EPPO Datasheet: *Cronartium quercuum*

Last updated: 2024-09-16

IDENTITY

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Preferred name: *Cronartium quercuum*
Authority: (Berkeley) Miyabe ex Shirai
Taxonomic position: Fungi: Basidiomycota: Pucciniomycotina: Pucciniomycetes: Pucciniales: Cronartiaceae
Other scientific names: *Cronartium asclepiadaceum var. quercuum* Berkeley, *Cronartium cerebrum* (Peck) Hedgcock & W.H.Long, *Cronartium harknessii* (J.P. Moore) E. Meinecke, *Endocronartium harknessii* (J.P. Moore) Hiratsuka, *Peridermium cerebrum* Hedgcock & W.H.Long, *Peridermium giganteum* Mayr, *Peridermium harknessii* J.P. Moore, *Peridermium mexicanum* Arthur & F. Kern
Common names: Eastern gall rust of pine, Western gall rust of pine, pine gall rust
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EPPO Categorization: A1 list
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EPPO Code: CRONQU

Notes on taxonomy and nomenclature

Cronartium quercuum causing the Eastern gall rust of pine was initially observed on *Quercus nigra* in the United States (Shirai, 1899). Initially, three North American *Cronartium* species, *C. fusiforme*, *C. strobilinum*, and *C. conigenum*, were regarded as synonyms of *C. quercuum* due to morphological similarities (Arthur, 1934). However, some taxonomists, including Cummins (1962), and Peterson (1973) considered these species to be distinct, and this was subsequently confirmed by molecular phylogenetic studies (Zhao *et al*., 2022).

Based on differences in aecial hosts, it has also been considered that *C. quercuum* is a species complex that comprises several *formae speciales* (Burdsall and Snow, 1977; Kuhlman and Kaneko, 1991): *C. quercuum* f. sp. *banksiana* (on *Pinus banksiana*), *C. quercuum* f. sp. *virginiana* (on *P. virginiana*) and *C. quercuum* f. sp. *echinatae* (on *P. echinata*), and *C. quercuum* f. sp. *fusiforme* (on *P. taeda* and *P. elliottii*). The latter is now considered to be a distinct species: *C. fusiforme* (as explained above).

A population of pine gall rust in Asia, initially attributed to *C. quercuum*, was found to be a separate species, *C. orientale* (Kaneko, 2000), and this was confirmed by molecular phylogenetic analyses (Zhao *et al*., 2022). In these phylogenetic studies, *C. quercuum* forms a distinct clade, including its 'endotype relatives', once identified as *Endocronartium harknessii* (Hiratsuka, 1969). Therefore, the Western gall rust of pine, *C. harknessii* (formerly placed in *Endocronartium*) which is an asexual and autoecious form (only found on *Pinus* spp.) has been synonymized with *C. quercuum*. In this document we will refer to the heteroecious form as *C. quercuum sensu stricto.*

Delimitation of species boundaries among *Cronartium* gall rusts is a challenging issue due to their morphological similarities on the aecial host and variation in the life cycles. The numerous changes which have been made to the species delineation of *C. quercuum* have created uncertainties about past data, in particular on geographical distribution and host range.

HOSTS

Cronartium quercuum alternates between the aecial host - *Pinus* spp. of the subsections Australes and Pinus, and the telial host - *Quercus* spp and *Castanea* spp. However, one of its forms (formerly known as *C. harknesii*) is autoecious and can complete its life cycle solely on *Pinus* species.

The most important aecial hosts of *C. quercuum* in North America are two- and three-needled *Pinus* spp., of which the most economically and ecologically important is jack pine (*P. banksiana*), across Central and Eastern Canada. The autoecious form causes economic losses on lodgepole pine (*Pinus contorta*). The pathogen is also reported on shortleaf pine (*P. echinata*) and Virginia pine (*P. virginiana*) in the North-Central and Eastern USA. The European Scots pine (*P. sylvestris*), widely planted in North America, is susceptible. Other *Pinus* spp. are attacked to a limited extent in different parts of North America: western yellow pine (*P. ponderosa*) planted in the Eastern USA, Table Mountain pine (*P. pungens*), red pine (*P. resinosa*) and pitch pine (*P. rigida*) in the Eastern USA, sand pine (*P. clausa*) and spruce pine (*P. glabra*) in the South-Eastern USA. Records on slash pine (*P. elliottii*) and loblolly pine (*P. taeda*) probably refer to *C. fusiforme*. In Mexico, other species are recorded as hosts (*P. leiophylla* var. *chihuahuana*, *P. montezumae*). The European species Austrian pine (*P. nigra*) has been found to be susceptible in North America. The main potential host in the EPPO region would appear to be *P. sylvestris*, and possibly also *P. nigra.*

