EPPO Datasheet: *Melampsora medusae*

Last updated: 2021-10-21

IDENTITY

Preferred name: *Melampsora medusae*
Authority: von Thümen
Taxonomic position: Fungi: Basidiomycota: Pucciniomycotina: Pucciniomycetes: Pucciniales: Melampsoraceae
Other scientific names: *Caeoma faulliana* Hunter, *Melampsora albertensis* Arthur, *Uredo medusae* (von Thümen) Arthur
Common names: conifer/poplar rust, leaf rust of poplar
view more common names online...
EPPO Categorization: A2 list
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EPPO Code: MELMME

more photos...

Notes on taxonomy and nomenclature

Melampsora medusae Thüm. and *M. albertensis* Arth. were recognized as distinct species throughout the first half of the 20th century (Sinclair & Lyon, 2005), and then synonymized by Ziller (1965) as *M. medusae*. Nevertheless, differences in urediniospore morphology and telial host range prompted Shain (1988) to split *M. medusae* into two formae speciales: *Melampsora medusae* f. sp. *deltoidae* (later renamed '*deltoidis'*) is pathogenic primarily on *Populus deltoides* (section *Aigeiros*), whereas *M. medusae* f. sp. *tremuloidae* (or '*tremuloidis')* is pathogenic primarily on *Populus tremuloides* (section *Populus*) and produces slightly smaller urediniospores (Shain 1988). Furthermore, a recent multigene phylogeny study showed that these two formae speciales are distinct phylogenetic lineages and therefore should be considered again as distinct species (Vialle *et al.* 2013).

HOSTS

The telial hosts of *M. medusae* f. sp. *deltoidis* are *Populus* spp. belonging to the section *Aigeiros* and *Tacamahaca*, especially *P. balsamifera*, *P. deltoides*, *P. nigra*, and their hybrids and cultivars, whereas the only telial host of *M. medusae* f. sp. *tremuloidis* with reported infection in nature is *P. tremuloides*, belonging to the section *Populus*. The aecial hosts are conifers in the family Pinaceae. In North America, *Larix laricina*, *L. occidentalis*, *Pseudotsuga menziesii*, *Pinus contorta* and *P. ponderosa* are the principal hosts for the aecial state of the fungus found infected in nature (Ziller, 1965; 1974). In addition, many other conifers, such as *Larix* spp., *Pinus* spp. *Abies* spp., *Tsuga mertensiana*, *Picea sitchensis*, have been artificially infected at the seedling stage. For more information, see Walker & Hartigan (1972) and Pinon (1986).

Telial hosts of *Melampsora medusae* f. sp. *deltoidis*

Host plant scientific name	Bibliographic reference	Comment
Populus deltoides	Ziller (1974)	Section *Aigeiros*
P. nigra	Walker *et al.* (1974)	Section *Aigeiros*
P. deltoides x *P. nigra*	Schipper & Dawson (1974)	Section *Aigeiros*
P. balsamifera	Walker *et al.* (1974)	Section *Tacamahaca*
P. maximowiczii	Hiratsuka (1939)	Section *Tacamahaca*
P. simonii	Sharma & Heather (1976)	Section *Tacamahaca*
P. deltoides x *P. balsamifera*	Schipper & Dawson (1974)	Intersectional
P. trichocarpa x *P. deltoides*	Van Kraayenoord (1984)	Intersectional
P. maximowiczii x *P. trichocarpa*	Van Kraayenoord (1984)	Section *Tacamahaca*
P. mexicana	Lloyd & Smith (2018)	Section *Abaso*
P. szechuanica	Zheng *et al.* (2019)	Section *Tacamahaca*
P. yunnanensis	Zheng *et al.* (2019)	Section *Tacamahaca*

Telial host of *Melampsora medusae* f. sp. *tremuloidis*

Host plant scientific name	Bibliographic reference	Comment
Populus tremuloides	Ziller (1955)	Section *Populus*

