regulated and infested counties to educate them on proper cultural practices and how to best manage *Phytophthora ramorum* at their sites.
- Project with Lani Yakabe and Jim MacDonald at UCD Plant Pathology to describe other aerial *Phytophthora* species that are causing disease in California nurseries.<sup>3</sup>
- Continued collaboration with Niklaus Grünwald, ARS for genotyping of California nursery isolates of *Phytophthora ramorum*.
- Scientific paper with Niklaus Grünwald and others regarding the nomenclature of *P. ramorum* lineages.<sup>4</sup>
- Tested many oaks of private residences across the 14 infested counties - the bulk of them coming from Portola Valley in San Mateo County.
- PPDB scientist, Cheryl Blomquist, attended the ribbon-cutting ceremony of the National Orna-

<sup>1</sup> Evaluation of molecular markers for *Phytophthora ramorum* detection and identification: testing for specificity using a standardized library of isolates. Martin, F.N., Coffey, M.D., Zeller, K., Hamelin, R.C., Tooley, P., Garbelotto, M., Hughes, K.J.D., Bilodeau, G.J., Levy, L., Blomquist, C. L., and Berger, P.H. *Phytopathology*: 99 (4). 2009.

<sup>2</sup> Collar rot on Italian alder trees in California caused by *Phytophthora siskiyouensis*. Rooney-Latham, S., Blomquist, C. L., Pastalka, T., and Costello, L. Online. *Plant Health Progress* doi:10.1094/PHP-2009-0413-01-RS. 2009.

<sup>3</sup> Identification and frequency of *Phytophthora* species causing foliar diseases in California ornamental nurseries. Yakabe, L.E., Blomquist, C.L., Thomas, S.L., MacDonald, J.D. *Plant Disease* 93 (9): 883-890. 2009

<sup>4</sup> Standardizing the Nomenclature for Clonal Lineages of the Sudden Oak Death Pathogen, *Phytophthora ramorum*. Grünwald, N.J. et al. *Phytopathology* 99 (7): 792-795. 2009.



Scientific aide Matt Watters extracts DNA from nursery samples that tested positive for *Phytophthora* spp. by immunoassay for further PCR testing.

mentals Research Site at Dominican University of California (NORSDUC) in San Raphael, California October 26, 2009. This USDA-funded facility is being constructed to study nursery plant pathogens in a real-world nursery setting. Kathy Kosta holds the permit for *Phytophthora ramorum* for the site and the CDFA lab provides scientific and diagnostic support to the facility managers. The secure site is the first of its kind with state of the art soil and water containment and treatment.

<http://www.hungrypests.com/blog/?p=276>.

- PPDB scientists assisted with a cursory inspection of the NORSDUC site and surrounding campus for the presence of diseases caused by *Phytophthora ramorum*; samples collected during the survey are being processed by PPDB staff; this survey is ongoing and will be conducted quarterly throughout 2010.
- PPDB scientists provided training, and scientific resources to staff at NORSDUC including collection and processing of samples for *Phytophthora ramorum*, stream and soil baiting techniques, and how to culture and identify *Phytophthora ramorum* using different types of semi-selective media.
- PPDB scientist, Cheryl Blomquist was appointed to the Research Committee for the NORSDUC. Duties will include helping to review proposals for research to be conducted at the site.
- PPDB scientists were invited speakers at the 2009 Forest Pest Council Meeting in Woodland, CA.
- PPDB staff provided documentation, including our lab's soil baiting protocol, to the USDA for review.

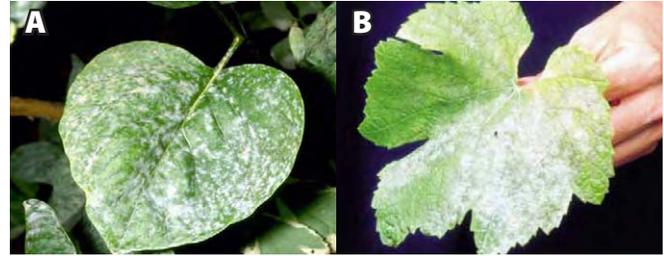
# The Powdery Mildews: An Overview of California's Most Prevalent Yet Biologically Complex Fungi

C. Blomquist and J. White

Powdery mildews are obligate, biotrophic, phytopathogens classified in the phylum Ascomycota and order Erysiphales. They comprise some of the California's most diverse, frequently noticed fungi, infecting approximately 10,000 species of cultivated and native angiosperms worldwide. Signs of powdery mildew diseases are easily recognized by the conspicuous development of abundant mycelium and conidia on the host plant surface which appear white to gray and powdery (Figure 1). In the past decade there have been fundamental changes in our understanding of the Erysiphales, and consequently in the taxonomy of this group. Research on molecular phylogeny using DNA sequencing has resulted in the creation of new genera and the description of many new powdery mildew fungi. As part of this taxonomic revision, familiar species have undergone changes in genus names.

The powdery mildew fungi are obligate parasitic species that generally infect specific host plants within individual plant families (e.g. Cucurbitaceae, Apiaceae, Solanaceae, Brassicaceae,) Individual powdery mildew (PM) species tend to have narrow host ranges. There are, however, different PM species that may infect the same host plant species within a specific plant family (e.g. *Podosphaera xanthii* and *Golovinomyces cichoracearum* infect Cucurbitaceae ) (Figure 2). Conversely, and less commonly, a PM species may infect more than one host belonging to completely different families (e.g. *Leveillula taurica* infects both onion and tomato). Identification of the host plant species is an important consideration for PM species determination.

Powdery mildews are a very diverse group of fungi that cause economic loss and harm to a wide range of agricultural crops including grape, onion, tomato, cucumber, watermelon, pepper, sugar beet, strawberry, fruit trees, small grains, hops, and sunflower. Many ornamental and culinary herb crops are also susceptible to infection. Historically the PMs in North America, except those infecting the most important agricultural hosts, have not been well described. One of the reasons was that the powdery mildew experts worked in Europe and Japan, not North America. This has changed recently with Dr. Dean Glawe in Washington State taking on this important group as his area of specialty. Over the last several years, Dr Glawe has described the PMs in the Pacific Northwest and developed an on-line key for powdery mildew identification. Due to his work and the work of collaborators, new mildews and mildew hosts are being identified every year in the



**Figure 1.** Powdery white mycelium and conidia developing on leaf surfaces is a typical sign of powdery mildew disease. **A.** *Erysiphe syringae* infecting *Syringa vulgaris* (common lilac). **B.** *E. necator* severely infecting *Vitis* sp. (Chardonnay grape).



**Figure 2.** Greenhouse powdery mildew infections of cucumber are a serious problem. Both *Podosphaera xanthii* and *Golovinomyces cichoracearum* infect the Cucurbitaceae plant family and may infect the same host plants.

United States including weed hosts such as fringed willow-herb, poison-hemlock (See attached Koike article), cut leaf geranium, and garlic mustard. PM species that infect weeds and native plants are especially important to identify and characterize if they share hosts with economically important crops. PM-infected weeds and native plants can provide an initial and continuing source of inoculum for neighboring agricultural and nursery crops.

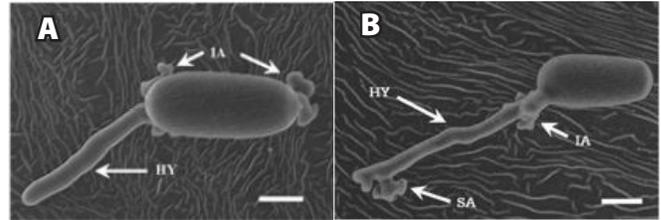
Symptoms of powdery mildew infection vary depending on the species, host and environmental conditions. Common signs on a host plant include the conspicuous hyphae and powdery conidial production on leaf surfaces, stems, flowers, and fruits. This growth is usually whitish and sometimes turns grayish to yellow or light brown with age. Moderate to severe infections can cause leaf disfiguration, distortion and scarring of leaves, stems, petioles and buds. Fruit can also be infected directly as in the case of *Erysiphe neca-*



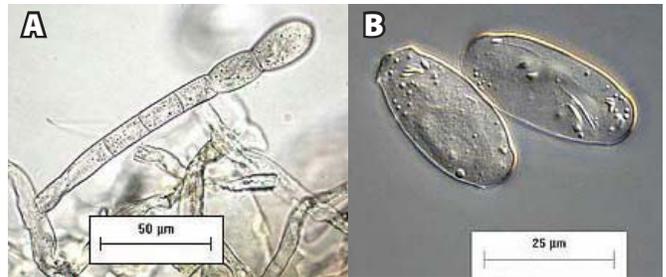
**Figure 3.** *Erysiphe necator* powdery mildew infecting fruit of *Vitis* sp. (grape). Severely damaged fruit often splits open. When berries of purple or red cultivars become infected during ripening the fruit fails to color properly resulting in blotchy appearance and less marketability of whole fruit.

tor on grape (Figure 3). With fruits such as muskmelon and honeydew severe foliar infections of powdery mildew can result in decreased fruit sugar content, reducing fruit quality and marketability.

