Phytophthora Species From Oak and Tanoak Forests in California and Oregon[1]

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Introduction

The current sudden oak death (SOD) epidemics in Europe and western North America triggered a search of North American oak forests for other *Phytophthora* species, and the results from the western United States have been surprising. *Phytophthora ramorum* has been the main quarry, and as an aerial pathogen, it is a surprise in itself. It isn't alone, however.

Results

Fifteen distinct taxa have been at least partially characterized from trees, soil or streams in oak forests in Oregon and California. Eleven are named species; four of these were described within the last five years. Four taxa await formal nomenclature, including the widespread and abundant aquatic species called "*P.g. chlamydo*." The number of *Phytophthora* species is mushrooming. Streams where SOD occurs have particularly rich *Phytophthora* flora. Seven of the 15 taxa, including *P. ramorum* and *P. nemorosa*, as well as the ubiquitous *P. gonapodyides* and *P. g. chlamydo*, have been recovered from streams. *P. cambivora* and the closely related *P. europaea* are occasionally recovered by baiting, and there are numerous unnamed isolates, including one group related to, but morphologically distinct from, *P. tropicalis*, and another closer to *P. capsici*. "Early detection" stream monitoring networks are in place for *P. ramorum* in both California and Oregon. The number of *Phytophthora* isolates of other species that these networks are yielding is overwhelming. We have developed an automated "single-strand-conformational-polymorphism" (SSCP) system, combining ITS and COX spacer primers to allow us to screen large numbers

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of isolates quickly against a suite of reference species (see Poster by Hansen et al., this Proceedings). Although we have only begun to work through our backlog of isolates, it is already clear that more species will be added to the list.

The most notorious forest *Phytophthora* species, *P. cinnamomi*, causes significant losses in forests around the world. It is present and destructive in ornamental plantings or orchards, especially in California, but is only associated with significant damage in forest plant communities in two locations. In Southern California, Matteo Garbelotto has reported it killing woodland coast live oak near infested avocado orchards, and killing manzanitas, including a rare species, adjacent to an infested Christmas tree plantation. In both cases DNA markers showed a close relationship between the forest isolates and the agricultural strains. *P. citricola, P. cambivora, P. syringae* and *P. cactorum* are also occasionally encountered in forest situations. These and other species dominate the *Phytophthora* flora on oaks in urban settings and in nurseries, yet remain rare in western forests despite repeated introductions. Clearly these common "agricultural" species of *Phytophthora* have requirements for aggressive pathogenicity that are not met in forest environments.

P. nemorosa was recently described from stem cankers on coast live oak and tanoak and leaves of various hosts. It resembles, and is closely related to, *P. ilicis* (present on holly within the SOD range). Symptoms and host range are similar to those of *P. ramorum*, although *P. nemorosa* appears to be a native forest pathogen. A third *Phytophthora* species is also present as a foliar and bark pathogen in western oak forests. *P. pseudosyringae* was first described from European oak forest soils, but is present and causes disease in western tanoak and coast live oak forests. It was first reported and is most abundant in California, but is present in Oregon as well. Other *Phytophthora* species have been isolated less frequently from leaves and stems of various SOD hosts, including *P. gonapodyides*, *P. syringae*, *P. europaea* and something akin to *P. capsici*. *P. ramorum* and *P. lateralis*, the invasive pathogen of Port-Orford-cedar, are closely related, and their ranges overlap in Oregon. *P. lateralis* also has the potential for aerial dispersal. The coincidence of two closely related species appearing as invasive exotics in the same area remains unexplained.

Discussion

The diverse array of Phytophthora species present in western forests raises a number of challenging questions. Most practically, it highlights the need for careful and complete diagnostics when working with symptomatic plant tissues. Can we distinguish indigenous from exotic species? What are these pathogens doing ecologically? What should be the regulatory consequences of these species? Why are

species known as soil inhabitants in Europe found as aerial pathogens here? Are western mixed-evergreen forest species unusually susceptible to species of Phytophthora in general? Does the moderate, Mediterranean climate favor foliar infection? These and many other questions remain.