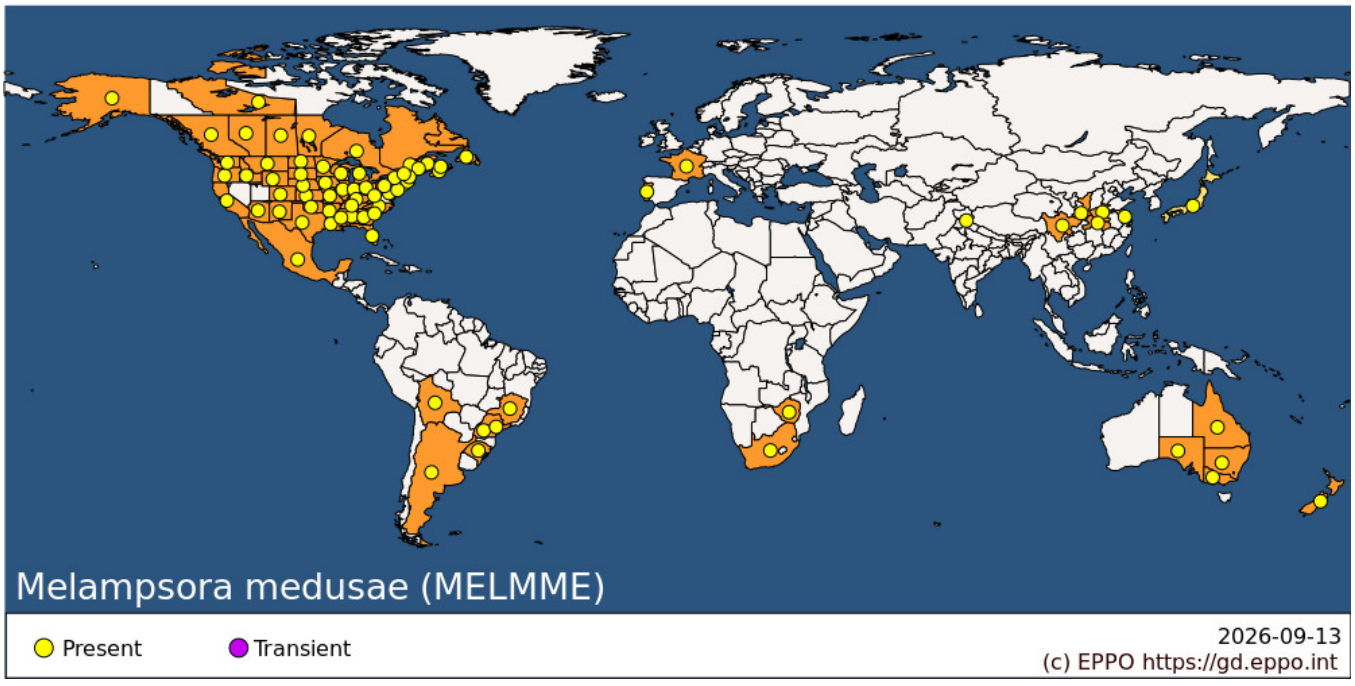
Aecial hosts of *Melampsora medusae* with reported infection in nature

Host plant scientific name	Bibliographic reference
Larix laricina	Ziller (1974)
L. occidentalis	Ziller (1974)
L. decidua	Spiers (1975)
Pseudotsuga menziesii	Molnar & Sivak (1964)
Pinus contorta	Ziller (1974)
P. ponderosa	Molnar & Sivak (1964)

Host list: *Larix decidua*, *Larix laricina*, *Larix occidentalis*, *Larix*, *Pinus contorta*, *Pinus ponderosa*, *Pinus*, *Populus balsamifera*, *Populus deltoides*, *Populus maximowiczii*, *Populus mexicana*, *Populus nigra*, *Populus simonii*, *Populus szechuanica*, *Populus tremuloides*, *Populus x canadensis*, *Populus x generosa*, *Populus yunnanensis*, *Populus* × *ontariensis*, *Populus*, *Pseudotsuga menziesii*

GEOGRAPHICAL DISTRIBUTION

M. medusae is indigenous to North America. Based on the poplar clones infected outside North America, it appears that only *M. medusae* f. sp. *deltoidis* has spread from there to other continents (Hiratsuka, 1939; Dupias, 1965; Wilkinson & Spiers, 1976; Zheng *et al*., 2019). There is no evidence that *M. medusae* f. sp. *tremuloidis* has ever been found on any other continent. Although *M. medusae* f. sp. *deltoidis* was first reported from Spain about one century ago (Fragoso, 1925), it has failed to become invasive in Europe and its distribution is restricted to Southwestern Europe (Pinon, 1986; Desprez-Loustau *et al*., 2007). The report from Uruguay (Walker, 1975) is based on a single doubtful record, which may refer to other *Melampsora* spp.