The telial hosts in North America are in the Fagaceae family, mainly *Quercus* spp., of the Section Lobatae (red oak group) and generally not in the Section Quercus (white oak group). A common telial host species is the northern red oak (*Q. rubra*). Reporting *C. quercuum* on its telial host is complicated by the fact that *C. quercuum* cannot be distinguished from *C. fusiforme* on the telial host without molecular testing; therefore, many records of *C. quercuum* on telial hosts could have been confounded with *C. fusiforme*. North American *Castanea* spp. such as *C. dentata* and *C. pumila* have also been recorded as hosts. Despite one confirmed report on *Q. rubra* in Honduras (Zhao *et al*., 2022), the situation concerning telial hosts in Central America is not clear. Host records from Asia (e.g. *Q. serrata*, *Castanopsis*) most probably correspond to other *Cronartium* species (likely *C. orientale*, and *C. strobilinum*).

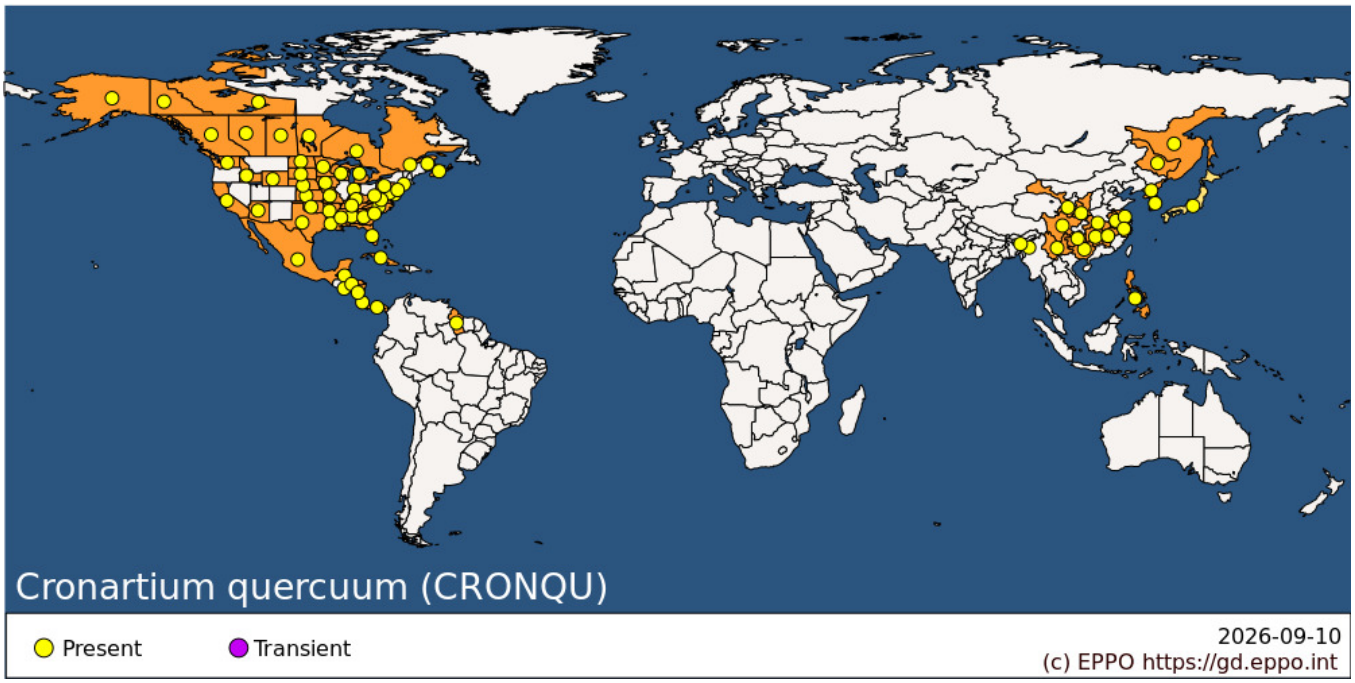
The host list presented below belongs to *C. quercuum sensu lato,* and is mainly based on a literature review (Arthur, 1934; CABI, 2021, Gäumann, 1959; Hiratsuka *et al*., 1992; Kuprevich and Ulyanishchev, 1975) and herbarium records (MyCoPortal, 2024). This list needs to be verified and updated by further study, mainly through molecular techniques to confirm the identity of the pathogen.