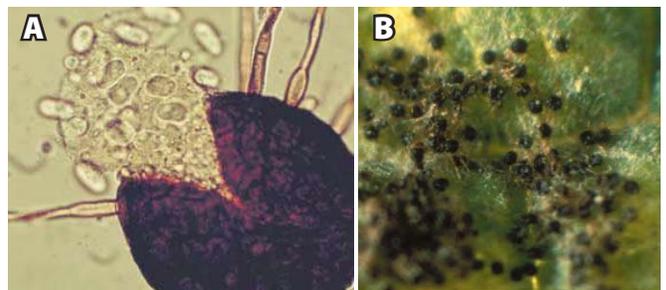
Initial infection starts after a spore germinates on a susceptible host and vegetative hyphae grows superficially on the plant epidermal surface. Appressoria (Figure 4) are specialized lateral outgrowths of hyphae that function by attaching mycelium firmly to host tissue. Appressoria form from the vegetative hyphae and initiate the production of haustorial feeding/infection structures which degrade and penetrate the plant cells. Mycelia grows and develops into conidiophores which produce conidia (spores). Conidiophores develop either on the plant surface or emerge thru plant stomata producing single conidia or conidial chains (Figure 5). Conidia are usually produced on the plant and released during the growing season. At the end of the growing season the powdery mildew fungus may produce sexual spores, known as ascospores, in a sac-like ascus enclosed in a fruiting body, which forms unique types of surface appendages, called a chasmothecium (ascocarp). Ascospores are released when a crack develops in the ascocarp wall (Figure 6). The appendages may aid in attaching the fruiting bodies to hosts, particularly to the bark of woody plants, where they may overwinter. This fungal state may over summer also when green host tissue is not available. *Erysiphe necator*, formerly *Uncinula necator*, grape powdery mildew, survives and overwinters as mycelium in dormant grapevine buds and as chasmothecium in the Central Valley of California. Powdery mildews are polycyclic diseases that impair photosynthesis, stunt growth, and increase the rate of host tissue senescence. In regions with severe winters, both anamorphic and teleomorphic stages commonly occur in infection cycles, but in regions with mild winters such as the Pacific Northwest and much of California, teleomorphic states may occur less frequently.



**Figure 4.** Scanning electron micrographs A. Initial appressoria (IA) formed at both poles of a conidium. B. Both initial and secondary appressoria (SA) form from hyphae (HY) on the leaf surface. *Erysiphe pulchra*, powdery mildew of Dogwood (*Cornus florida* L.)



**Figure 5.** A. Conidiophore developing from vegetative hyphae on the leaf surface. This species of powdery mildew, *Sphaerotheca dipsacearum* on *Dipsacus sylvestris* (noxious weed host) produces conidial chains and is formed on a cylindrical shaped foot-cell. B. Conidia (spores) that exhibit presence of fibrosin bodies (comma or rod-shaped) are characteristic of this particular species.



**Figure 6.** *Erysiphe necator*, grape powdery mildew teleomorphic state. A. Chasmothecium (ascocarp) fruiting body, exhibiting surface appendages, releasing ascospores. B. Advanced severe infection on *Vitis* sp. exhibiting typical mature dark chasmothecia on lower leaf surface. Immature fruiting bodies are usually a light to dark orange color.



**Figure 7.** Conidiophores emerging from leaf stomata. *Oidiopsis sicula* (anamorph state of *Leveillula taurica*) powdery mildew on *Capsicum annuum* (pepper)

During most of the agricultural growing season a powdery mildew pathogen reproduces by air-dispersed conidia. One of the reasons that PM diseases are more common and severe in warm, dry climates is that spores can germinate, infect and disperse in the absence of free water on the leaves if the relative humidity is high enough. Conidia are released on a daily cycle from midmorning to midday. Optimal spore development and dissemination tend to be associated with relatively low humidity, surface dryness and high temperatures. Available water from the host plant, guttation, dew, rain and limited overhead irrigation increases host susceptibility to infection. Conidial production is more prevalent in shaded areas as in powdery mildew of cucumber, *Podosphaera xanthii*, where infection increases under the shade of the large overlapping leaves in greenhouse grown plants.

Currently there are five major tribes and approximately 17- 20 described genera within each of the clades classified in the order Erysiphales. The tribes include Erysipheae, Golovinomyceteae, Cystothecae, Phyllactiniaee, and Blumeriaceae. These taxonomic classifications are based on rDNA and ITS sequencing, morphological characters, life cycle characteristics and plant hosts. In the lab the Erysiphales can be identified by their anamorphic (asexual) or teleomorph (sexual) forms. Anamorphs are identified by the type of conidial development, singly or in chains, size, shape, and color of conidia, appressoria and conidiophore foot cell morphology, and presence or absence of distinct fibrosin bodies within conidia. Fibrosin bodies are refractive structures in conidia that are visible under light microscopy. Teleomorphs (sexual state) are identified by chasmothecial (ascocarp) morphology. Characteristics would include size and shapes of attached appendages, the number, size and shape of ascospores and spore release mechanisms. Contrary to most fungi, morphology of the anamorphic state is now used to distinguish between genera and teleomorph morphology is used to identify species within specific genera in a group. Host family specificity and geographical distribution are also important for correct species identifications.

Laboratory analysis of powdery mildew fungal species begins with identification of the host plant, followed by examination of symptomatic tissue with a compound microscope. for signs of the pathogen such as conspicuous white to gray powdery patches of mycelia, chlorotic to necrotic tissues/lesions/spots with characteristic hyphae, and fungal fruiting structures including conidiophores and chasmothecial ascocarps. Morphological characters of both the anamorph and teleomorph states may be examined. Formation of conidiophores producing conidia (spores) singly or in chains (multiples), size, shape, color of conidia, development of superficial hyphae on host surface or internal hyphae (endophytic) within host tissue producing conidiophores that emerge thru stomata (as in *Leveillula taurica* on tomato),

morphology of appressoria as lobed, nipple-shaped or non-existent, characteristics of conidiophore foot cells (inflated or cylindrical base and size), presence or absence of fibrosin bodies within conidia, are some common characteristics of the anamorphic state used for determinations. Size and shape of the chasmothecial fruiting structure, number, size, shape and color of ascospores and asci produced, type of ascocarp appendages (e.g. acicular or mycelioid, dichotomous branching, etc.), as well as ascocarp cell wall structure, are all important characteristics of a teleomorph state. Monographs, new reports and an online database named WSU Erysiphales Database are used to assist in pathogen determinations. At the Plant Pest Diagnostics Branch, are also working on being able to obtain rDNA sequences for PMs. In the past many PM specimens sent to the Plant Pathology laboratory were described as *Oidium sp.* because few descriptions of specific anamorphic PMs were available. Look for that to change this year. We will be increasingly able to put full names on PMs and add new pathogens to our pest ratings list.

During the past decade there have been fundamental changes in our understanding of powdery mildews. Molecular phylogenetic research has shown that Erysiphales belong to the Leotiomycetes (inoperculate discomycetes) rather than Pyrenomycetes or Plectomycetes as previously thought. Analysis of rDNA sequences indicate that identification of major lineages and classification are more closely correlated with anamorphic (asexual) morphology rather than by teleomorph (sexual) morphology. This change in taxonomy will enable us at the Plant Pest Diagnostics branch to give complete determinations on more PM species because on most of the samples we receive; only the asexual state is present.

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Figure 1B. Bob Emmett, from “Powdery Mildew in Wine Grapes in Western Australia”, by Diana Fisher and Dr. T. Wicks. Bull. No. 4575, ISSN 1448-0352, May 2003

Figure 2. Charles Averre, North Carolina State U., [Bugwood.org](http://Bugwood.org)

Figure 3. University of Georgia, Pl. Path. Archive, [Bugwood.org](http://Bugwood.org).

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Figure 6 A. Bob Emmett from “Powdery Mildew in Wine Grapes in Western Australia”, by Diana Fisher, and Dr. T. Wicks. Bull. No. 4575, ISSN 1448-0352, May 2003.

Figure 6B. University of Georgia Plant Pathology Archive, [Bugwood.org](http://Bugwood.org).

Figure 7. Photomicrograph by Cheryl Blomquist, Plant Pathologist, CDFA, CPPDB, Plant Pathology laboratory

## Powdery Mildew Fungi Identified in 2009

Pathogen	Rating	Common Name	Host	County	City
<i>Erysiphe necator</i>	C	Grape powdery mildew	<i>Vitis vinifera</i> ; <i>Vitis spp.</i>	Lake	Kelseyville
<i>Leveillula taurica</i>	C	Powdery mildew	<i>Lycopersicon esculentum</i>	Fresno	Firebaugh, Three Rocks
<i>Microsphaera berberidis</i>	C	Mahonia powdery mildew	<i>Mahonia fremontii</i> , <i>M. repens</i> , <i>M. aquifolium</i>	Riverside	San Jacinto
<i>Erysiphe syringae</i>	C	Lilac powdery mildew	<i>Syringa sp.</i> (Lilac)	Stanislaus	Patterson
<i>Oidium sp.</i>	C	Powdery mildew	<i>Brassica sp.</i> (Mustard)	Colusa	Maxwell
<i>Oidium sp.</i>	C	Powdery mildew	<i>Lycopersicon esculentum</i>	Fresno	Huron
<i>Oidium sp.</i>	C	Powdery mildew	<i>Verbena sp.</i>	Imperial	El Centro
<i>Oidium sp.</i>	C	Powdery mildew	<i>Rosa sp.</i>	Riverside	Palm Springs
<i>Oidium sp.</i>	C	Powdery mildew	<i>Cucumis melo</i>	San Joaquin	Acampo
<i>Oidium sp.</i>	C	Powdery mildew	<i>Salvia spathacea</i> (Sage)	Santa Barbara	Santa Barbara
<i>Oidium sp.</i>	C	Powdery mildew	<i>Penstemon sp.</i> (Beard Tongue)	Santa Barbara	Santa Barbara
<i>Oidium sp.</i>	C	Powdery mildew	<i>Nandina sp.</i> (Heavenly bamboo)	Santa Clara	San Jose
<i>Oidium sp.</i>	C	Powdery mildew	<i>Pyrus sp.</i>	Santa Cruz	Watsonville
<i>Oidium sp.</i>	C	Powdery mildew	<i>Cucurbita maxima</i>	Solano	Davis
<i>Oidium sp.</i>	C	Powdery mildew	<i>Cucumis melo</i>	Solano	Davis
<i>Oidium sp.</i>	C	Powdery mildew	<i>Helianthus annuus</i>	Solano	Dixon
<i>Oidium sp.</i>	C	Powdery mildew	<i>Helianthus annuus</i>	Sutter	Glenn
<i>Oidium sp.</i>	C	Powdery mildew	<i>Capsicum annuum</i>	Yolo	Not listed
<i>Oidium sp.</i>	C	Powdery mildew	<i>Citrullus lanatus</i>	Yolo	Colusa
<i>Oidium sp.</i>	C	Powdery mildew	<i>Cucurbita pepo</i>	Yolo	Williams, Woodland
<i>Oidium sp.</i>	C	Powdery mildew	<i>Helianthus annuus</i>	Yolo	Woodland
<i>Oidium sp.</i>	C	Powdery mildew	<i>Cucumis melo</i>	Yuba	Glenn
* <i>Oidiopsis sp.</i>	C	Powdery mildew	<i>Lisianthus sp.</i>	San Luis Obispo	Arroyo Grande
* <i>Oidiopsis sicula</i>	C	Powdery mildew	<i>Capsicum annuum</i>	Yolo	Woodland
<i>Podosphaera xanthii</i>	C	Powdery mildew	<i>Cucurbita maxima</i> (Pumpkin)	Solano	Dixon

