CALIFORNIA OAK MORTALITY TASK FORCE REPORT
APRIL 2011

MONITORING

A Sitka spruce (*Picea sitchensis*) tree has been found *P. ramorum* positive in the Republic of Ireland. The infected tree is approximately two meters tall and growing under the canopy of a large infected rhododendron. This is the first field record worldwide of *P. ramorum* infection in Sitka spruce; however, it had previously been found susceptible in laboratory tests. Spruce in the immediate area of Japanese larch outbreaks have been surveyed, and no further *P. ramorum* infections have been found. The area around the infected spruce has been quarantined. Monitoring will continue.

Annual forest surveys for *P. ramorum* have been ongoing in the Republic of Ireland since 2003. Until July 2010, *P. ramorum* had only been detected in forest areas on wild invasive rhododendron shrubs. Following the initial findings on Japanese larch in July 2010, an extensive national aerial and ground survey was conducted. To date, the surveys have confirmed the pathogen in Japanese larch at 11 forest locations totalling approximately 308 acres in five counties. Noble fir (*Abies procera*), beech, and Spanish chestnut (*Castanea sativa)* growing in close proximity to infected Japanese larch have also been found *P. ramorum* positive at a number of the sites. This is also the first report of *P. ramorum* infection on Noble fir. All infected trees are being removed to prevent disease spread.

European larch (*Larix decidua*) has been found *P. ramorum* positive in a woodland near Lostwithiel, Cornwall, in southwest England in an area with infected Japanese larch trees. This is the first time European larch has been found naturally infected with the pathogen. As with Japanese larch, symptoms include excessive bleeding, sunken or cankered areas of bark, wilting of the needles, graying of the canopy, and branch and shoot dieback with a distinctive ginger color. It has not yet been determined if European larch is a sporulating host.

To date, approximately 2 million Japanese larch (*Larix kaempferi*) trees have been felled in the UK in response to the *P. ramorum* outbreak. Since first identified as a host in August 2009, larch has been found infested in southwest England, Wales, Scotland, and the Isle of Man, and at nine sites in Northern Ireland. Aerial surveys for additional outbreaks will be underway in 2011 as soon as needle flush occurs.

P. ramorum* has been confirmed in a Lawson's cypress (*Chamaecyparis lawsoniana, called Port Orford-cedar in its native range) and on rhododendron at Balloch Castle Country Park on Loch Lomondside in West Dunbartonshire, Scotland where *P. lateralis* was confirmed in Lawson's cypress late in 2010 (the first time *P. lateralis* had been identified in Britain). The park is only the second site in Scotland where *P. ramorum* has been found in trees. Researchers now believe that the cause of the cypress and yew (*Taxus brevifolia*) decline at the park is *P. cinnamomi*. While *P. lateralis* and *P. ramorum* are genetically closely related, this is the first time they have been found in such close proximity.

RESEARCH

Hüberli, D. and Garbelotto, M. 2011. *Phytophthora ramorum* is a generalist plant pathogen with differences in virulence between isolates from infectious and dead-end hosts. Forest Pathology. DOI: 10.1111/j.1439-0329.2011.00715.x.

Summary: Variation in virulence was examined among isolates of *Phytophthora ramorum* from epidemiologically important or infectious (non-oak) and transmissive dead-end (oak) hosts from North America. Twelve isolates representative of the genetic, geographic and host range of *P. ramorum* in the western United States were inoculated on leaves of *Umbellularia californica* (bay laurel or bay) and stems of *Quercus agrifolia* (coast live oak). In spite of extreme genetic similarity among the isolates employed, and even within the same genotype, significant differences in lesion size were measured, suggesting virulence in this pathogen is also controlled by epigenetic factors. A strong positive correlation between lesion size on bay laurel and coast live oak provides experimental evidence *P. ramorum* is a generalist pathogen that lacks host specificity. Isolates from non-transmissive oaks were significantly less pathogenic both on oaks and bays than isolates from infectious hosts. These results are essential to further our understanding of the epidemiology and evolutionary potential of this pathogen. A quantitative differential in virulence of isolates from hosts with different epidemiological roles has been described for many animal diseases, but is a novel report for a plant disease.

