Endophytic Fungal Flora from Eastern White Pine Needles and Apple Tree Leaves as a Means of Biological Control for White Pine Blister Rust

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White pine (Pinus strobus L.) is one of the most valuable timber species in eastern Canada and it is highly susceptible to white pine blister rust caused by Cronartium ribicola J.C. Fisher. A biocontrol agent effective against C. ribicola would be a useful tool for the management of young white pine plantations and naturally regenerating stands. Inhibition of teliospore production or basidiospore development in the early infection stages on pine needles would provide effective biocontrol. We report here on the biodiversity of fungal endophytes found in needles of P. strobus consisting of some 91 putative species, nursery tests of 63 isolates of needle endophytes to inhibit infection on white pine seedlings, and in vivo test trials of two isolates of Microsphaeropsis arundinis against C. ribicola on Ribes glandulosum leaves. Seven of the endophytes tested were found to inhibit infection by C. ribicola. The most interesting species of fungal endophyte, labeled Species A, is represented by two isolates in our collection. Control seedlings presented on average more than ten yellow spots whereas seedlings treated with Species A had fewer than 0.2 spots per seedling. The apple scab biocontrol agent Microsphaeropsis arundinis, strains P-176 and P-130, showed great potential for inhibiting C. ribicola on red currant leaves. Strain P-130 infected on average 96.4% of the uredinia and strain P-176 was similarly effective with 89.2% of the uredinia being infected.

Investigations for the Biological Control of Cogongrass

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Cogongrass (Imperata cylindrica) is a rhizomatous perennial grass of tropical and subtropical regions. It infests over 0.5 billion ha worldwide. Cogongrass was introduced accidentally at Mobile, Alabama, as packing material from Japan in 1912 and intentionally from the Philippines into Mississippi and Florida in 1921 as a potential forage grass and for erosion control. Cogongrass was unacceptable as a forage and it was too weedy for erosion control. Now cogongrass infests about 1 million ha in Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, Texas, and Virginia, where it has become a pernicious weed of agricultural, forestry, urban, and natural areas. Currently, the only effective
control for cogongrass is repeated applications of non-selective herbicides and/or tillage. Three skipper butterfly (Lepidoptera: Hesperiidae) species, *Ancyloxypha numitor*, *Atalopedes campestris*, and *Hylephila phyleus* were discovered feeding on cogongrass leaves. In caged greenhouse feeding experiments at Stoneville, Mississippi, all three species fed, pupated, and emerged as adults; however, only two of 10 *H. phyleus* larvae reached adulthood. At larval maturity, *A. campestris* larvae were about twice the length and four times the weight of *A. numitor* larvae. Only *A. campestris* was effective in reducing cogongrass foliage by as much as 50% at one larva per pot (10 cm diam). Because all three species generally feed on grasses, including bermudagrass, corn, johnsongrass, sugarcane, St. Augustine grass, and several native grasses, it is unlikely that *A. campestris* could be used in biological control of cogongrass unless the life cycle was terminated prior to the next generation. Several methods including parasitism, radiation, or sterile hybrids may allow augmentative biological control of cogongrass with *A. campestris* or other general grass-feeding lepidopterous larvae. Additional research is being conducted at Stoneville, Mississippi, to investigate the potential for biological control on cogongrass.

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**Promising Native/Adventive Pathogens and Insect Agents for the Biological Control of Houndstongue in Canada**

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Houndstongue (*Cynoglossum officinale*) is an introduced noxious weed that is a serious problem on the rangelands of central British Columbia (BC), Canada. This biennial is a concern because it invades newly-established pastures, grows in place of valuable forage, has barbed seeds which attach to cattle causing irritation, represents potential market losses, and is toxic to livestock. Biocontrol is considered by cattlemen a feasible and economic long-term solution to the control of houndstongue. In addition to releasing European insects for its control, we have conducted surveys in BC in search for native or adventive insects and pathogens found attacking houndstongue. The most promising organisms for integration into a biocontrol program are pathogens and include the pycnidial fungus *Phoma pomorum*. This fungus is highly host specific and causes early loss of older leaves on houndstongue rosettes and reduced plant biomass. The fungal pathogen *Fusarium acuminatum* was shown to seriously damage the root system of houndstongue which led to severe stunting of plants. The fungus *Erysiphe cynoglossi* causes powdery mildew on the leaves of houndstongue and has a significant negative impact on growth and reproduction. Seed production was reduced by about 50% in field tests. A new pathovar of the bacterium *Pseudomonas syringae* was discovered that was specific to houndstongue. A preliminary field study indicated that *P. syringae* reduces winter survival and vigour in houndstongue. Several plant viruses also were shown to infect houndstongue, causing stunting and reproductive losses in some instances. Sphere, rod, and potyvirus-like virus particles have been located within plant material using the transmission electron