\*Asexual stage of *Leveillula taurica*.

table prepared by J. White

## Selected Photographs of Powdery Mildews

(Includes 2009 PPDB Detections and other Interesting Powdery Pathogens)



Figure 1. *Leveillula taurica*, powdery mildew on *Allium cepa* (onion). A. Early infection symptoms appear on older leaves as whitish powdery lesions late in the growing season. B. As the infection progresses the leaves become chlorotic, necrotic and exhibit distortion. Mycelium (hyphae) develop on the epidermal surface or intercellularly (endophytic) among mesophyll cells producing conidiophores within host tissue which emerge thru leaf stomata. Two types of conidia (spores) are produced (dimorphic) characteristic of this fungus. *L. taurica* has a wide host range including Solanaceous crops such as tomato



Figure 2. *Leveillula taurica*, powdery mildew on tomato (*Lycopersicon esculentum*). Powdery mildew commonly infects tomatoes grown in greenhouses and high tunnels, but may be detected on field grown tomatoes during dry summers. Profuse white to gray mycelium, necrosis and blighting of tomato leaves are typical symptoms.



Figure 3. *Erysiphe necator* powdery mildew on *Vitis* sp. (grape). Typical sign of grape powdery mildew disease development where flag shoots (stunted shoots) and shaded areas are characteristic infection sites with ash-gray to powdery white mycelia growth. Grape PM is an economically important persistent fungal problem and if uncontrolled it may cause serious crop losses and impair wine quality.



Figure 4. *Erysiphe necator* grape powdery mildew. Early season infections on canes produce typical blackish lesions on immature canes (upper) which develop reddish-brown on the mature canes (lower). Losses caused by PM may include leaf, shoot and stalk damage which interferes with vine metabolism and fruit quality; infected flowers with poor fruit set and reduced yield; berry cracking/splitting which predisposing plants to other infections; and general reduction in vine vigor and productivity.

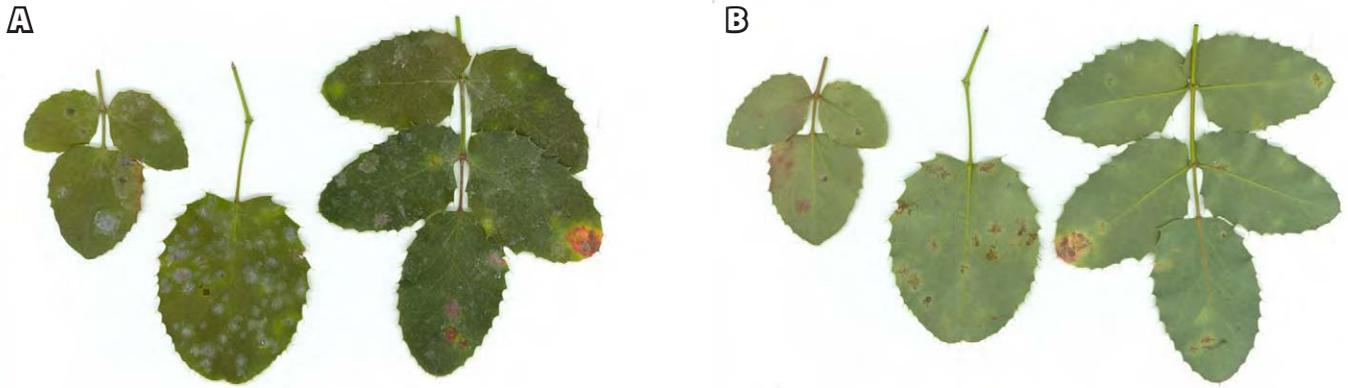


Figure 5. *Microsphaera berberidis* powdery mildew of *Mahonia* sp. Powdery mildew was identified by the CPPDB Plant Pathology laboratory from three species of *Mahonia*: *M. fremontii*, *M. repens*, and *M. aquifolium* from Riverside County in 2009. A. Typical symptoms of powdery whitish to light gray mycelial growth on the upper leaf surface. B. chlorotic/necrotic lesions caused by PM infection exhibited on lower leaf surface.

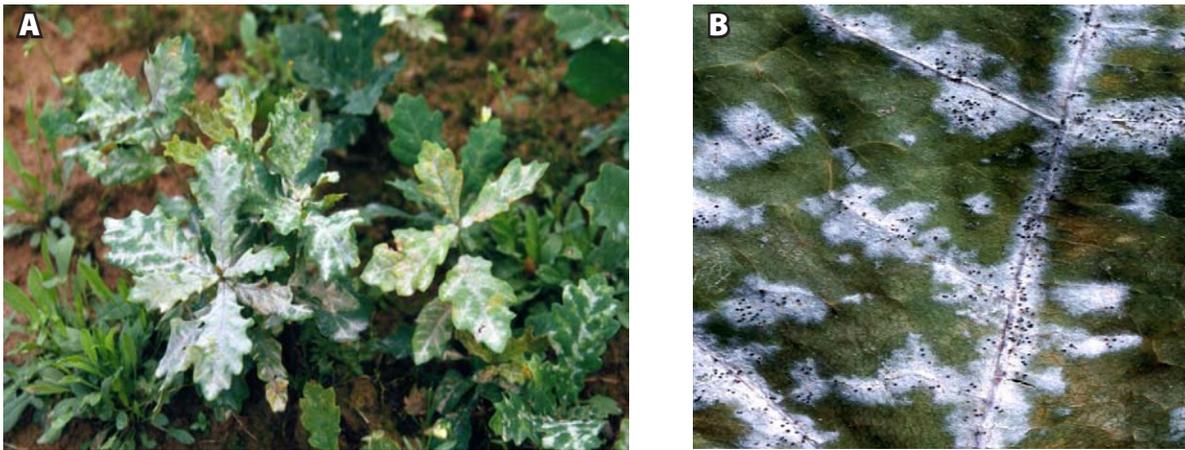


Figure 6. *Erysiphe alphitoides* powdery mildew on *Quercus* spp. (Fagaceae family). A. Typical signs of powdery white mycelium on oak leaf surfaces. Native oaks growing wild among the weeds may serve as sources of inoculum to adjacent agricultural fields. B. Black chasmothecial fruiting structures of the fungal sexual state.

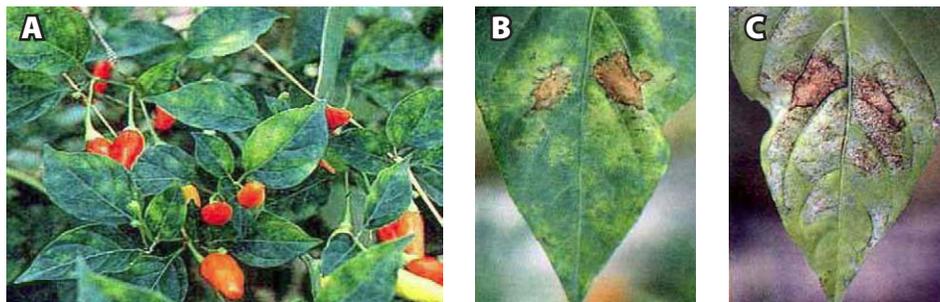


Figure 7. *Oidiopsis sicula* (anamorph state) powdery mildew of *Capsicum annuum* (pepper). (Note the teleomorph state is *Leveillula taurica*). A. Typical symptoms of infection on upper leaf surfaces of a pepper plant are chlorotic spots that coalesce to a blotchy appearance. Eventually the leaves will turn necrotic and defoliate thus causing reduction in crop yields and fruit quality. B. Yellow (chlorotic) blotches and necrotic areas develop on upper leaf surface. C. Powdery white mycelium growing in affected leaf areas on lower leaf surface. Development of *O. sicula* is favored by warm (approx. 25degrees C) and dry (less than 80% RH) days followed by humid (approx greater than 85% RH) nights. Young plants are less susceptible than older plants in the case of this PM species on pepper.

