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56

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Rhizina Root Rot of Conifers

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Introduction

Rhizina root rot of conifers is caused by the fungus *Rhizina undulata* (Ascomycetes, Pezizales), which commonly fruits on recently burned forest soil. *Rhizina undulata* occurs in temperate regions throughout the world, and in Europe, Japan, and South Africa it incites a root rot of pole-sized conifers known as "group dying". Infection is frequently initiated on trees adjacent to sites burned by the bonfires of forest workers, and may progress radially for several years. In North America, Rhizina root rot is associated with seedling death and occasionally causes significant damage in clear-cut areas recently planted after slash burning.

Dead lodgepole pine seedling surrounded by *Rhizina* fruiting bodies

Hosts and Distribution

Mortality due to Rhizina root rot is usually limited to conifers. Attempts to induce root disease in various hardwoods have failed. Lack of pathogenicity to hardwoods is further substantiated by the fact that fruiting bodies do not occur in areas where conifers are absent prior to burning. Incidence of fruiting bodies is higher in areas previously covered with old-growth stands and on acid soils.

In temperate regions of Europe and North America, *R. undulata* has been associated with the death of *Abies, Larix, Picea, Pinus, Pseudotsuga, Thuja* and *Tsuga* species. In Great Britain and Canada, pathogenicity has been demonstrated on Scots pine (*Pinus sylvestris*) and (in vitro) lodgepole pine (*P. contorta*). In Japan, inoculation tests proved pathogenicity to seedlings of Japanese red pine (*P. densiflora*), Japanese black pine (*P. thurbergii*), Japanese larch (*Larix leptolepis*) and *Abies sachalinensis*. Other coniferous and deciduous species were listed as potential hosts in Japan but no other associations were proven experimentally. In South Africa and Swaziland, *Rhizina* fruiting bodies have been associated with ten species of pine, both in newly planted and pole-sized stands. In the United States, the fungus has recently been reported from western Oregon and Washington and is historically reported from central states and the eastern coastal states from Maine to South Carolina.

In Canada, *Rhizina undulata* occurs in British Columbia, Saskatchewan, Ontario, New Brunswick, and Quebec. Reports from British

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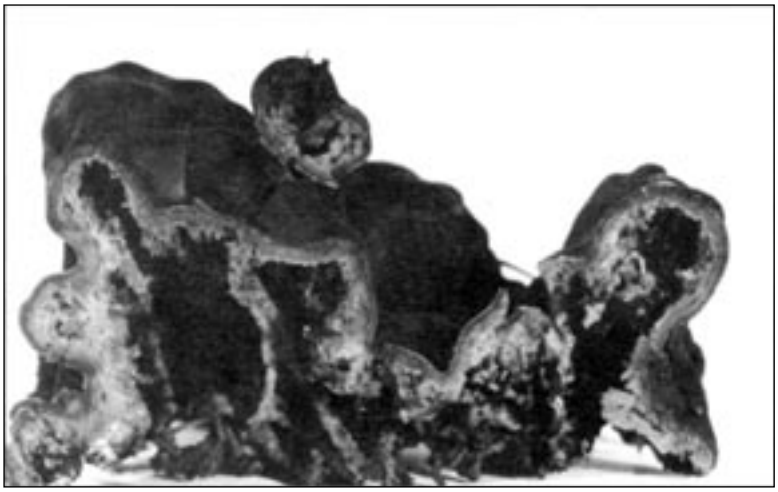
Columbia indicate that fruiting predominantly occurs in wetter areas of the Prince Rupert, Nelson, and Prince George forest regions, the southwest coast of the mainland, and Vancouver Island. These regions largely correspond to the Coastal Western Hemlock and Interior Cedar Hemlock biogeoclimatic subzones.

Life History

Rhizina undulata is facultatively parasitic, and may persist as a weak saprophyte once established in a food base such as dead roots or wood. Fruiting bodies (apothecia) may appear from May to November, but are most common in late summer and fall in wet years. Apothecia develop at least 15 weeks after a burn and are capable of releasing ascospores throughout the growing season; they can even remain viable after being frozen for short periods. Ascospores are wind-borne for short distances before settling on the soil where they can remain dormant and viable for up to 2 years. Heat stimulates spore germination, and under laboratory conditions germination percentages were highest when ascospores were heated at 37° for 3 days. An average of only 5% of the ascospores germinated without heat treatment.

Under natural conditions, narrow zones peripheral to and underneath burned sites attain temperatures that stimulate germination, while in hotter areas ascospores and mycelium are destroyed. *Rhizina* will not become established in burned areas unless ascospores were present prior to burning, the soil was acidic, and live conifer roots were present. The fungus proliferates after fire not only because of these conditions, but also because the fire acts as a soil sterilant, eliminating more aggressively saprophytic fungi that would otherwise become established first.