EPPO Region: France (mainland), Portugal (mainland)
Africa: South Africa, Zimbabwe
Asia: China (Henan, Hubei, Jiangsu, Shaanxi, Sichuan), India (Himachal Pradesh), Japan
North America: Canada (Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland, Northwest Territories, Nova Scotia, Ontario, Prince Edward Island, Québec, Saskatchewan), Mexico, United States of America (Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Idaho, Illinois, Indiana,

Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Vermont, Washington, West Virginia, Wisconsin, Wyoming)
South America: Argentina, Bolivia, Brazil (Minas Gerais, Parana, Rio Grande do Sul, Sao Paulo)
Oceania: Australia (New South Wales, Queensland, South Australia, Victoria), New Zealand

BIOLOGY

M. medusae f. sp. *deltoidis* is heteroecious but, in mild climates, the urediniospore stage is able to overwinter in buds and bark of *Populus* spp. without the need for an alternate host (Walker *et al.*, 1974; Wilkinson & Spiers, 1976). Basidiospores from overwintered telia on *Populus* infect conifer needles in spring. Pycnia and aecia are produced on these needles, and aeciospores, which may be carried over long distances in the wind, infect susceptible poplars in the summer; these spores cannot reinfect the conifer hosts. The urediniospores produced on poplars can also be carried long distances by wind (Wilkinson & Spiers, 1976). Urediniospores are the main source of inoculum in the Southern Hemisphere and warmer regions of the Northern Hemisphere, in which the overwintering of teliospores with the subsequent spring formation of basidiospores and alternation on coniferous hosts has not yet been observed (Walker, 1975; Sinclair and Lyon, 2005). In its native range (North America), it was shown that *M. medusae* f. sp. *deltoidis* alternates in the northern larch-poplar area of sympatry, and then spreads asexually to southern regions without larch (Bourassa *et al.*, 2007).

The penetration of poplar leaves by *M. medusae* f. sp. *deltoidis* is accomplished by germ tubes which are formed by the urediniospores. These germ tubes follow the leaf surface and enter the leaf through the stomata with or without forming appressoria. Substomatal vesicles are formed which extend and delimit several cells, of which one functions as the haustorial mother cell; this forms a haustorium and finally establishes the host infection (Spiers & Hopcroft, 1988).

Wet, warm and humid weather conditions favour rapid spread of the disease. For more information, see Hepting (1971), McMillan (1972), Ziller (1974), Spiers & Hopcroft (1985; 1988).

Studies on different *M. medusae* f. sp. *deltoidis* isolates showed the occurrence of several distinct races of the fungus which also varied in their aggressiveness (Prakash & Thielges, 1987; Newcombe *et al.*, 2000). This diversity of virulence is mainly influenced by temperature (Prakash & Thielges, 1989), but also by geographical location. In experiments, isolates from a northern latitude were more aggressive than isolates sampled at a more southern latitude (Prakash & Thielges, 1987).

The introduction of *M. medusae* f. sp. *deltoidis* into the southern hemisphere also resulted in its hybridization with the Eurasian poplar rust fungus *M. laricis-populina*, which was also introduced, resulting in the hybrid taxon *M.* x *medusae-populina* (Spiers & Hopcroft, 1994; Frey *et al.*, 2005). Similarly, upon its introduction in the Pacific Northwest of the USA, *M. medusae* f. sp. *deltoidis* has hybridized with the native rust fungus *M. occidentalis*, resulting in the hybrid taxon *M.* x *columbiana* (Newcombe *et al.*, 2000, 2001).