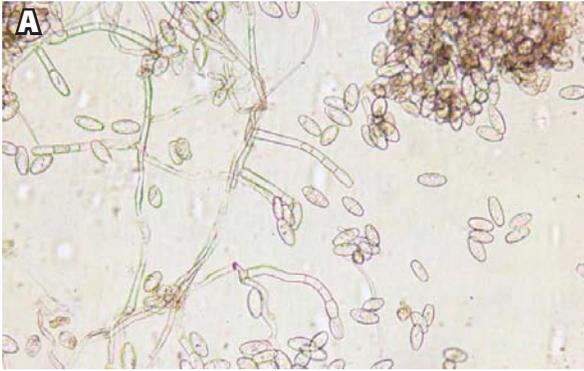


Figure 8. *Podosphaera xanthi* (syn. *Sphaerotheca fuliginea*) powdery mildew on *Cucumis sativus* (cucumber). Conidia are produced in chains, hyaline (clear), ellipsoid to ovoid or doliform, developing from unbranched conidiophores with cylindrical foot cells. Some of the morphological characteristics of the fungus that can be identified with the compound microscope. A. photomicrograph 200x, clear tape water mount, B. 400x.

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Figure 8. Charles Averre, North Carolina State University, [Bugwood.org](http://Bugwood.org).

# Update on Powdery Mildew Diseases From the Central Coast Region of California

Steven T. Koike, University of California Cooperative Extension, Monterey County

Powdery mildew is perhaps one of the most common and readily diagnosed diseases of plants. The familiar white to gray mycelial and conidial growth is well known to almost everyone. In fact, this extensive familiarity may cause many people to overlook powdery mildews, fail to recognize undocumented powdery mildew-host plant cases, and fail to remain current regarding powdery mildew taxonomy and pathogen names. In recent years, a number of powdery mildew developments (Table 1) have taken place on the central coast region of California.

## Recently described powdery mildews

On a number of plants, previously unreported powdery mildew diseases have been observed and described. All of these cases appear to be first-time reports for the state. For a few of these diseases, they appear to be first-time reports for North America. Precise identification of the pathogen and the completion of other tests, such as pathogenicity tests and host range evaluations, are needed to fully appreciate the importance of such reports. For example, the recent documentation of powdery mildew on poison-hemlock weed (Figure 1) provided us with epidemiological links to powdery mildew



Figure 1. *Erysiphe heraclei*, powdery mildew on leaves of poison-hemlock (weed) growing in coastal California, first report of this powdery mildew in North America. Identification and photograph by S.T. Koike and D. A. Glawe.

Table 1. Recent Powdery Mildew Developments from the Central Coast Region of California from 2007 to 2009

### 1. Recently Described Powdery Mildews for California

Host	Powdery Mildew
lamb's ear	<i>Neoerysiphe galeopsidis</i>
matilija poppy	<i>Leveillula taurica</i>
periwinkle	<i>Golovinomyces orontii</i>
rosemary	<i>Oidium</i> spp. (ID pending)
fringed willowherb (weed)	<i>Podosphaera epilobii</i>
poison-hemlock (weed)	<i>Erysiphe heraclei</i>
cutleaf geranium (weed)	<i>Oidium</i> spp. (ID pending)

### 2. Increased Powdery Mildew Severity or Crop Damage

Host	Powdery Mildew
celery	<i>Erysiphe heraclei</i>
lettuce	<i>Golovinomyces cichoracearum</i>
pepper	<i>Leveillula taurica</i>

### 3. Chronic Powdery Mildew Concerns

Host	Powdery Mildew
grape	<i>Erysiphe necator</i>
strawberry	<i>Podosphaera aphanis</i>

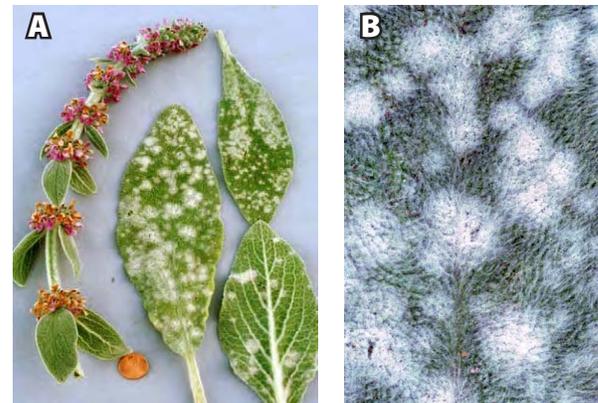


Figure 2. A. Signs of powdery mildew on *Stachys byzantine* (Lamb's Ear) caused by *Neoerysiphe galeopsidis*. B. Disease signs of white to grayish patches of mycelia on leaf surface. Observed in Salinas, Monterey County. First report in North America. Identification and photograph by S.T. Koike and D. A. Glawe.

of celery. Along with confirming that poison-hemlock and celery are hosts of the same mildew, we found that poison-hemlock isolates can cause disease on celery but apparently not on parsley. Diseased weeds may therefore be an inoculum source for powdery mildew of celery.

## Increased powdery mildew severity or crop damage

For some vegetable crops, powdery mildew has been observed for many years but never caused any concern to growers. However, in recent years some of these powdery mildews are becoming more severe and are starting to cause crop damage. Lettuce and celery crops were rarely affected by powdery mildew until recently. For pepper, powdery

mildew severity goes up and down throughout the years; currently, disease levels have been moderate to high.

### Chronic powdery mildew concerns

For crops such as grape and strawberry, powdery mildew is an annual concern and is always an economic threat to production. Currently, grape and strawberry continue to

be plagued by powdery mildew and growers must rely on integrated pest management practices to obtain control of the problem. It is notable that these two crops are examples of name changes of the pathogens: grape powdery mildew caused by *Erysiphe necator* (formerly *Uncinula necator*); strawberry powdery mildew caused by *Podosphaera aphanis* (formerly *Sphaerotheca macularis*).

## Seed Health Testing

Y. Zhang and T. Tidwell

The Seed Health Testing laboratory of California Department of Food and Agriculture performs seed health tests on samples officially drawn and sealed by the Agricultural Commissioner's office, which acts on behalf of USDA APHIS. Results from these seed health tests help fulfill the phytosanitary requirements of foreign and domestic trading partners for various agricultural seeds and propagules.

In 2009, the seed health testing laboratory staff conducted 133 seed health tests. This figure was significantly less than the 2008 total of 569 tests. Samples submitted for testing originated from 14 different clients in California and other states.

The tests performed by the Seed Health Testing Laboratory involved 13 different types of agricultural or horticultural seed (Table 1), some of which are non-treated, and some

**Table 1. Types of seed tested for seed borne plant pathogens in the year 2009.**

Seed	Number	Seed	Number
Alfalfa	9	Onion	37
Barley	6	Squash	4
Beet	2	Spinach	1
Cabbage	2	Tomato	4
Cucumber	4	Watermelon	3
Eggplant	1	Wheat*	56
Lettuce	4		

\*Wheat sample total includes 53 seed samples tested for *Tilletia indica* as part of the National Karnal Bunt Survey. Other grain species also occasionally require testing for *T. indica*

which are treated with various chemicals. The majority of the tests were performed on Wheat and Onion seed. These 2 crops alone accounted for 70% of the 2009 seed health tests. Eleven other plant species accounted for the other 30% of the seed tests. Seed Health Testing laboratory staff conducted tests to detect a total of 21 different seed borne pathogens, which included 17 fungi, 1 bacterium, 2 viruses and 1 viroid (Table 2).

**Table 2. Pathogens for which seed was tested at the Plant Pest Diagnostics Center in 2009.**

Pathogen	Number
<b>Fungi</b>	
<i>Aspergillus niger</i>	1
<i>Botrytis allii</i>	30
<i>Botrytis byssoidea</i>	1
<i>Cladosporium cucumerinum</i>	2
<i>Erwinia tracheiphila</i>	2
<i>Fusarium solani</i>	2
<i>Phytophthora capsici</i>	4
<i>Puccinia allii</i>	1
<i>Sclerotinia spp.</i>	2
<i>Septoria lactucae</i>	3
<i>Tilletia controversa</i>	1
<i>Tilletia indica</i>	60
<i>Uromyces betae</i>	2
<i>Urocystis cepulae</i>	2
<i>Urocystis agropyri</i>	1
<i>Verticillium albo-atrum</i>	9
<i>Verticillium dahliae</i>	1
<b>Bacteria</b>	
<i>Xanthomonas campestris pv.</i>	3
<b>Viruses</b>	
Squash mosaic virus	2
Tomato ringspot virus	2
<b>Viroids</b>	
Potato spindle tuber viroid	2

# Nursery Annual Survey of Deciduous Fruit Trees, Nut Trees, and Grapevines

Y. Zhang, D. Marion, C. Banzhof, J. Estoque & A. Ballesteros

The California Fruit Tree, Nut Tree and Grapevine Improvement Advisory Board (IAB) allocates funds each year for survey of deciduous fruit tree, nut tree and Grapevines for a range of viruses of concern by industry. These trees are part of the registered increase block that are used to produce planting material for the industry. This survey is carried out by the staff of the Nursery, Seed and Cotton Program of the CDFA Pest Exclusion branch, including Plant Pathologists, field Agricultural Biologists, and Seasonal Agricultural Aides.