Host list: *Castanea dentata, Castanea pumila, Castanopsis, Pinus banksiana, Pinus caribaea, Pinus clausa, Pinus contorta, Pinus echinata, Pinus elliottii, Pinus glabra, Pinus halepensis, Pinus lawsonii, Pinus leiophylla, Pinus mugo, Pinus muricata, Pinus nigra, Pinus pinaster, Pinus ponderosa, Pinus pungens, Pinus radiata, Pinus resinosa, Pinus rigida, Pinus serotina, Pinus sylvestris, Pinus taeda, Pinus teocote, Pinus virginiana, Quercus acutissima, Quercus agrifolia, Quercus alba, Quercus bicolor, Quercus chapmanii, Quercus coccinea, Quercus falcata, Quercus macrocarpa, Quercus marilandica, Quercus michauxii, Quercus mongolica, Quercus muehlenbergii, Quercus pagoda, Quercus phellos, Quercus rubra, Quercus serrata, Quercus velutina*

GEOGRAPHICAL DISTRIBUTION

It seems that *C. quercuum sensu stricto* is restricted to North, Central and South America. In North America, *C. quercuum* mainly occurs over a range from the Great Lakes area southeast awards, in the areas of mainly deciduous forest where the telial hosts (oaks and chestnuts) are abundant. The recent molecular studies (Zhao *et al*., 2022) confirmed the presence of the species in Canada, the USA and Honduras.

The distribution map below belongs to *C. quercuum sensu lato* and is based on literature review (Arthur, 1934; CABI, 2021; Gäumann, 1959; Hiratsuka *et al*., 1992, Kuprevich and Ulyanishchev, 1975) and herbarium records (MyCoPortal, 2024). However, past reports of *C. quercuum* in Asia may be referring to different species, in particular to *C. orientale* which has been documented in China, Japan, the Republic of Korea, and the Russian Far East (Kaneko, 2000; Zhao *et al.*, 2022). Further studies are needed to clarify the distribution of *C. quercuum*, mainly through molecular techniques to confirm the identity of the pathogen.



EPPO Region: Russian Federation (Far East)
Asia: China (Anhui, Gansu, Guangxi, Guizhou, Heilongjiang, Hubei, Hunan, Jiangsu, Jiangxi, Shaanxi, Sichuan, Yunnan, Zhejiang), India (Manipur, Meghalaya), Japan, Korea, Democratic People's Republic of, Korea, Republic of, Philippines
North America: Canada (Alberta, British Columbia, Manitoba, New Brunswick, Northwest Territories, Nova Scotia, Ontario, Québec, Saskatchewan, Yukon Territory), Mexico, United States of America (Alabama, Alaska, Arizona, Arkansas, California, Connecticut, Delaware, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, North Carolina, North Dakota, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, Washington, West Virginia, Wisconsin, Wyoming)
Central America and Caribbean: Belize, Costa Rica, Cuba, El Salvador, Honduras, Nicaragua, Panama
South America: Guyana

BIOLOGY

Spermogonia and aecia are produced in the spring and early summer, one to several years after infection of the aecial hosts. Aeciospores, produced in the aecia, are windborne and may be carried over long distances. These spores cannot re-infect the aecial host on which they were produced but can infect the telial host (except for the autoecious form). Approximately two weeks after infection of the telial host by aeciospores, uredinia develop on the abaxial leaf surface. Uredinia are continuously produced throughout the summer and urediniospores produced therein reinfect the telial hosts. Urediniospores are windborne and may be carried over long distances. Telia are produced in late summer and the teliospores germinate in place to produce basidiospores. Basidiospores are sensitive to drying and solar radiation and mostly released in high humidity during night time (Sinclair and Lyon, 2005). Dispersal is usually limited to an area within 1.5 km of the telial host.

