

North American, Non-*Ribes* Alternate Hosts of *Cronartium Ribicola*: Ongoing Studies to Determine their Significance and Impact to Whitebark Pine

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To effectively manage white pine blister rust, caused by *Cronartium ribicola*, it is critical to understand the roles of local alternate hosts in the disease cycle and epidemiology in pine stands. Our ability to predict the progress of epidemics is questionable since the discovery of widespread species in the Orobanchaceae that can act as alternate hosts, i.e., *Pedicularis racemosa* and some *Castilleja* species (McDonald et al. 2006; Zambino et al. 2006). It is presently unknown how and when these hosts were acquired in North America and what influence they have on blister rust epidemiology. For these reasons, it is important to understand the life history of *C. ribicola* in eastern Asia—the pathogen’s putative center of origin—and the relationships among non-*Ribes* hosts in Asia and North America.

In Asia, utilization of alternate host species appears to vary considerably among regions. For example, Hyun and Koo (1981) reported that *C. ribicola* inoculum in Korea was able to infect *P. resupinata* but not a *Ribes* species (*Ribes hudsonianum*, a native of North America); however, native Korean *Ribes* species were not tested. In Japan, inoculation tests have shown rust sources vary in their abilities to infect *Ribes* and *Pedicularis* species. Inoculum from a *Pinus strobus* plantation in Japan infected only *Ribes* while inoculum from *Pinus pumila* at higher elevations infected *Pedicularis* or both genera (Yokota and Uozumi 1976). As *C. ribicola* adapts to diverse environments in North America, similar patterns of host utilization may appear, depending upon co-occurrence of white pines with different combinations of *Ribes*, *Pedicularis*, and *Castilleja* in different environments.

Recent studies have elucidated phylogenetic relationships among many species of *Pedicularis* and sister genera (Bennett and Mathews 2006, Ree 2006, Wolfe et al. 2005). Of relevance to white pine blister rust are the relationships among susceptible *Pedicularis* species in Asia and North America. Analysis of mitochondrial and nuclear DNA sequences showed a close phylogenetic relationship between *P. resupinata* and *P. yesoensis* (Ree 2006). These species are the major hosts in Korea and Japan, respectively. We performed a phylogenetic analysis of different *Pedicularis* species from Asia and North America using previously published DNA sequence (internal transcribed spacer of the nuclear ribosomal DNA) (Ree 2006 and Wolfe et al. 2005). The results indicate that North American *Pedicularis* species are well dispersed among several clades. *Pedicularis racemosa*, native to North America and susceptible to *C. ribicola*, is closely related to *P. yesoensis* and *P. resupinata*. However, in Asia, *C. ribicola* can also utilize species within other clades of

Pedicularis. For instance, *P. chamissonis* is a susceptible species in Japan that is found in a separate clade; it is currently undetermined if this species has close relatives in North America. Thus, *C. ribicola* may have a wider potential host range in North American *Pedicularis* and *Castilleja* than is currently recognized. Current plans are to address fundamental questions regarding utilization of non-*Ribes* hosts. Molecular genetic studies and inoculation experiments are underway to address genetic relationships among rust isolates from different alternate and primary hosts in Asia and North America, phylogenetic relationships among host species, and whether diverse rust sources can utilize *P. racemosa*.

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