A total of 50,363 stone fruit samples were tested for two ilarviruses, Prune dwarf virus (PDV) and Prunus necrotic ringspot virus (PNRSV) during the calendar year 2009. These samples were collected from 3 nurseries in the Sacramento district and 16 nurseries in the Fresno district. Tests were performed in a combination Enzyme-Linked Immunosorbent Assay (ELISA) for both viruses. Most of the samples were from the nursery registration and certification program (42,190), of which 170 (0.40%) tested positive for PDV and/or PNRSV. There were also 8,173 service samples tested, of which 80 (0.98%) were positive for PDV and/or PNRSV. Each positive sample was further tested by ELISA to determine which specific virus is responsible for the infection. The result revealed that 58 (23.2%) were infected with PDV, 181 (72.4%) with PNRSV, and 11 (4.4%) with mixed infection of both viruses (Figure 1).

During the month of May 2009, Grapevines in the nursery program were surveyed for Grapevine fanleaf virus (GFLV) for 20 participating nurseries: four in Redding, six in Sacramento, and ten in the Fresno district. Each sample was composed of young shoot tips from five vines and tested by ELISA. The virus was not detected from any of the 1182 samples tested.

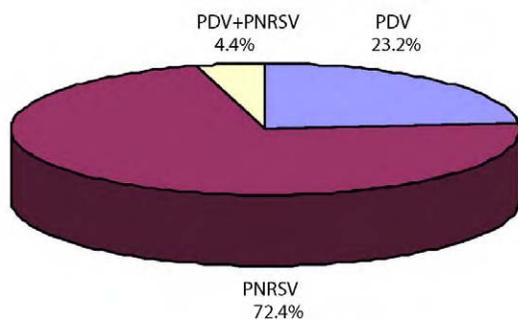


Figure 1. Percent of specific virus infection of positive samples.



Technical staff process stone fruit leaves for testing as part of the California Fruit Tree, Nut Tree and Grapevine Improvement Advisory Board (IAB) program to produce virus-free planting material for the industry

Grapevines were also surveyed for Grapevine leafroll associated viruses 2 (GLRaV2) and 3 (GLRaV3) from September to November. A total of 3534 samples from fifteen participating nurseries (1 in Redding, 6 in Sacramento, and 8 in Fresno district) were tested by ELISA. None of these samples tested positive for GLRaV 2, but 77 samples from the Fresno district tested positive for GLRaV 3. Removal of infected vines and delimitation surveys of adjacent areas were advised.

The number of trees surveyed by the Nursery Registration and Certification (R&C) program has increased significantly over the past two decades, from less than 10,000 trees in 1991 to more than 50,000 trees in 2009 (Figure 2). The number of infected trees in the R&C program have been kept in a very low level of about 0.5% while the number of infected trees not in the R&C program (service samples) were much higher from about 1% to 7% (figure 3). This program has played a very important role in supporting the California nursery and agriculture industry.

## Acknowledgements

This project is supported by the California Fruit Tree, Nut Tree, and Grapevine Improvement and Advisory Board, Pest Exclusion biologists, and participating nurseries.

Figure 2. Number of trees tested by ELISA each year.

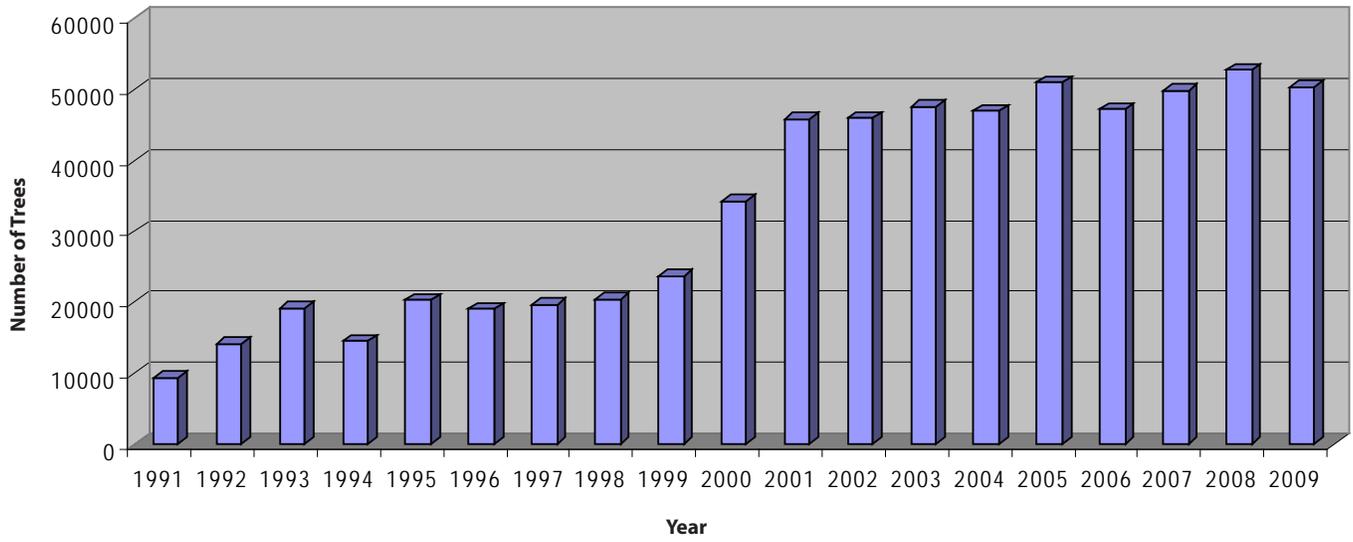
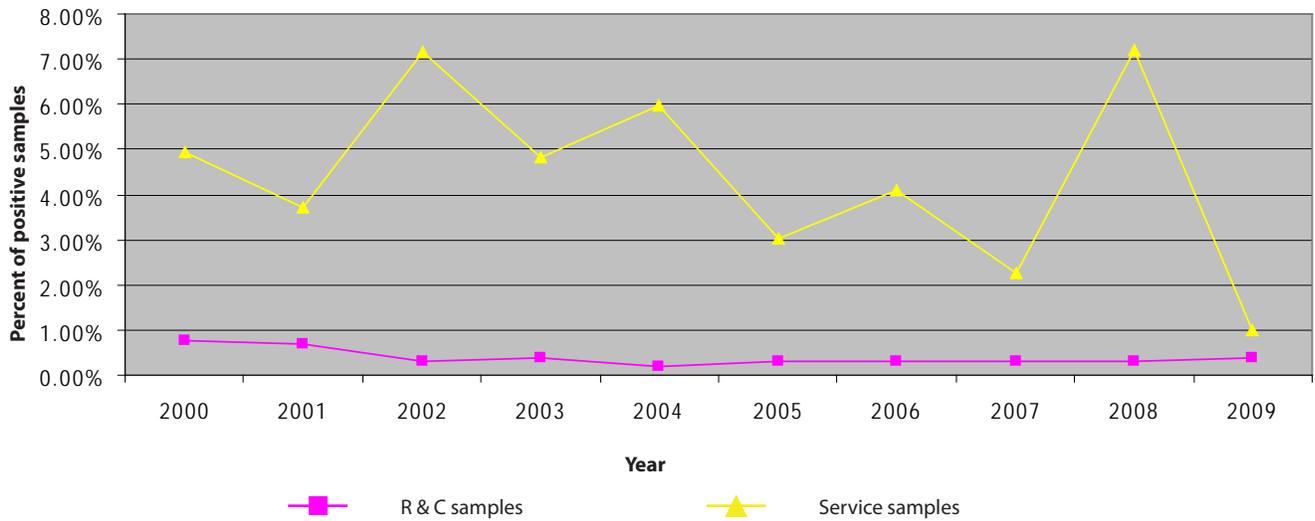


Figure 3. Detection of PDV/PNRSV from R&C and service samples



# NEMATOLOGY LABORATORY REPORT

2009 NEMATOLOGY LABORATORY STAFF

## PLANT NEMATOLOGISTS

John Chitambar  
Ke Dong  
Sergei Subbotin

## TECHNICAL STAFF

René Luna

## SCIENTIFIC AIDES

Matt Beyers  
Myra Ballestros  
Duanna Challenger  
Rowena DeLeon  
Courtney O'Brien  
Kristi Sanchez

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The Nematology Laboratory of the Plant Pest Diagnostics Branch (PPDB) provides diagnostic support for the protection of California's agricultural industry against economically important plant parasitic nematodes associated with plant disease. Based largely on the nematode diagnostic support provided by the Laboratory, government agencies are able to:

- Provide nursery certification and standards of pest cleanliness.
- Prevent the introduction and spread of regulatory significant pests.
- Provide phytosanitary certification of foreign export commodities.

## ROLES AND RESPONSIBILITIES

The general responsibilities of PPDB Nematologists include the following four major areas:

### Diagnostics:

Processing of soil and plant tissue samples for nematode extraction and the identification of plant parasitic nematodes using precise and appropriate scientific techniques.

### Consultations:

Expert technical assistance to agricultural counties, CDFA Nursery, Seed and Cotton, and External and Internal Quarantine phytosanitary certification programs, agricultural industry, growers, University of California, USDA, other state agencies, Western Plant Pest Diagnostics Network, and private citizens.

### Training:

Educational classes provided to California agricultural county and state biologists, regulatory inspectors as well as other scientific and non-scientific communities.

### Research:

In Nematode diagnostics, and nematode extraction techniques. In addition, the Nematologists conduct individual and collaborative research projects with national and international Nematologists.

## Nematology Laboratory Staff

The Nematology Laboratory comprises three Senior Nematologists, one Senior Agricultural Biological Technician and a support staff of five Scientific Aides.