The windborne basidiospores infect the first-year pine needles during summer and autumn (Sinclair and Lyon, 2005). Host infection occurs by direct penetration of the branches or stems, following basidiospore germination. This results in the production of swellings or galls that are typical for this rust. The time between infection of the aecial hosts and the formation of spermogonia ranges from several weeks to more than two years. Cross-fertilisation of the spermogonia occurs by insects carrying the spermatia or through hyphal anastomoses (Sinclair and Lyon, 2005). Spermogonia on the aecial hosts are produced on the galls on branches and stems. After several weeks (up to one year), aecia are produced where spermogonia previously appeared, producing yellow to orange (rarely white) aeciospores. The aeciospores have thick walls, tolerate U.V. light and desiccation and can disperse over long distances (Sinclair and Lyon, 2005).

The fungus overwinters in branches, stems and galls of *Pinus* spp. The fungus is perennial in pine tissue after

infection and grows into the outer rings of sapwood (Sinclair and Lyon, 2005).

DETECTION AND IDENTIFICATION

Symptoms

Symptoms on *Pinus* spp. (aecial host) are difficult to see on the needles. Usually, the first visible symptoms are the swellings on branches or stems that become spherical galls with a rough appearance. Aeciospores and/or spermatia, produced in an orange spermatial fluid, are produced on these galls in the spring. The needles of affected limbs can become stunted and fall. The galls rarely cause mortality directly, except if they occur on the main stem, in which case they can cause stem breakage. Severely infected trees may have hundreds of galls on their branches and stem. On the telial host, uredinia and/or telia can be seen on the abaxial surface of leaves from the early summer until the autumn.

Morphology

Spermogonia intracortical, on trunks or branches, Spermatia hyaline, oblong-elliptic, ovoid or tear-shaped; 4-5 x 2-3 µm. Aecia intracortical, erumpent, on trunks or branches, 3-10 mm long, with thick cerebroid peridium, peridia consisting of two cell layers. Aeciospores 15-23 x 23-33 µm, obovoid or ellipsoid, wall hyaline, 2.5-3.5 µm thick, coarsely verrucose except for the base. Uredinia hypophyllous, scattered or in groups, small, yellow, covered by dome-shaped peridium. Urediniospores obovoid or ellipsoid, 14-21 x 17-32 µm, with hyaline, 2-3 µm thick, echinulate walls, germ pores scattered. Telial hypophyllous, in a filamentous column, 2-3 mm long, 100-175 µm wide, brown, straight or curved. Teliospores elongated or fusoid, 14-21 x 29-43 µm, walls almost hyaline, smooth, 2-3 µm thick. Basidiospores yellow-orange, ellipsoid; 4 x 6 µm, length-to-width ratio 1.3-1.7.

Detection and inspection methods

Inspection of seedlings for the presence of swellings on pine trunks or branches could reveal the potential presence of the pathogen on seedlings and saplings. The best way to detect the pathogen in the absence of visible symptoms is by DNA based tests. A PCR test that was initially designed to target *C. harknessii* can detect *C. quercuum* f. sp. *banksiana* (Ramsfield and Vogler, 2010). This test can discriminate between *C. quercuum* f. sp. *banksiana* and all other *C. quercuum* formae speciales as well as *C. fusiforme*. Two *Cronartium* genus tests can be used for the detection of multiple species of phytosanitary concern, including *C. quercuum, C. coleosporioides, C. comandrae, C. comptoniae, C. fusiforme* and *C. ribicola* (Bergeron *et al*., 2019).

PATHWAYS FOR MOVEMENT

Cronartium quercuum can be carried into new areas on plants for planting of the aecial hosts (*Pinus* spp.), as has occurred in parts of the USA. *Cronartium* spp. can be carried over considerable distances as wind-borne aeciospores (e.g. more than 400 km for *C. ribicola;* Maloy, 2003) and can survive considerable periods in the airborne state (Chang & Blenis, 1989). The long incubation period of *Cronartium* rusts means that latent infections easily go undetected unless post-entry quarantine is applied. As *Cronartium* spp. require live host tissues to survive, the risks associated with movement of non-squared coniferous wood seems to be limited (EFSA, 2018). As the alternate hosts of *C. quercuum* are deciduous and infection is restricted to the leaves, there should be no risk in shipment of dormant material. Similarly, there is no known risk in movement of *Pinus* seeds or pollen.