The mycelium of *R. undulata* can form whitish to yellowish, branching, root-like strands up to 1-2 mm thick. These rhizoids ramify from the food bases through the soil at a rate of up to 2.5 m/yr, and it has been demonstrated that removal of the food base stops their growth. When rhizomorphs contact a susceptible conifer root, the root becomes colonized by the fungus. Branching, whitish to yellowish mycelial strands may be seen on the root surface. Penetration usually takes place at the lenticels, where a thick mycelial pad develops. The lenticels become resin-soaked and necrotic as the fungus spreads into adjacent root tissue. In vitro experiments have shown that at low temperatures (10°C), *R. undulata* reduces conifer seed germination, probably by infecting seed via cracks in the seed coat before radical emergence.



Vertical section of a fruiting body

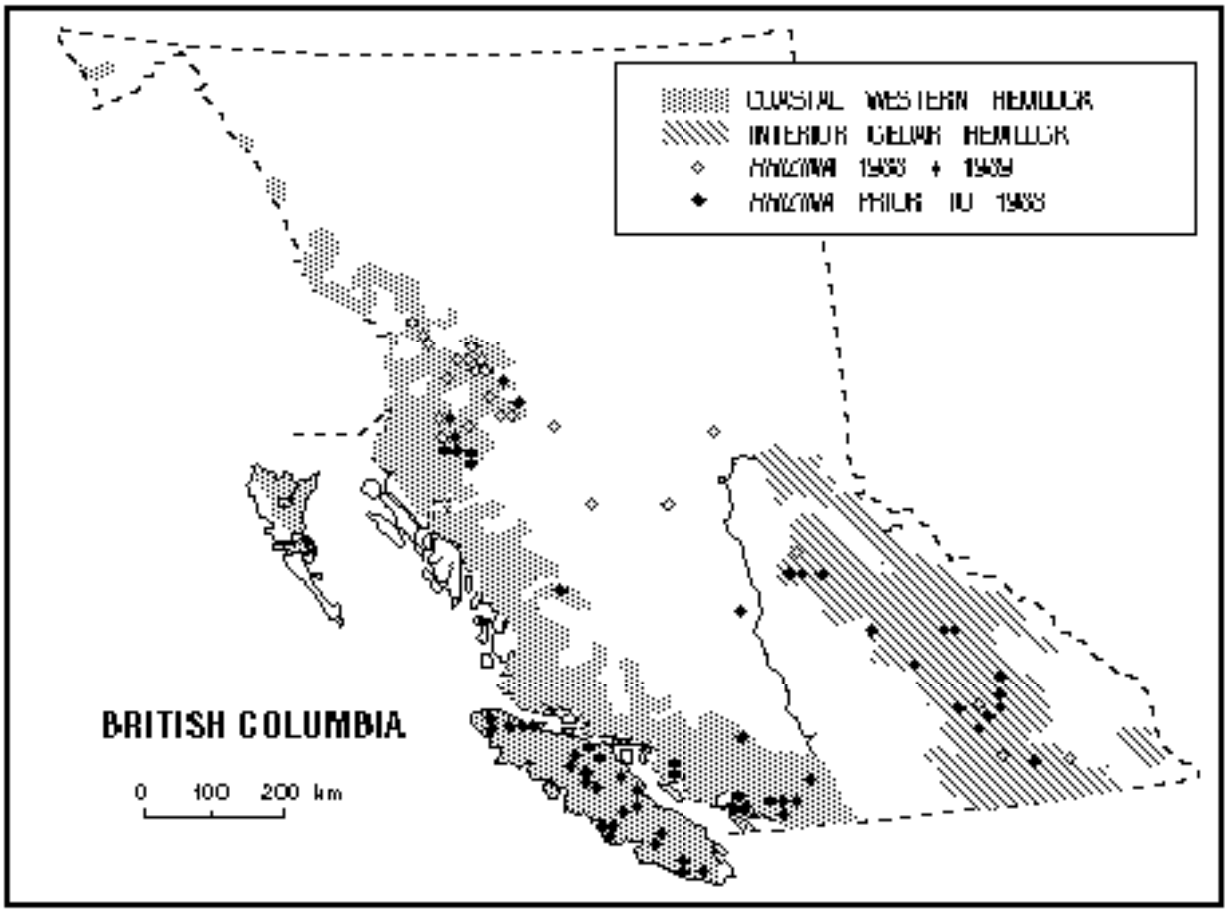
Symptoms and Identification

Diagnosis of Rhizina root rot is difficult unless fruiting bodies are found within 0.5 m of the dead host. The presence of apothecia is especially necessary when diagnosing seedling mortality, as mycelium on seedling roots usually does not persist after seedling death. Seedlings often appear to be girdled at and below the soil line, and the girdled areas take on the appearance of beetle galleries. Attempts to culture the fungus are often unsuccessful, perhaps because the fungus is rapidly overgrown by more vigorous soil saprophytes.