## Specific Responsibilities And Expertise Of Individual Nematologists

### DR. JOHN J. CHITAMBAR

Handling of high-risk external and internal quarantine (including seed) samples for nematode extraction. Supervises laboratory staff on quarantine sample processing techniques. Provides training in nematode sampling, sample handling and processing, and preliminary nematode identification. Coordinates, plans and directs laboratory activities associated with potato cyst nematode (*Globodera pallida*, *G. rostochiensis*), and white tip of rice nematode (*Aphelenchoides besseyi*) surveys. Provides expert technical assistance to Federal and State nematode permit evaluations, also State pest ratings evaluations and assignments. Assesses and develops morphological diagnostics tools, using light microscopy, scanning electron microscopy, transmission electron microscopy. Expertise in diagnoses of the following nematode groups: burrowing nematodes (*Radopholus similis*, *Radopholus* spp.), reniform nematodes (*Rotylenchulus reniformis*, *Rotylenchulus* spp.), stem and bulb nematode (*Ditylenchus dipsaci*), sheath nematodes (*Hemicycliophora* spp.), and ring nematode (*Criconemella* spp.)

### DR. KE DONG

Plans, develops guidelines, directs and coordinated laboratory diagnostic activities associated with the State-wide Nematode Survey. Works with CDFA biologists and agricultural counties to decide on geographical regions and target plant hosts for survey. Maintains and upgrades the internet-based CDFA Pest and Damage Record (SISPDR) system for the nematology program. Supervises temporary employees to work on survey sample processing. Diagnosis

of root-knot nematode species (*Meloidogyne* spp.) using protein and isoenzymes analysis and PCR techniques. Expertise in diagnoses of the following nematode groups: root-knot nematodes (*Meloidogyne* sp.), needle nematodes (*Longidorus* spp. Plant virus vectors), dagger nematodes (*Xiphinema* spp. Plant virus vectors), and stubby-root nematodes (*Paratrichodorus* spp. Plant virus vectors).

**DR. SERGEI SUBBOTIN**

Handling of Nursery samples for nematode extraction. Assesses and develops new molecular nematode diagnostic tools and techniques: PCR-RFLP, PCR with specific primers, and Real-time PCR, DNA bar-coding of Californian plant parasitic nematodes, DNA probes. Provides training in application of molecular techniques for nematode diagnostics. Collaborates with European Plant Protection Organization (EPPO) on nematode diagnostics. Expertise in diagnoses of the following nematode groups: cyst-forming nematodes (Heteroderidae), lesion nematodes (Pratylenchidae), sting nematode (*Belonolaimus* spp.), and pinewood nematode (*Bursaphelenchus* spp.), gall-forming nematodes (Anguiniidae and stunt nematodes (*Tylenchorhynchus* spp.).

**Table 1 Nematode Sample Load: broken down by program and source**

<b>Nematode Detection Program</b>	<b>No. of samples</b>
<b>Quarantine (total)</b>	<b>2,546</b>
Incoming External Quarantine	1,813
Border Station Interceptions	82
Export Phytosanitary Certification	642
Others	9
<b>Nursery (total)</b>	<b>1,401</b>
Registration and Certification (includes garlic & strawberry)	1,124
Nematode Control (includes stone-fruit & nut trees)	273
Others	4
<b>Commercial (total)</b>	<b>3,917</b>
Potato Cyst Nematode Survey	3,734
Golden Nematode Trace-forward Survey (2008 balance)	8
CAPS California Nematode Survey (05-08 deficit samples)	120
Assistance to other agencies	31
Others	24
<b>Total</b>	<b>7,864</b>

# Detection of Plant Parasitic Nematodes in California

J. Chitambar, K. Dong, S. Subbotin and R. Luna

The Nematology Laboratory of the Plant Pest Diagnostics Branch (PPDB) provides diagnostic support for the protection of California's agricultural industry against economically important plant parasitic nematodes associated with plant disease. Based largely on the nematode diagnostic support provided by the Laboratory, government agencies are able to 1) provide nursery certification and standards of pest cleanliness, 2) Prevent the introduction and spread of regulatory significant pests, and 3) Provide phytosanitary certification of foreign export commodities.

The Nematology Laboratory comprises three Senior Nematologists, one Senior Agricultural Biological Technician and a support staff of three Scientific Aides.

The role and responsibilities of the State Nematologists are mainly four-fold:

- Identification of plant parasitic nematodes in regulatory and survey samples. Diagnosis of nematode related agricultural problems.
- Professional consultations provided to state, federal, university, industry, commercial and private agency personnel.
- Training in nematode sampling, processing, and preliminary identifications provided to county and state personnel.
- Education of students and other groups in nematology topics (Figure N1)
- Research in nematode taxonomy, methodologies, and other areas of regulatory nematology.

The Senior Agricultural Biological Technician is responsible for the effective and timely management of the support

staff, sample processing, data management and other related operations of the Laboratory.

## Nematode Sample Load

During 2009 a total of 7,864 samples were diagnosed at the Laboratory. A breakdown of sample type per program is presented in Table 1. The bulk of quarantine samples include those entering the State through the External Quarantine for Burrowing and Reniform Nematodes program and those exported to other countries through the Quarantine Phytosanitary Certification Program. Most nursery samples of plants for sale by the grower comprised garlic (20 seed bulb samples), strawberries (1,012 foliage and root samples), grape and stone fruits (365 root and soil samples) collected through the State's Registration and Certification, and Nematode Control programs.

## Detections of Interest and Significance

Two Quarantine pests namely, burrowing nematode (*Radopholus similis*) and reniform nematode (*Rotylenchulus reniformis*) were detected in 2009.

The burrowing nematode was detected in imported quarantine shipments of *Epipremnum aureum* from Florida to San Mateo County. The species is not present in California and is a migratory endo-parasite. CDFA's external quarantine program has successfully prevented the long-term establishment of this devastating nematode pest within California agriculture. If allowed entry, establishment and spread, the burrowing nematode can cause serious economic loss, primarily to the State's citrus, strawberry, carrot and ornamental production. The reniform nematode, was detected in eleven shipments of *Dracaena* spp. plants from the Big Island of Hawaii to San Diego, San Francisco and Orange Counties. The



Left to Right: *Radopholus similis* (Burrowing Nematode) within citrus roots; Adult female *Rotylenchulus reniformis*; Adult female *Rotylenchulus reniformis* (stained red) feeding on plant root.

quarantine nematode was also detected in two shipments of ornamental plants from Florida destined to Orange County. *Rotylenchulus reniformis* is not present in California agriculture and is a threat primarily to the State's cotton, grape and citrus production.

**Status of Current Survey Projects**  
**Potato Cyst Nematode 2009 Survey**

In 2009, CDFA's Nematology Laboratory was involved in the potato cyst nematode survey project which was sponsored by the United States Department of Agriculture (USDA) and part of the latter's national survey project. The operational responsibilities for the two projects (sample collection) were undertaken by the Pest Detection and Eradication Program Branch (PDEP), while survey planning, sample processing and nematode diagnostics were conducted by the Nematology Laboratory, CDFA-PPDB. [In addition, CDFA nematologists were involved both individually and collectively in research, training, consultations, professional seminars and committee participatory responsibilities.]

The Survey was in accordance with USDA's plan to re-convene surveys for the potato cyst nematode every two years. The plan was initiated in 2006 after the first detection of the pale cyst potato nematode, *Globodera pallida*, in Idaho. The 2009 survey was based on California's 2008 potato acreage cultivated to seed and production potatoes. In addition to the 2008 acreage, 11 seed potato fields representing 2009 potato acreage, were included. Seed potato was cultivated in four counties, viz., Kern, San Joaquin, San Luis Obispo and Santa Barbara, while production potato was cultivated in seven counties: Kern, Marin, Modoc, San Benito, Siskiyou, Sonoma and Yolo. Unlike the 2006 sampling protocol whereby only perimeter regions of fields were sampled, in 2009 entire fields were sampled. All fields per county cultivated to seed potato were sampled, while only ten percent of production potato fields per county were randomly selected for the survey. In both types of fields, soil sampling was done at a rate of three one-pound composite soil samples per acre. Samples were sent in their entirety to the Nematology Laboratory for processing and cyst nematode diagnosis.



**Potato cyst nematode on potato root**

Soil samples were processed specifically for the extraction of nematode cysts using a combination of the gravity sieving and sugar centrifugation techniques.

A total of 3,734 soil samples were processed and examined. Potato cyst nematodes were not found in any samples, however, cabbage cyst nematode, *Heterodera cruciferae* was found in soil samples collected from a single field in Santa Barbara County.

**Completion Of Earlier Surveys**  
**Golden Nematode Trace-forward Survey**

The 2007 detection of the Golden nematode in two potato fields in Alberta, Canada led to the development of USDA-APHIS sponsored "Golden Nematode Trace-forward Survey" of US states, including California, that received seed and/or production potatoes from Alberta, possibly traceable from 1998 and forward, or at least, three years back for seed and one year back for commercial production. The survey was necessary in order to achieve early detection of possible GN introductions into California. A total of eight samples only were collected from fields made available for sampling in 2009, thereby, completing the State-wide survey. No Golden nematode or cyst nematodes of any kind were found in this survey.



**Golden nematode, *Globodera rostochiensis*; Left to Right: Cysts; crushed cyst with eggs; second stage larvae.**

### CAPS (Statewide) Nematode Survey

This survey, commonly known as the CAPS survey was funded by the National Cooperative Agricultural Pest Survey (CAPS) of USDA-APHIS. The survey was re-funded and continued in 2008 having commenced in spring 2005 and funded through 2006, although the work continued well into 2007. Twenty-two target nematode species of quarantine and economic interest were targeted in the survey.