DETECTION AND IDENTIFICATION

Symptoms

On Populus

The first symptoms of infection are yellow uredinia, which appear 1-2 weeks after infection on the underside of the leaves (or both sides, in heavy infections). Lower leaves are affected first and then infection spreads over the whole tree; the leaves desiccate and fall prematurely. Trees may be stripped of all foliage within 3 weeks. Similar symptoms may be caused by other *Melampsora* spp. (*M. laricis-populina, M. allii-populina*) which are widespread on poplars in Europe.

On conifers

As for other conifer-alternating poplar rusts, the impact of *M. medusae* on its aecial host is much lower than on the telial host. The current year's needles become discoloured and necrotic and bear pycnia and aecia. The infected needles die and fall.

For more information, see Ziller (1955), Hepting (1971), McMillan (1972), Walker & Hartigan (1972), Sharma & Heather (1977), Vialle *et al.* (2011).

Morphology

In general, size measurements of *M. medusae* urediniospores are not sufficient for positive identification. However, the presence of smooth (non-echinulate) patches at the equator of urediniospores is a highly diagnostic feature of *M. medusae*, since no other *Melampsora* species infecting poplar shares this feature (Vialle *et al.*, 2011). Therefore, morphological diagnosis is quite straightforward (Desprez-Loustau *et al.*, 2007), but it remains time-consuming, especially for detecting a small amount of *M. medusae* urediniospores in a mixture with those of other more abundant *Melampsora* spp., which would be likely to be the case in Europe (EPPO Diagnostic Protocol PM 7/93). However, the two *formae speciales* of *M. medusae* cannot be distinguished with morphology since they share grossly identical morphological features and can only be distinguished according to their respective host range, or using a DNA-based method (see below).

Aeciospores are 16-21 x 19-26 µm, with wall bilaterally thickened (3-4 µm) on opposite sides. Urediniospores are ellipsoid or obovoid, with wall bilaterally thickened, and with smooth areas at the equator; the smooth areas are best seen when spores are trapped in air bubbles; therefore, when making mounts, the cover slip should be dropped on quickly to include as many bubbles as possible; use x40 objective and x10 eye-piece; varying size measurements are reported: 26-35 x 15-19 µm; 22-36 x 13-21 µm. This variability may result from the fact that urediniospores of *M. medusae* f. sp. *deltoidis* are larger than those of *M. medusae* f. sp. *tremuloidis* (Shain, 1988). Teliospores 10-15 x 29-45 µm, with wall evenly thick; however, their diagnostic value is too uncertain to be of use.

For more information, see EPPO Diagnostic Protocol PM 7/93 (under revision), Kraayenoord *et al.* (1974), Ziller (1974), Shain (1988), Vialle *et al.* (2011).

DNA-based identification and detection methods

The difficulties (i) to detect small amounts of *M. medusae* when mixed with other *Melampsora* species, and (ii) to distinguish *M. medusae* from other *Melampsora* species at the aecial stage prompted the development of several molecular identification and detection methods. Husson *et al.* (2013) developed a series of PCR primers targeting the ITS (Internal Transcribed Spacer) region of the rDNA to detect *M. medusae* f. sp. *deltoidis*, *M. laricis-populina*, and *M. allii-populina*. This method is species-specific, highly sensitive, and detects also *M. medusae* f. sp. *tremuloidis.* However the *M. medusae*-specific primers cross-react with two species infecting aspens, *M. laricis-tremulae* and *M. pinitorqua*. Boutigny *et al.* (2013a) developed a real-time PCR method also targeting the ITS region, which is highly specific for *M. medusae sensu lato* and highly sensitive. Boutigny *et al.* (2013b) also developed a second real-time PCR method targeting the large ribosomal RNA subunit (28S), which is highly specific for *M. medusae* f. sp. *deltoidis* and does not cross-react with *M. medusae* f. sp. *tremuloidis*, nor with *M. occidentalis.* In addition, two real-time PCR tests specific for *M. medusae sensu lato* were developed through whole-genome comparison (Bergeron *et al.*, 2019).