Kasuga, T.; Kozanitas, M.; Bui, M.; Hüberli, D.; Rizzo, D.; and Garbelotto, M. 2011. Host induced epigenetic alteration in *Phytophthora ramorum*. Fungal Genetics Reports 58(Suppl): P.97. (Presented at the 26th Fungal Genetics Conference, Monterey, CA, March 15-20, 2011.)

An oomycete plant pathogen *Phytophthora ramorum* is responsible for two distinctive diseases; (1) Sudden Oak Death, which is characterized by lethal bole cankers on oaks, and (2) Ramorum blight, which causes necrotic lesions on leaves of diverse shrub species such as bay laurel and Rhododendrons (foliar hosts). It has been noticed that although a single clonal lineage dominates in Californian forests, isolates originating from oaks tend to be less virulent on both oak and foliar hosts than those from foliar hosts, and colonies of oak isolates look irregular and are somatically unstable. We hypothesized that because *P. ramorum* in California is exclusively clonal, most of the aforementioned phenotypic variations should be due to difference in gene regulation rather than genetic polymorphism. We have conducted microarray mRNA profiling and found that hundreds of genes encoding for transposable elements were highly active in some isolates derived from oak trees, which we termed transposon derepressed phenotype (TDP). RT-qPCR was then employed to measure the expression level of transposons in one hundred *P. ramorum* isolates derived from diverse host species. It was found that 64% of isolates derived from oak hosts showed TDP, whereas only 9% of isolates from foliar hosts showed TDP. We hypothesize that *P. ramorum* incurs epigenetic alterations within and beneath oak bark, which resulted in derepression of transposons.

Matari, N. and Blair, J.E. 2011. Comparative Genomics Suggests the Presence of RNA Interference in Oomycetes. Fungal Genetics Reports 58(Suppl): #8. (Presented at the 26th Fungal Genetics Conference, Monterey, CA, March 15-20, 2011.)

RNA interference is a natural process eukaryotes use to regulate gene expression. Here we used comparative genomic approaches to identify the genes involved in RNA interference within available Oomycete genomes. Amino acid sequences of proteins known to be involved in RNAi biogenesis from human, *Drosophila*, and *Arabidopsis* were collected and used as references to search Oomycete genomes for the presence of homologs. Dicer, drosha, argonaute, and pasha protein sequences were used as queries as they are known to be crucial for RNAi biogenesis and are heavily conserved between different organisms. Searches yielded that *Phytophthora ramorum, P.capsici, P.infestans, P.sojae*, and *Saprolgenia parasitica*, as well as outgroups *Thalassiosira pseudonana* (diatom) and *Ectocarpus siliculosus* (brown alga), all contain proteins that are homologous to the reference sequences. Pfam was used to verify that each homolog contained the appropriate protein domains known to be involved in RNAi biogenesis. Phylogenetic analysis of both protein and nucleotide data suggest that these genes have also experienced multiple rounds of duplication within Oomycetes. These results suggest that Oomycete genomes contain the appropriate genes necessary for RNA interference. Currently, nucleotide alignments are being used to design primers for both genomic PCR and RT-PCR for test for the presence and expression of these genes in locally collected isolates of *Phytophthora* and *Pythium*.

Meijer, H.J.G.; Kay, J.; ten Have, A.; Govers, F.; and van Kan, J.A.L. 2011. The Aspartic Proteinase Family of Three *Phytophthora* Species. Fungal Genetics Reports 58(Suppl): #64. (Presented at the 26th Fungal Genetics Conference, Monterey, CA, March 15-20, 2011.)

Pepsin-like aspartic proteinases (APs) are produced in a wide variety of species and contain conserved motifs and landmark residues. APs fulfil critical roles in infectious organisms and their host cells. *Phytophthora* species are oomycete plant pathogens with major social and economic impact. Several of which have been sequenced. The genomes of *Phytophthora infestans, P. sojae* and *P. ramorum* contain 11-12 genes encoding APs, resolved into 5 clades by phylogenetic analysis. Several subfamilies contain an unconventional architecture, as they either lack a signal peptide or a propart region. One of the *Phytophthora* APs is an unprecedented fusion protein with a putative G- protein coupled receptor as the C-terminal partner. The others appear to be related to well-documented enzymes from other species including a vacuolar enzyme that is encoded in every fungal genome sequenced to date. The oomycetes also have enzymes similar to plasmepsin V, a membrane-bound AP in the malaria parasite *Plasmodium falciparum,* that cleaves effector proteins during their translocation into the host red blood cell. The translocation of *Phytophthora* effectors to host cells is topic of intense research in which APs might be involved.