The main goal in 2009 was to fill the deficit of samples not collected in 2006-2007 due to a sudden stop in funding of the project. Only 120 samples were collected, thereby more filling the gap. None of the target nematode species was detected; however, other commonly found nematode species in California were detected.

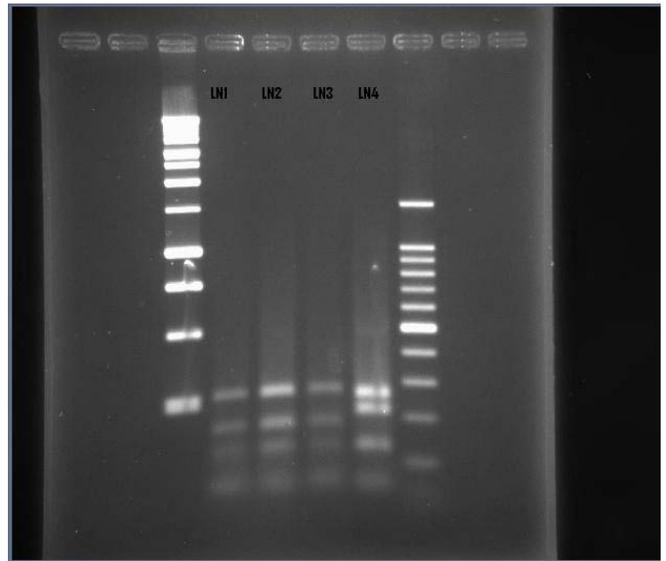
### Workshops, Conferences And Annual Meetings

State nematologists participated in several professional meetings in 2009. These included mainly: 1) 41<sup>th</sup> Annual California Nematology Workshop held in Salinas, California, and in partnership with the University of California (UC) Nematology Departments at Davis and Riverside. The workshop was held in congruence with the Soil Fungus Symposium and designed for an audience of pest control advisors and applicators, growers, farmers, retail and nursery employees, municipal, county and state employees, park and recreation personnel, educators, university educators and students, and consultants; 2) Annual meeting of the University of California Division of Agriculture and Natural Resources (DANR) Nematology Workgroup in Salinas, California. State nematologists serve as members of the workgroup along with UCD and UCR Nematology Department faculty. The main purpose of the workgroup is to collaboratively plan and coordinate research and extension program activities that directly concern California agriculture; presentations were made by State nematologists at each event.

Throughout the year, Nematologists, with the aid of the laboratory staff, conducted several educational presentations to students and other visitors from schools, colleges, University of California, plant industries, private, county, state and federal agencies



Soybean cyst nematode, *Heterodera glycines* (cysts).



PCR profile of Columbia root knot nematode, *Meloidogyne chitwoodi* (LN1-LN3) and Northern root knot nematode, *Meloidogyne hapla*, (LN4).



Stem and bulb nematode, *Ditylenchus dipsaci* (anabiotic, fourth stage larvae).

# Research on Molecular Diagnostics & Phylogeny of Nematodes

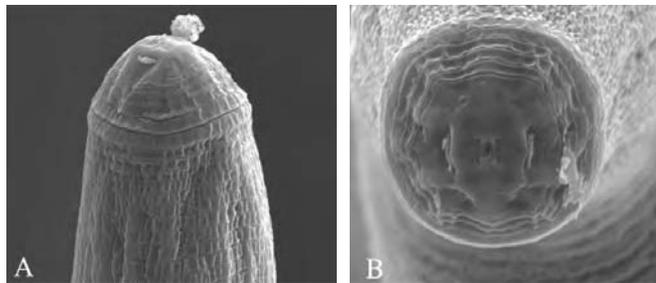
S. A. Subbotin

Dr. Subbotin's research is devoted to different aspects of molecular and traditional diagnostics and systematics of plant parasitic nematodes.

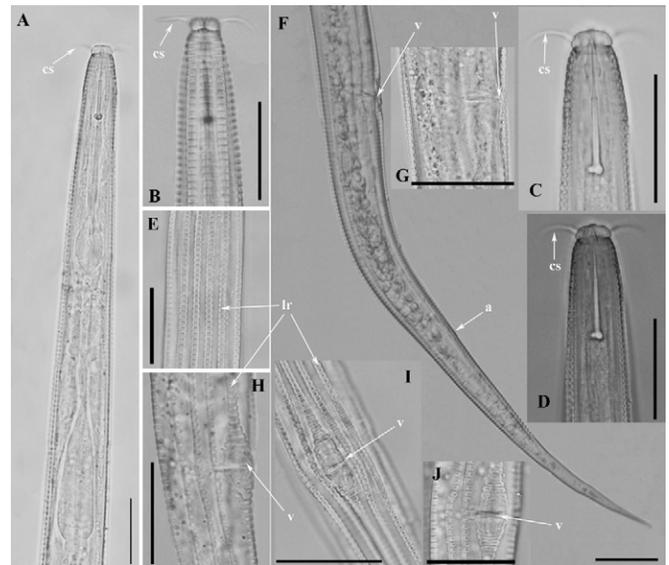
## Research Papers Published In 2009

Van den Berg E., **Subbotin S.A.**, Handoo Z.A. & Tiedt L.R. 2009. *Hirschmanniella kwazuna* sp. n. from South Africa with notes on a new record of *H. spinicaudata* (Schuermans Stekhoven, 1944) Luc & Goodey, 1964 (Nematoda: Pratylenchidae) and on the molecular phylogeny of the genus *Hirschmanniella* Luc & Goodey, 1964. *Nematology* 11: 523-540.

**Abstract.** A new species of the genus *Hirschmanniella*: *H. kwazuna* sp. n. is described from grasses in undisturbed veld from South Africa. *Hirschmanniella spinicaudata* (Schuermans Stekhoven, 1944) Luc & Goody, 1963 is reported from South Africa for the first time. *Hirschmanniella kwazuna* sp. n. is characterized by having a very irregular heat-relaxed body posture, a 1522- 2049  $\mu\text{m}$  long body, a low rounded lip region with four to five lip annuli, a 18 -22.5  $\mu\text{m}$  long stylet, an areolated lateral field along whole length of body, a filled spermatheca, a tail with 62-81 ventral annuli narrowing to tip with a ventral mucro, angular crystal-like inclusions within body cavity in most of the specimens and a phasmid which is situated 12-24 annuli or 15-26  $\mu\text{m}$  anterior to tail tip. Males similar to female including the crystal-like inclusions and tail curved strongly dorsad in most specimens. Juveniles similar to female with ventral tail projection more peg-like. Molecular sequence analysis using the D2-D3 expansion segments of 28S, partial 18S and ITS rRNA sequences allowed distinguishing *Hirschmanniella kwazuna* sp. n. from *H. loofi* and other species of the genus. Phylogenetic analyses based on analysis of the D2-D3, 18S and ITS rRNA genes are given for eight, ten and five valid and unidentified *Hirschmanniella*



*Hirschmanniella kwazuna* sp. n. Male, SEM. A: Anterior region, lateral view; B: Lip region, en face view (After Van den Berg et al., 2009).



Light micrographs of female *Eutylenchus excretorius* Ebsary & Eveleigh, 1981. A: Anterior region; B-D: Lip region end showing cephalic setae; E: Mid-body region; F: Posterior region; G, H, J: Vulval region. Scale bars = 20  $\mu\text{m}$  (After Palomareus-Rius et al., 2009).

species, respectively.

Palomareus-Rius J.E., **Subbotin S.A.**, Liebanas G., Landa B.B. & Castillo P. 2009. *Eutylenchus excretorius* Ebsary & Eveleigh, 1981 (Nematoda: Tylenzorinae) from Spain with approaches to molecular phylogeny of related genera. *Nematology*, 11, 343-354.

**Abstract.** Nematode surveys in indigenous vegetation in northern Spain revealed the presence of a nematode population of the genus *Eutylenchus* associated with moist sandy soils in the rhizosphere of common reed (*Phragmites* sp.) in the riverside of Tera river in Garray (Soria province). Morphological and morphometrical studies on this population fits with *Eutylenchus excretorius*, representing the first report for Spain and southern Europe and the fifth report in Europe after Germany, Poland, Czech Republic and Russia. SEM studies were carried out for the first time in this species and showed four lips separated by deep grooves. Each lip bears an elongated, flexible, recurved projection (seta) 12 (11-13)  $\mu\text{m}$  long, proximal third wide, gradually attenuating, distal end rounded. Molecular characterisation of *Eutylenchus excretorius* using several genes is provided. Sequence of D2-D3 expansion segments of 28S rRNA gene of this population was identical to that previously studied from Germany. Phylogenetic analysis using D2-D3 of 28S rRNA and partial 18S rRNA gene sequences of tylenchid nematodes revealed



The cabbage cyst nematode, *Heterodera cruciferae* **A**. Infected cabbage field; **B**. Cysts; **C**: White female on a root (After Chizhov et al., 2009).

that *E. excretorius* was clustered with *Cephalenchus hexalineatus*. Position of *E. excretorius* on majority consensus BI phylogenetic tree reconstructed using heat shock protein 90 gene was not well resolved. Nevertheless, in some Bayesian Inference trees obtained after exclusion of the third nucleotide positions, *E. excretorius* formed a clade with *C. hexalineatus*.

Chizhov V.N., Pridannikov M.V., Nasonova L.V & **Subbotin S.A.** 2009. *Heterodera cruciferae* Franklin, 1945, parasite of *Brassica oleraceae* L. from floodland fields in the Moscow region, Russia.