PATHWAYS FOR MOVEMENT

M. medusae has a high potential for natural spread. Urediniospores of the pathogen can be spread by wind over long distances. Many examples of aerial long-distance dispersal of rust spores across and even between continents have been documented (Brown & Hovmoller, 2002). For instance, Nagarajan & Singh (1990) stated that urediniospores of rust fungi, once they reach an altitude of 1.5-2.0 km, can spread a disease transatlantically and quoted the spread of coffee leaf rust, *Hemileia vastatrix*, from Angola to Brazil in 1966 as an example of this wind-borne transatlantic spread of rust fungi. Similarly, the dispersal pathway of the emerging Ug99 lineage of the wheat stem rust fungus *Puccinia graminis* f. sp. *tritici* from East Africa to Central Asia was modeled (Meyer *et al.*, 2017).

Successful airborne spread of *M. medusae* f. sp. *deltoidis* has been reported regarding the introduction of the fungus into New Zealand in 1973. From Australia, where the pathogen had been first recorded in 1972, the fungus spread 2000 km by wind to the islands of New Zealand where it was detected in March 1973 (Wilkinson & Spiers, 1976). High correlations were calculated between the wind patterns in this area and the infected sites in Australia and the newly detected infestation sites in New Zealand (Brown, 1984).

In international trade, the pathogen can also be spread on infected planting material of the various hosts, including on cuttings. In addition, it could also be theoretically spread on cut branches, although it is not known if such international trade exists.

PEST SIGNIFICANCE

Economic impact

Severe damage by *M. medusae* f. sp. *deltoidis* results from premature leaf drop and loss of vigour in young susceptible poplars. In New South Wales, Australia, the disease spread over 1200 ha in 6 weeks (Walker & Hartigan, 1972). The disease was very damaging in both Australia and New Zealand in the 1970s, where poplar has been introduced into a new environment. However, in eastern Canada where *M. medusae* f. sp. *deltoidis* is native, extensive damage has also been reported on poplars in nurseries and plantations as well as in natural forests.

M. medusae f. sp. *deltoidis* has been reported in southwestern France at sporadic intervals for more than 50 years but is rare and of no economic significance (Pinon & Frey, 2005; Desprez-Loustau *et al.*, 2007; Husson *et al.*, 2013). This may be due to environmental factors which seem to limit its spread, probably because of overwintering problems, host alternation and/or ecological constraints (Pinon, 1986). It should be recalled that the other European *Melampsora* spp., especially *M. laricis-populina*, cause very similar symptoms and damage in European poplar plantations, and have been, up till now, of much greater significance (Pinon & Frey, 2005).

M. medusae f. sp. *deltoidis* has spread rapidly in Australia and New Zealand and this emphasizes the potential threat to *Populus* spp. The susceptibility and uniformity of the poplar stands encountered may facilitate spread.

Control

Some resistant poplar cultivars are available and can be indirectly selected for resistance by the number and rate of closure of the stomata (Siwecky, 1974). Prakesh & Heather (1989) reported on the partial resistance of *P. deltoides* clones against two races of *M. medusae* f. sp. *deltoidis*, but also stressed the need to maintain a wide host diversity to manage the disease.

Phytosanitary risk

M. medusae f. sp. *deltoidis* is very damaging in part of its range, and susceptible poplars (e.g. *P. nigra*) are important tree species in the EPPO region, both for wood production and for ecosystems services. The isolates of *M. medusae* f. sp. *deltoidis* currently present in Europe do not seem aggressive and have had no tendency to spread over many decades; as such, they present little risk to other European countries. However, there is a risk that one of the known aggressive isolates of *M. medusae* f. sp. *deltoidis* may be introduced into the EPPO region, which could then cause serious losses, particularly in areas with a mild winter where no alternate host is required. Moreover, *M. medusae* has been shown to be able to hybridize with other *Melampsora* spp., especially *M. laricis-populina*, thus leading to the emergence of new fungal pathogen taxa and novel host?pathogen associations.

M. medusae f. sp. *tremuloidis* has only been recorded on the American aspen (*P. tremuloides*), a species which is only occasionally used as an ornamental in the EPPO region and is therefore a lower risk than *M. medusae* f. sp. *deltoidis*.