Spaulding, H.L. and Rieske, L.K. 2011. A glimpse at future forests: predicting the effects of *Phytophthora ramorum* on oak forests of southern Appalachia. Biological Invasions. DOI: 10.1007/s10530-010-9895-4.

Abstract: The highly pathogenic *Phytophthora ramorum*, causal organism of sudden oak death (SOD), is established in forests of the Pacific Northwest (USA) and is threatening invasion of other regions. Given the breadth of its host range, with dozens of asymptomatic ornamental hosts and with oaks, *Quercus* spp., in the red oak (*Erythrobalanus*) subgenus particularly susceptible, we investigated the consequences of its invasion and establishment in oak-dominated deciduous forests of the eastern USA. We evaluated the nature and extent of pathogen invasion using vegetation assessments coupled with growth simulations. The woody plant community was assessed in three strata (upper, mid- and lower) and was used to characterize forest composition and structure. Using the Forest Vegetation Simulator (FVS), we then projected woody vegetation growth 50 years into the future with and without the effects of SOD. In forest simulations lacking pathogen invasion, little change in composition or structure is forecasted. Both red oaks and white oaks (subgenus *Leucobalanus*) increase slightly but significantly over the length of the simulation. In contrast, in SOD-affected forests our projections predict a significant loss of red oaks within 10 years of pathogen invasion. Basal area of white oaks and non-oaks is expected to increase more so in the absence of red oaks. The loss of red oaks to pathogen infection will result in greater increases in red maple, *Acer rubrum*, and yellow poplar, *Liriodendron tulipifera*, than in forests free of SOD. Loss of red oak represents a significant loss of hard mast, with potentially devastating consequences for wildlife. Red oak loss will also affect decomposition rates, nutrient cycling, forest structure, and timber values, with consequences for forest health and sustainability.

Tooley, P.W.; Browning, M.; and Leighty, R.M. 2011. Infectivity and Sporulation of *Phytophthora ramorum* on Northern Red Oak and Chestnut Oak. Journal of Phytopathology. DOI: 10.1111/j.1439-0434.2011.01797.x.

Abstract: We evaluated the effect of moisture period on foliar disease development by *Phytophthora ramorum* on 2- to 3-year-old northern red oak (*Quercus rubra*) and chestnut oak (*Q. prinus*). We also determined the propensity of *P. ramorum* to form sporangia and chlamydospores on these two host species. Leaves were dip-inoculated with ca. 5000 sporangia/ml of *P. ramorum* isolate Pr-6 and incubated at 100% relative humidity in dew chambers in darkness for up to 6 days. Several plants were removed each day to a greenhouse, and foliar infection was evaluated on day 7. Sporangia were collected over a 7-day period from diseased foliage in a mist tent. A significant relationship between moisture period and disease incidence was found for both tree species. Chestnut oak exhibited significantly greater disease incidence and severity compared with northern red oak. However, sporulation levels were larger in northern red oak over the 7-day period of sporangia collection, and northern red oak also produced significantly greater numbers of sporangia per square centimetre of lesion area compared with chestnut oak. Chlamydospore production in diseased leaves sampled 1 month

following moist incubation was also significantly greater for northern red oak compared with chestnut oak. Knowledge of *P. ramorum* sporulation capacity in relation to disease incidence and severity on Eastern US oak species will help determine the potential for epidemic development should the pathogen become established in this region.

RELATED RESEARCH

Érsek, T. and Ribeiro, O.K. 2010. Mini Review Article: An annotated list of new *Phytophthora* species described post 1996. Acta Phytopathologica et Entomologica Hungarica 45 (2), pp. 251-266. DOI: 10.1556/APhyt.45.2010.2.2.

Fairweather, M.L. and Geils, B.W. 2011. First Report of the White Pine Blister Rust Pathogen, *Cronartium ribicola*, in Arizona. Plant Disease 95(4), page 494. DOI: 10.1094/PDIS-10-10-0699.

Hong, C.; Gallegly, M.E.; Richardson, P.A.; and Kong, P. 2011. *Phytophthora pini* Leonian resurrected to distinct species status. Mycologia, 103(2), pp. 351–360. DOI: 10.3852/10-058.