Other host symptoms such as discolored foliage indicate stress brought on by root decay, and are indistinguishable from symptoms of other root rots or drought.

All of the environmental factors influencing the pathogenicity of *Rhizina undulata* are not yet known. Fruiting bodies can frequently be found adjacent to apparently healthy seedlings, so the presence of apothecia alone does not necessarily indicate Rhizina root rot was the sole cause of death.

Apothecia of *Rhizina undulata* are characterized by their dull chestnut-brown to blackish color, tough flesh, undulating surface, and yellowish to ochre undersurface bearing numerous branched, root-like rhizoids. Apothecia have a whitish to yellowish margin when young, and turn black when overmature. Mature fruiting bodies may be up to 6 cm wide; one or more may coalesce, and thus appear even larger. Apothecia often develop above dying roots or burned wood in the soil.



Correspondence of biogeoclimatic zones with incidence of *Rhizina undulata* in British Columbia

Damage

No studies on the economic impact of Rhizina root rot have as of yet been conducted. In western Great Britain, greatest damage occurs to Sitka spruce (*Picea sitchensis*) where large groups are killed around fires lit during thinning operations. Individual outbreaks around fire sites frequently covered areas reaching 0.1-0.2 ha in size. In the Netherlands, species of pine are most commonly affected; both seedlings and trees in age classes from 20-50 years may be attacked. Loss of Japanese black and red pines to group dying are significant in Japan. In South Africa, government agencies in the Eastern Transvaal stopped slash burning in 1975 due to heavy losses of newly planted pine.

In British Columbia, loss due to Rhizina root rot was first recorded in 1967 when Douglas-fir planted near Mission City suffered 15% mortality and an 80% loss was experienced near Powell River. Subsequent surveys showed that damage was slightly reduced the following year and nonexistent thereafter.

Although fruiting bodies were detected occasionally, disease incidence was only sporadically reported until another widespread outbreak in 1988-1989. Damage in these two years was significant to Douglas-fir, western hemlock, Sitka spruce, lodgepole pine, and Engelmann spruce in wetter sites of the Prince Rupert, Nelson and Prince George forest regions.

Seedling mortality was highest in the Prince Rupert Region where in 1988 an outbreak was discovered. In 1989, up to an additional 17% of the seedlings were killed on 10 sites first infected in 1988. Surveys in 1989 showed that an average of 46% of the western hemlock (range 2 to 74%) were killed in five plantations; 30% of the lodgepole pine (range 1 to 69%) at 16 sites; 22% of the Sitka spruce were killed at seven sites, and 11% of the western red cedar were killed at three sites.

Conversely, a 1972 report from Western Oregon and Washington indicated that *R. undulata* fruiting bodies were abundant on recently burned and planted clearcuts, but that seedling mortality associated with the fungus was minimal. Apothecia also were common in 1987 in several cutblocks north of Hazelton in the Prince Rupert Forest Region of British Columbia, but there was no damage to spruce and pine seedlings.

Control

In Europe where group dying is prevalent, the banning of bonfires is effective in preventing Rhizina root rot. Trenches (0.3 m deep x 0.3 m wide) around burned sites help prevent radial spread of the fungus.

In British Columbia and other areas where seedling death occurs in replanted, slash-burned sites, several practices may be used to assess and prevent future occurrences of disease. Immediate replanting is possible in regions such as the dry interior where fruiting of *Rhizina* is sporadic. In wetter regions where *Rhizina* fruits abundantly, loss due to root rot may be greatly reduced if planting is delayed for at least two years, although such practices have drawbacks such as increased weed competition. If burning has occurred from 10 to 16 months earlier, a survey for fruiting bodies prior to planting would indicate if planting should be further delayed. Avoiding planting sites immediately adjacent to food bases such as stumps and large pieces of burned wood might also prevent spread of the fungus.

Chemical or biological control methods are not known at this time.

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* Copies of this report are available for study at the library of the Pacific Forestry Centre in Victoria, British Columbia.

Additional Information

Additional copies of this and other leaflets in this Forest Pest Leaflets series, as well as additional scientific details and information about identification services, are available by writing to:

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