PHYTOSANITARY MEASURES

Import of plants for planting of conifers, and *Populus* with leaves, is prohibited in many EPPO countries (e.g. the EU, EFSA PHL Panel *et al.*, 2018).

To limit the risk of introduction of the rust via infected plant material, plants for planting (other than seeds) and cut branches (including Christmas trees) of *Larix*, *Picea*, *Pinus*, *Populus*, *Pseudotsuga* and *Tsuga* should have been grown in a pest free area for *M. medusae* or in a place of production which has been confirmed free from the rust during the preceding growing period (EPPO Standard PM 8/2 *Coniferae*; EPPO Standard PM 8/7 *Populus*).

It may be noted that the EU has recently revised the quarantine status of *M. medusae* and now only regulates *M. medusae* f. sp. *tremuloidis* as a quarantine pest (EFSA PHL Panel *et al.*, 2018; EU, 2019).

REFERENCES

Bergeron M-J, Feau N, Stewart D, Tanguay P, Hamelin RC (2019) Genome-enhanced detection and identification of fungal pathogens responsible for pine and poplar rust diseases. *Plos One* **14,** e0210952.

Bourassa M, Bernier L, Hamelin RC (2007) Genetic diversity in poplar leaf rust (*Melampsora medusae* f. sp *deltoidae*) in the zones of host sympatry and allopatry. *Phytopathology* **97,** 603-610.

Boutigny A-L, Guinet C, Vialle A, Hamelin R, Frey P, Ioos R (2013a) A sensitive real-time PCR assay for the detection of the two *Melampsora medusae formae speciales* on infected poplar leaves. *European Journal of Plant Pathology* **136,** 433-441.

Boutigny A-L, Guinet C, Vialle A, Hamelin RC, Andrieux A, Frey P, Husson C, Ioos R (2013b) Optimization of a real-time PCR assay for the detection of the quarantine pathogen *Melampsora medusae* f. sp. *deltoidae*. *Fungal Biology* **117,** 389-398.

Brown JS (1984) Recent invasions of Australia and New Zealand by pathogenic fungi and counter measures. *EPPO Bulletin* **14**, 417-428.

Brown JKM, Hovmoller MS (2002) Aerial dispersal of pathogens on the global and continental scales and its impact on plant disease. *Science* **297**, 537-541.

Desprez-Loustau M-L, Robin C, Reynaud G, Déqué M, Badeau V, Piou D, Husson C, Marçais B (2007) Simulating the effects of a climate-change scenario on the geographical range and activity of forest-pathogenic fungi. *Canadian Journal of Plant Pathology* **29,** 101-120.

Dupias G (1965) Les rouilles des peupliers dans les Pyrénées et le bassin sous-pyrénéen. *Bulletin de la Société Mycologique Française* **81,** 188-196.

EPPO Standard PM 7/93 Diagnostic protocol for *Melampsora medusae*. (under revision). Available at https://gd.eppo.int/taxon/MELMME/documents.

EPPO Standard PM 8/2 Commodity-speci?c phytosanitary measures for *Coniferae*. Available at https://gd.eppo.int/standards/PM8/

EPPO Standard PM 8/7 Commodity-speci?c phytosanitary measures for *Populus*. Available at https://gd.eppo.int/standards/PM8/

EU (2019) Commission Implementing Regulation (EU) 2019/2072 of 28 November 2019 establishing uniform conditions for the implementation of Regulation (EU) 2016/2031 of the European Parliament and the Council, as regards protective measures against pests of plants, and repealing Commission Regulation (EC) No 690/2008 and amending Commission Implementing Regulation (EU) 2018/2019. http://data.europa.eu/eli/reg_impl/2019/2072/oj

Fragoso RG (1925) Flora Iberica. II. Uredinales. Museo Nacional de Ciencias Naturales, Madrid, pp. 198–199.

Frey P, Gérard P, Feau N, Husson C, Pinon J (2005) Variability and population biology of *Melampsora* rusts on poplars, in *Rust diseases of willow and poplar,* eds. MH Pei & AR McCracken. Wallingford, UK, CAB International, 63-72.