PEST SIGNIFICANCE

Economic impact

The *Cronartium* rusts cause very important diseases throughout the world, resulting in malformation, reduced vigour and death of trees and seedlings of the aecial hosts. However, their abundance depends primarily on the abundance

of the alternate host (Gross *et al.*, 1983). Impact of the autoecious forms can be greater as they can spread without the telial hosts. *C. quercuum* is damaging in nurseries and young plantations of *Pinus* in North America, where it has been recorded to cause 25% losses on *P. sylvestris*. In general, however, it attracts much less attention in the North American literature than the closely related *C. fusiforme* the autoecious form. There is no particular indication of economic importance in Central America. If *C. quercuum* were introduced to Europe, it is possible that native hosts such as *P. sylvestris* could be more susceptible to the pathogen, as is often the case for non-co-evolved host and pathogens. On its telial hosts, *C. quercuum* affects only the leaves without causing severe damage, and is thus of no direct practical importance.

Control

The disease can be controlled by removing infected material, either by pruning infected branches on the aecial hosts (*Pinus* spp.) or by eliminating infected trees or seedlings. Removing the alternate host is not a viable option to control *C. quercuum*, as the alternate host species, *Quercus* spp., are crucial both ecologically and economically as forest trees, , though nurseries should be located away from infection sources. The use of fungicides is feasible in nurseries or ornamental trees. Research on triadimefon demonstrated that foliar sprays can both prevent infections for up to 14 days after application and eliminate infections that developed up to 14 days prior to spraying (Rowan, 1984). Breeding for resistance is probably the best approach to control this disease (Burnes *et al.*, 1989). Successful breeding programs have identified resistance genes in pines to other closely related rusts such as in fusiform rust (*C. fusiforme*) and western gall rust (Yanchuk *et al.*, 1988), where coevolution with the host has been demonstrated (MacAllister *et al*., 2022).

Phytosanitary risk

The risk presented by non-European *Cronartium* species to the EPPO region is classically exemplified by reference to the quarantine pest *C. ribicola* (Phillips, 1988), which has made it almost impossible to grow *P. strobus* commercially in most areas in Europe and North America to which the fungus was introduced from Asia.

The potential risk of establishment and spread of introduced *Cronartium* spp. depends on the prevalence of the telial hosts concerned. The telial hosts of *C. quercuum* are, in North America, mainly *Castanea* and *Quercus* species indigenous to that continent. No information seems to be available on the susceptibility of European species of these genera. The most widespread European oaks are "white oaks" (subgenus Quercus), and thus belong to the group which is not susceptible to *C. quercuum* in North America. North American red oaks are planted to a limited extent in Europe (e.g. especially *Q. rubra*). The European evergreen oaks (e.g. *Q. ilex*) could be susceptible, but there is no direct evidence of this. The Asian telial host *Q. serrata* is a rarely cultivated garden ornamental in Europe. It is not clear how many other Asian species may be telial hosts, but in general Asian oaks are not commonly grown in Europe. The most important European pine (*P. sylvestris*) has suffered serious losses from *C. quercuum* at the nursery stage in North America. However, establishment of *C. quercuum* in Europe would also depend on the susceptibility of some European *Castanea* or *Quercus* species. Accordingly, *C. quercuum* can be considered to present a potential risk for the EPPO region.

PHYTOSANITARY MEASURES

Since symptoms may not be apparent for many years after infection, the only practical safeguard is to prohibit entry of the *Pinus* host plants for planting from countries where *C. quercuum* occurs. Other phytosanitary measures could require that these plants are produced in pest-free areas or pest free place of production (with its immediate vicinity also free from the pest during the last growing season). *Castanea* and *Quercus* spp. should only be imported in a dormant state, without leaves. Wood of *Pinus* should originate from pest-free areas, or should be debarked or should have been appropriated treated (EPPO 2017ab, 2010).

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Datasheet history

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