Ostry, M.E.; Venette, R.C.; and Juzwik, J.. 2011. Decline As a Disease Category: Is It Helpful? Phytopathology 101 (4), pp. 404-409. DOI: 10.1094/PHYTO-06-10-0153.

Sturrock, R.N.; Frankel, S.J.; Brown, A.V.; Hennon, P.E.; Kliejunas, J.T.; Lewis, K.J.; Worrall, J.J.; and Woods, A.J. 2011. Climate change and forest diseases. Plant Pathology 60, 133–149. Doi: 10.1111/j.1365-3059.2010.02406.x.

COMTF 2011 MEETING

The California Oak Mortality Task Force 2011 meeting will take place May 25, 2011 and June 1, 2011 ***online***, with each one-hour session focusing on challenging *P. ramorum*-related topics. On May 25, attendees will participate in a virtual "field trip," as speakers discuss *P. ramorum* management-related issues in the field, and on June 1, presenters will focus on issues dealing with *P. ramorum*-related pathways. There is no charge to participate, but preregistration is required. Forest health specialists, land managers, regulators, nursery industry representatives, tribal members, arborists, researchers, Master Gardeners, and other interested parties are encouraged to attend. For more information, see the "Calendar of Events" below.

PERSONNEL

Roddie Burgess, who lead the Forestry Commission's Plant Health Service for 14 years, has retired. Effective April 4, 2011, John Morgan will assume Burgess' position. Prior to his new appointment Morgan had been head of the Commission's Plant & Seed Supply Business Unit for 13 years, overseeing the production and supply of more than 300 million forestry plants from the Commission's tree nurseries.

John McDonald retired from the Canadian Food Inspection Agency and will no longer be the lead contact for Canada's *P. ramorum* regulatory program. As of March 28, 2011, Dominique Pelletier, Horticulture Division Soil Section Chief, is handling the

P. ramorum docket. Pelletier can be reached at (613) 773-7180 or Dominique.Pelletier@inspection.gc.ca.

RESOURCES

The Oregon Association of Nurseries "Digger" March 2011 newsletter featured "A Tale of Three Nurseries." The story provided *P. ramorum*-related best management practices to help growers avoid problems. To access the newsletter, go to: http://www.oan.org/associations/4440/files/digger/Digger_MAR_2011_p33-36.pdf

"Sudden Oak Death Impacts on Oregon South Coast Forests 2001-2009" is presented as part of Oregon's Forest Atlas 2010 online edition (see : http://www.oregon.gov/ODF/RESOURCE_PLANNING/forestatlas.shtml). A map and description of *P. ramorum* spread in the state are available.

The UK Forestry Commission has published a comprehensive update on the *P.* *ramorum* Japanese larch outbreak. To access current knowledge, symptoms, diagnosis, treatment, actions, regulations, owners' responsibilities, financial assistance, and other information, go to: http://www.forestry.gov.uk/forestry/INFD-8EJKP4.

CALENDAR OF EVENTS

4/9 – Carmel Valley Community Meeting – Responding to the Threat of Sudden Oak Death. 10:30 am – 12:00 pm. Hidden Valley Theater Dining Room, 88 W. Carmel Valley Rd., Carmel Valley, CA 93924. For more information, contact Kerry Fangioso at (831) 620-1098 or kfrangioso@ucdavis.edu or Katie Palmieri at kpalmieri@berkeley.edu

4/16 – Guidelines for Managing Oak Rangelands; webinar series field trip to Sierra Foothill Research and Extension Center; 10:00 a.m. – 3:00 p.m.; Intended for oak woodland landowners, certified range managers, and registered professional foresters; This series is designed to create an awareness of the importance of managing oak woodlands and to present alternative management strategies.; Registration is $25. To register, go to http://ucanr.org/oakwebinar. Registered participants will receive follow-up log-in instructions. For more information, contact Richard Standiford at (510) 643-5428 or standifo@berkeley.edu. Note: As the webinar has already started, those who register now will get access to a recording of already completed sessions, and a link for the upcoming sessions.

4/20 - SOD Treatment Workshop; Meet at oak outside of Tolman Hall, UC Berkeley Campus; 1 – 3 p.m.; Pre-registration is required. This class is free and will be held rain or shine. To register, or for questions, email kpalmieri@berkeley.edu, and provide your name, phone number, affiliation and license number (if applicable), and the date for which you are registering. For more information, go to http://nature.berkeley.edu/garbelotto/english/sodtreatmenttraining.php.