Hepting GH (1971) Diseases of forest and shade trees of the United States. *Agricultural handbook* No. 386, pp. 209, 212, 299, 382, 387. Forest Service, US Department of Agriculture, USA.

Hiratsuka N (1939) Miscellaneous notes on the East Asiatic Uredinales with special reference to the Japanese species (VI). *Journal of Japanese Botany* **15**, 621-627.

Husson C, Ioos R, Andrieux A, Frey P (2013) Development and use of new sensitive molecular tools for diagnosis and detection of *Melampsora* rusts on cultivated poplar. *Forest Pathology* **43,** 1-11.

EFSA PLH Panel (EFSA Panel on Plant Health), Jeger M, Bragard C, Caffier D, Candresse T, Chatzivassiliou E, Dehnen?Schmutz K, Gilioli G, Grégoire JC, Jaques Miret JA, Macleod A, Navajas Navarro M, Niere B, Parnell S, Potting R, Rafoss T, Rossi V, Urek G, Van Bruggen A, Van Der Werf W, West J, Winter S, Boberg J, Gonthier P, Pautasso M (2018) Pest categorisation of *Melampsora medusae*. *EFSA Journal* **16**(7), 5354. 28 pp. https://doi.org/10.2903/j.efsa.2018.5354

Kraayenoord CWS van, Laudon GF, Spies AG (1974) Poplar rusts invade New Zealand. *Plant Disease Reporter* **58**, 423-427.

McBride RP (1965) A microbiological control of *Melampsora medusae*. *Canadian Journal of Botany* **47**, 711-715.

McMillan R (1972) Poplar leaf rust hazard. *New Zealand Journal of Agriculture* **125**, 47.

Meyer M, Cox JA, Hitchings MDT, Burgin L, Hort MC, Hodson DP, Gilligan CA (2017) Quantifying airborne dispersal routes of pathogens over continents to safeguard global wheat supply. *Nature Plants* **3,** 780-786.

Molnar AC, Sivak B (1964) *Melampsora* infection of pine in British Columbia. *Canadian Journal of Botany* **42**, 145-158.

Nagarajan, S.; Singh, D.V. (1990) Long-distance dispersion of rust pathogens. *Annual Review of Plant Pathology* 28, 139-153.

Newcombe G, Stirling B, Bradshaw HD (2001) Abundant pathogenic variation in the new hybrid rust *Melampsora x columbiana* on hybrid poplar. *Phytopathology* **91,** 981-985.

Newcombe G, Stirling B, McDonald S, Bradshaw HD (2000) *Melampsora x columbiana*, a natural hybrid of *M. medusae* and *M. occidentalis*. *Mycological Research* **104,** 261-274.

Pinon J (1986) Situation de *Melampsora medusae* en Europe. *EPPO Bulletin* **16**, 547-551.

Pinon J, Frey P (2005) Interactions between poplar clones and Melampsora populations and their implications for breeding for durable resistance, in *Rust diseases of willow and poplar,* eds. M.H. Pei & A.R. McCracken. Wallingford, UK, CAB International, 139-154.

Prakash CS, Heather WA (1985) Adaption of *Melampsora medusae* to increasing temperature and light intensities on a clone of *Populus deltoides*. *Canadian Journal of Botany* **64**, 834-841.

Prakash CS, Heather WA (1989) Inheritance of partial resistance to two races of leaf rust *Melampsora medusae* in eastern cottonwood, *Populus deltoides*. *Silvae Genetica* **38**, 90-94.

Prakash CS, Thielges BA (1987) Pathogenic variation in *Melampsora medusae* leaf rust of poplars. *Euphytica* **36**, 563-570.

Prakash CS, Thielges BA (1989) Interaction of geographic isolates of *Melampsora medusae* and *Populus*: effect of

temperature. *Canadian Journal of Botany* **67**, 486-490.

Sinclair WA, Lyon HH (2005) *Diseases of trees and shrubs.* Comstock Publishing Associates.

Schipper AL, Dawson DH (1974) Poplar leaf rust - a problem in maximum wood production. *Plant Disease Reporter* **58**, 721-723.

Shain L (1988) Evidence for *formae speciales* in poplar leaf rust fungus *Melampsora medusae*. *Mycologia* **80**, 729-732.