**Abstract.** During nematological survey the cabbage cyst nematode *Heterodera cruciferae* were found from cabbage growing in fields along the Oka river, Ozerskii and Serpuchovskii districts of the Moscow region, Russia. It is the first finding of this nematode in the Moscow region. Rape, rutabaga and radish were identified as host-plants for this nematode. Morphological, morphometrical and molecular characterisation as well as description of symptoms induced by *H. cruciferae* are given.

## Manuscripts Submitted For Publication In 2010

Madani M., **Subbotin S.A.**, Ward L. J., Li X. & De Boer S.H. 2010. Molecular characterization of Canadian populations of potato cyst nematodes, *Globodera ros-tochiensis* and *G. pallida* using ribosomal nuclear RNA and cytochrome *b* genes. *Canadian Journal of Plant Pathology* (in press).

De Luca F., Troccoli A., Duncan L.W., **Subbotin S.A.**, Waeyenberge L., Moens M. & Inserra R.N. 2010. Characterization of a population of *Pratylenchus hipp-peastri* from bromeliads and description of its related new species, *P. floridensis* n. sp. and *P. parafloridensis* n. sp. from grasses in Florida. *Nematology* (in press).

Palomares-Rius J.E, Castillo P., Liébanas G., Vovlas N., Landa B.B., Navas-Cortés J.A. & **Subbotin S.A.** 2010. Molecular and morphological analyses on the root-lesion nematode genera *Pratylenchus* and *Zygotylenchus* with description of *Pratylenchus hispaniensis* sp. n. *Nematology* (in press).

Palomares-Rius J.E, Vovlas N., **Subbotin S.A.**, Troccoli A., Cantalapiedra-Navarrete C., Liébanas G., Chizhov V.N., Landa B.B. & Castillo P. 2010. Molecular and morphological characterization of *Sphaeronema alni* Turkina & Chizhov, 1986 (Nematoda: Sphaeronematidae) from Spain and comparison with a topotype population from Russia. *Nematology* (in press).

Van den Berg E., **Subbotin S.A.**, Tiedt L.R. 2010. Morphological and molecular characterization of *Hemicyclophora lutosus* Loof & Heyns, 1969 and *H. typica* de Man, 1921 from South Africa (Nematoda: Hemicyclophoridae). *Nematology* (in press).

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# 2009 PRESENTATIONS

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- Baalbaki, R.** . “Elements of a scientific paper.” Seed Technology Journal Workshop. Association of Official Seed Analysts and the Society of Commercial Seed Technologists, Annual Meeting, Fort Collins, CO.
- Blomquist, C.L.** “An introduction to the National Ornamental Research Nursery at Dominican University.” 57<sup>th</sup> Annual California Forest Pest Council Meeting, Nov. 17, Woodland, CA.
- Blomquist, C. & S. Rooney-Latham** . “News from the Diagnostician’s Desk.” 58th Annual California Forest Pest Council Meeting. Nov. 17-18. Woodland, CA.
- Blomquist, C.L., Rooney-Latham, S. & T. Tidwell** . “Graduate Level Diagnostics Course taught by NPDN Diagnosticians.” Second National Meeting of the National Plant Diagnostic Network. Dec. 6-10. Miami, FL.
- Castillo P., Palomares-Rius, J.E., Liebanas G., Vovlas N., Landa B.B., Navas-Cortes J.A. & **S.A. Subbotin**. “Molecular and morphological phylogeny of the root-lesion nematode genera *Pratylenchus* and *Zygotylenchus*.” (Poster) The Second International Congress of Tropical Nematology, Oct. 4-9. Macceio, Brazil
- Epstein, M.** “Identification of False Codling Moth, LBAM and the European Grape Vine Moth.” CDFA Pest Detection and Emergency Projects Training Workshop. Oct. 30. Commerce, California.
- Epstein, M.** “Identification of False Codling Moth and Light Brown Apple Moth.” CDFA/County Departments of Agriculture Workshop, Feb. 26. Fresno, CA.
- Epstein, M.** “False Codling Moth, European Grape Vine Moth and a previously unknown caterpillar of a native California slug moth”. Meeting of the Lorquin Entomology Club, Rancho Dominguez, California.
- Epstein, M.** Workshop on identification of invasive species of leafrollers. For CDFA staff in the Los Angeles area. Oct. 23. Los Angeles, CA.
- Epstein, M.** Evening lecture on little known Lepidoptera caterpillars in California. Oct. 23. Corporate headquarters of Bioquip for the Lorquin Entomology Club.
- Estep, C., S. Gaimari, M. Hauser, K. Hoffman, P. Kerr & J. Leathers.** “Review of pest flies (Diptera: Tephritidae, Drosophilidae) detected in California from 2004 to present.” Second National Meeting of the National Plant Diagnostic Network. Dec. 6-10. Miami, FL.
- Gaimari, S.D.** “A dipterist’s trek through Western Australia.” CDFA-PPD seminar series, Sacramento, CA.
- Gaimari, S.D.** “A dipterist’s trek through Western Australia.” Northern California Entomological Society, Sacramento, CA.
- Gaimari, S.D.** “Taxonomic identification and its relationship to systematic research: A few comments on the applied side of things.” Bay Area Biosystematists Society, Berkeley, CA.
- Garrison, R.W.** . “Diversity of Neotropical Zygotera.” Invited Plenary talk: 6th WDA International Congress of Odonatology. Jun. 7-12. Xalapa, Mexico. Organized by Worldwide Dragonfly Association and Instituto de Ecología, UNAM
- Garrison, R.W.** . “Research on the Neotropical Odonata: current results and challenges ahead.” CDFA-PPD seminar series, Dec. 10. Sacramento, CA.
- Hauser, M.** “The Spotted Winged *Drosophila* in California.” Spotted Wing *Drosophila* Meeting, Nov. 2. University of California, Davis.
- Hauser, M.** “The Spotted Winged *Drosophila* in California.” University of California Cooperative Extension Meeting, Aug. 26. Watsonville, CA
- Hauser, M.** “The Arthropod fauna of the UAE.” Pacific Coast Entomological Society meeting, Nov. 20. Sacramento, CA
- Hauser, M.** “*Drosophila suzukii* - Identification, History and International Perspective.” Invited talk, Spotted Wing *Drosophila* Meeting, Nov. 2. Davis, CA
- Hauser, M.** “When vinegar flies go bad – the case of the spotted winged *Drosophila*.” Invited talk, CDFA seminar series, Sept. 17. Sacramento, CA.

- Hauser, M.** "Spotted Winged *Drosophila* (SWD) in California." Invited talk, Grower information meeting, Aug. 26. Watsonville, CA.
- Hauser, M.** "The hoverfly genus *Eumerus* in Australia - amazing flies from down under." CDFA-PPD seminar series, Aug. 20. Sacramento, CA.
- Hauser, M.** "The syrphid genus *Eumerus* in Australia" Invited talk, 5th International Symposium on Syrphidae, June 20. Novi Sad, Serbia
- Price, R. A., & R. P. Adams.** "The evolving classification of *Callitropsis* and *Cupressus* (Cupressaceae)." Paper presented at the Botanical Society of America/ American Society of Plant Taxonomists annual meeting, July. Snowbird, Utah.
- Rooney-Latham, S & C.L. Blomquist .** "Stump the Expert Panel" at the 58th Annual California Forest Pest Council Meeting. Nov. 17-18. Woodland, CA.
- Rooney-Latham, S & C.L. Blomquist .** "Palm Wilt and Other Diseases Affecting *Phoenix* Species in California." 58th Annual California Forest Pest Council Meeting. Nov. 17-18. Woodland, CA.
- Rooney-Latham, S & C.L. Blomquist .** "Palm wilt and other fungi associated with palm dieback in California." Second National Meeting of the National Plant Diagnostic Network. Dec. 6-10. Miami, FL.
- Stouthamer, R., J. G. Morse, P. F. Rugman-Jones, L. J. Robinson, A. Urena, and **G. W. Watson.** "Armored scale Blythe Border Station sampling / dispersal studies." Presentation made by Professor Joseph Morse (UC Riverside) at the California Avocado Grower Seminar Series, March 14 at San Luis Obispo, CA, Mar. 15 at Ventura, CA and Mar. 16 at Temecula, CA.
- Subbotin S.A.** "DNA barcoding, the way ahead: examples for tylenchs." The Second International Congress of Tropical Nematology, 4-9 Oct. Maceio, Brazil.
- Subbotin S.A.** "Molecular characterization of populations of *Nacobbus* from North and South America." The Second International Congress of Tropical Nematology, 4-9 Oct. Maceio, Brazil.
- Tidwell, T.E.** "Diagnosing Horticultural Problems." Presentation to UC Davis Environmental Horticulture class, Department of Plant Sciences, Apr. 6. Sacramento, CA.
- Tidwell, T.E.** "Tree Disease Diagnosis" Presentation to Sacramento Tree Foundation, Jan. 21. Sacramento, CA.
- Watson, G.W.** "Scales and whiteflies: the challenges of a sessile lifestyle." CDFA-PPDC seminar, Mar. 19. Sacramento, CA.
- Watson, G.W.** "Scales and whiteflies: the challenges of a sessile lifestyle" North California Entomologists' Club. May 7. Davis, CA.
- Yakabe, L.E., Parker, S.R., & D.A. Kluepfel .** "Development and incidence of systemic populations of *Agrobacterium tumefaciens* in Paradox rootstocks." Walnut Research Conference, Jan. 21-23. Bodega Bay, CA.