4/30 – Guidelines for Managing Oak Rangelands; webinar series field trip to Hopland Research and Extension Center; 10:00 a.m. – 3:00 p.m.; For more

information, see the 4/16 listing above or contact Richard Standiford at (510) 643-5428 or standifo@berkeley.edu.

5/11 - SOD Treatment Workshop; meet at oak outside of Tolman Hall, UC Berkeley Campus; 1 – 3 p.m.; Pre-registration is required. For more information, see the 4/20 listing above.

5/16 – 5/18 - National Workshop on Climate and Forests; DuBois Conference Center; Northern Arizona University Campus, Flagstaff Arizona; For more information, go to http://www.safnet.org/natworkshop11/index.cfm.

5/23 – 28 - Fourth International Workshop on Oomycetes: *Phytophthora,* *Pythium* and *Phytopythium*; University of Maryland Department of Plant Science & Landscape Architecture; College Park, Maryland; University of Maryland Department of Plant Science & Landscape Architecture; College Park, Maryland.

5/25 - CA Oak Mortality Task Force 2011 Meeting: Sudden Oak Death/*Phytophthora ramorum*: A Global Perspective on Management and Movement Webinar, **Part 1**, "Virtual 'Field Trip' of *Phytophthora ramorum* Wildland Management;" 9:00 – 10:00 a.m.; Advanced registration is required. There is no cost to participate. For more information, or to register, go to COMTF 2011 Meeting. For question, contact Katie Palmieri at kpalmieri@berkeley.edu or Janice Alexander at jalexander@ucdavis.edu.

6/1 - CA Oak Mortality Task Force 2011 Meeting: Sudden Oak Death/*Phytophthora ramorum*: A Global Perspective on Management and Movement Webinar, **Part 2**, "Focus on *Phytophthora ramorum* Pathways;" 9:00 – 10:00 a.m.; Advanced registration is required. There is no cost to attend. For more information, or to register, go to COMTF 2011 Meeting. For question, contact Katie Palmieri at kpalmieri@berkeley.edu or Janice Alexander at jalexander@ucdavis.edu.

6/21 – 6/23 - Coast Redwood Forests in a Changing California: A Symposium for Scientists and Managers; University of California, Santa Cruz; For more information on the conference, go to http://ucanr.org/sites/redwood.

6/30 - Guidelines for Managing Oak Rangelands; webinar series field trip to Avenales Ranch, Pozo, San Luis Obispo County; 10:00 a.m. - 2:30 p.m.; For more information, see the 4/5 listing above or contact Richard Standiford at (510) 643-5428 or standifo@berkeley.edu.

7/26 - California Forest Pest Council, 2011 Insect, Disease, and Animal Damage Field Trip; Fort Bragg area, Mendocino County; Additional details will be forthcoming. For questions, contact Kim Camilli at kim.camilli@fire.ca.gov.

7/31 – 8/5/2011 – Disease and Insect Resistance in Forest Trees: Fourth International Workshop on the Genetics of Host-Parasite Interactions in Forestry; Valley River Inn; 1000 Valley River Way; Eugene, OR 97401; To register, or for more information, go to http://ucanr.org/sites/tree_resistance_2011conference/. For questions, contact Richard Sniezko at rsniezko@fs.fed.us; Katie Palmieri at (510) 847-5482 or kpalmieri@berkeley.edu; or Janice Alexander at (415) 499-3041 or jalexander@ucdavis.edu.

10/5 – 10/6/11 – The Seventh Meeting of the Continental Dialogue on Non-Native Forest Insects and Diseases; Boulder, Colorado; For more information, contact

Debbie Lee at dlee@resolv.org or (202) 965-6381 or Beth Weaver at bweaver@resolv.org or (202) 965-6211. For more information about the Dialogue go to: www.continentalforestdialogue.org.

11/8 – 11/11/11 - 2011 IUFRO Forest Protection Joint Meeting, Research Groups 7.02 – 7.03; Colonia del Sacramento, Uruguay; More information will be forthcoming. For questions, contact Alina Greslebin at agreslebin@ciefap.org.ar.

6/18 – 6/22/12 – Sudden Oak Death Fifth Science Symposium; More information will be forthcoming.