Sharma JK, Heather WA (1976) Physiologic specialization in poplar leaf rusts, *Melampsora medusae* Thum. and *M. larici-populina* Kleb. in Australia. *Proc. XIX Session FAO/IPC Working Party on Poplar Diseases. France*.

Sharma JK, Heather WA (1977) Infection of *Populus alba* var. *hickeliana* by *Melampsora medusae* Thüm. *European Journal of Forest Pathology* **7**, 119-124.

Siwecky R. (1974) The mechanism of poplar leaf resistance to fungal infection. *Polish Academy of Sciences, Annual Report, 1973*, 32 pp.

Spiers AG (1975) Species of *Melampsora* infecting conifers in New Zealand. *Plant Disease Reporter* **59**, 486-488.

Spiers AG, Hopcroft DH (1994). Comparative studies of the poplar rusts *Melampsora medusae*, *M. larici-populina* and their interspecific hybrid *M. medusae-populina*. *Mycological Research* **98,** 889-903.

Spiers AG, Hopcroft DH (1985) Ultrastructural studies of pathogenesis and uredinial development of *Melampsora larici-populina* and *M. medusae* on poplar and *M. coleosporioides* and *M. epitea* on willow. *New Zealand Journal of Botany* **23**, 117-133.

Spiers AG, Hopcroft DH (1988) Penetration and infection of poplar leaves by urediniospores of *Melampsora larici-populina* and *Melampsora medusae*. *New Zealand Journal of Botany* **26**, 101-111.

Trench TN, Baxter AP, Churchill H (1987) Report of *Melampsora medusae* on *Populus deltoides* in Southern Africa. *Plant Disease* **71**, 761.

Van Kraayenoord CWS (1984) National report on activities related to poplar and willow cultivation. International Poplar Commission, XVIIth session, Ottawa.

Vialle A, Feau N, Frey P, Bernier L, Hamelin RC (2013) Phylogenetic species recognition reveals host-specific lineages among poplar rust fungi. *Molecular Phylogenetics and Evolution* **66,** 628-644.

Vialle A, Frey P, Hambleton S, Bernier L, Hamelin R (2011) Poplar rust systematics and refinement of *Melampsora* species delineation. *Fungal Diversity* **50**, 227-248.

Walker J (1975) *Melampsora medusae*. *CMI Descriptions of Pathogenic Fungi and Bacteria* No. 480. CAB International, Wallingford, UK.

Walker J, Hartigan D, Bertus AL (1974) Poplar rusts in Australia with comments on potential conifer rusts. *European Journal of Forest Pathology* **4**, 100-118.

Walker J, Hartigan D (1972) Poplar rust in Australia. *Australian Plant Pathology Society Newsletter* 1, 3.

Wilkinson AG, Spiers AG (1976) Introduction of poplar rusts *Melampsora larici-populina* and *Melampsora medusae* to New-Zealand and their subsequent distribution. *New Zealand Journal of Science* **19**, 195-198.

Zheng W, Newcombe G, Hu D, Cao Z, Yu Z & Peng Z (2019) The first record of a North American poplar leaf rust fungus, *Melampsora medusae*, in China. *Forests* **10**(2), 182. https://doi.org/10.3390/f10020182

Ziller WG (1955) Studies of western tree rusts. II. *Melampsora occidentalis* and *M. albertensis*, two needle rusts of

Douglas-fir. *Canadian Journal of Botany* **33**, 177-188.

Ziller WG (1965) Studies of western tree rusts. VI. The aecial host ranges of *Melampsora albertensis*, *M. medusae* and *M. occidentalis*. *Canadian Journal of Botany* **43**, 217-230.

Ziller WG (1974) *The tree rusts of western Canada. Forest Service, British Columbia, Canada, Publications* No. 1329, pp. 144-147. Forest Service, British Columbia, Canada.

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CABI/EPPO (1992/1997) *Quarantine Pests for Europe (1st and 2nd edition)*. CABI, Wallingford (GB).

EPPO (1982) Data sheets on quarantine organisms, *Melampsora medusae. EPPO Bulletin* **12**(1), 81-86.

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