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Pest categorisation of *Melampsora medusae*

EFSA Panel on Plant Health (PLH),
Michael Jeger, Claude Bragard, David Caffier, Thierry Candresse, Elisavet Chatzivassiliou, Katharina Dehnen-Schmutz, Gianni Gilioli, Jean-Claude Grégoire, Josep Anton Jaques Miret, Alan MacLeod, Maria Navajas Navarro, Björn Niere, Stephen Parnell, Roel Potting, Trond Rafoss, Vittorio Rossi, Gregor Urek, Ariena Van Bruggen, Wopke Van der Werf, Jonathan West, Stephan Winter, Johanna Boberg, Paolo Gonthier and Marco Pautasso

Abstract

Following a request from the European Commission, the EFSA Plant Health Panel performed a pest categorisation of *Melampsora medusae*, a well-defined and distinguishable fungal species of the family Melampsoraceae. The pathogen is regulated in Annex IAI of Council Directive 2000/29/EC as a harmful organism whose introduction into the EU is banned. *M. medusae* is a heteroecious rust fungus with *Populus* spp. as primary telial hosts and various conifers (*Larix*, *Pinus*, *Pseudotsuga*, *Abies*, *Picea* and *Tsuga* spp.) as secondary aecial hosts. *M. medusae* is native to North America and has spread to South America, Africa, Asia, Oceania, as well as the EU, where *M. medusae* f. sp. *deltoidae* has been reported with a restricted distribution and low impacts from Belgium, south-west France and southern Portugal. The pest could spread to other EU countries, via dissemination of spores, movement of host plants for planting and cut branches. Climate is assumed not to be a limiting factor for the establishment of the pathogen in the EU. *M. medusae* is the most widespread and important Melampsora rust in North America. In western Canada, extensive damage has been reported to conifers and *Populus* spp. in nurseries and plantations as well as in woodlands. *M. medusae* is damaging in both Australia and New Zealand. The pest could have economic and environmental impacts in the EU if aggressive isolates of *M. medusae* were introduced into the EU. Import prohibition of host plants for planting is an available measure to reduce the risk of further introductions. Some resistant *Populus* cultivars are available. Moreover, increasing the genetic diversity of poplar plantations can prevent disease impacts. The main uncertainty concerns the factors explaining the low pathogenicity of the populations of *M. medusae* present in the EU. The criteria assessed by the Panel for consideration as a potential quarantine pest are met (the pest is present, but with a restricted distribution, and is officially under control). Given that plants for planting are not the main pathway of spread, not all criteria for consideration as a regulated non-quarantine pest are met.

Keywords: European Union, forest fungal pathogens, pest risk, plant pathology, quarantine, tree health

Requestor: European Commission

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Correspondence: alpha@efsa.europa.eu

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1. Introduction

1.1. Background and Terms of Reference as provided by the requestor

1.1.1. Background

Council Directive 2000/29/EC[1] on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community establishes the present European Union plant health regime. The Directive lays down the phytosanitary provisions and the control checks to be carried out at the place of origin on plants and plant products destined for the Union or to be moved within the Union. In the Directive's 2000/29/EC annexes, the list of harmful organisms (pests) whose introduction into or spread within the Union is prohibited, is detailed together with specific requirements for import or internal movement.

Following the evaluation of the plant health regime, the new basic plant health law, Regulation (EU) 2016/2031[2] on protective measures against pests of plants, was adopted on 26 October 2016 and will apply from 14 December 2019 onwards, repealing Directive 2000/29/EC. In line with the principles of the above mentioned legislation and the follow-up work of the secondary legislation for the listing of EU regulated pests, EFSA is requested to provide pest categorizations of the harmful organisms included in the annexes of Directive 2000/29/EC, in the cases where recent pest risk assessment/pest categorisation is not available.

1.1.2. Terms of reference

EFSA is requested, pursuant to Article 22(5.b) and Article 29(1) of Regulation (EC) No 178/2002,[3] to provide scientific opinion in the field of plant health.

EFSA is requested to prepare and deliver a pest categorisation (step 1 analysis) for each of the regulated pests included in the appendices of the annex to this mandate. The methodology and template of pest categorisation have already been developed in past mandates for the organisms listed in Annex II Part A Section II of Directive 2000/29/EC. The same methodology and outcome is expected for this work as well.

The list of the harmful organisms included in the annex to this mandate comprises 133 harmful organisms or groups. A pest categorisation is expected for these 133 pests or groups and the delivery of the work would be stepwise at regular intervals through the year as detailed below. First priority covers the harmful organisms included in Appendix 1, comprising pests from Annex II Part A Section I and Annex II Part B of Directive 2000/29/EC. The delivery of all pest categorisations for the pests included in Appendix 1 is June 2018. The second priority is the pests included in Appendix 2, comprising the group of *Cicadellidae* (non-EU) known to be vector of Pierce's disease (caused by *Xylella fastidiosa*), the group of *Tephritidae* (non-EU), the group of potato viruses and virus-like organisms, the group of viruses and virus-like organisms of *Cydonia* Mill., *Fragaria* L., *Malus* Mill., *Prunus* L., *Pyrus* L., *Ribes* L., *Rubus* L. and *Vitis* L. and the group of *Margarodes* (non-EU species). The delivery of all pest categorisations for the pests included in Appendix 2 is end 2019. The pests included in Appendix 3 cover pests of Annex I part A section I and all pests categorisations should be delivered by end 2020.

For the above mentioned groups, each covering a large number of pests, the pest categorisation will be performed for the group and not the individual harmful organisms listed under "such as" notation in the Annexes of the Directive 2000/29/EC. The criteria to be taken particularly under consideration for these cases are the analysis of host pest combination, investigation of pathways, the damages occurring and the relevant impact.

Finally, as indicated in the text above, all references to 'non-European' should be avoided and replaced by 'non-EU' and refer to all territories with exception of the Union territories as defined in Article 1 point 3 of Regulation (EU) 2016/2031.

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[1] Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. OJ L 169/1, 10.7.2000, p. 1–112.

[2] Regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants. OJ L 317, 23.11.2016, p. 4–104.

[3] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. OJ L 31/1, 1.2.2002, p. 1–24.

1.1.2.1. Terms of Reference: Appendix 1

List of harmful organisms for which pest categorisation is requested. The list below follows the annexes of Directive 2000/29/EC.

Annex IIAI

(a) Insects, mites and nematodes, at all stages of their development

Aleurocanthus spp.
Anthonomus bisignifer (Schenkling)
Anthonomus signatus (Say)
Aschistonyx eppoi Inouye
Carposina niponensis Walsingham
Enarmonia packardi (Zeller)
Enarmonia prunivora Walsh
Grapholita inopinata Heinrich
Hishomonus phycitis
Leucaspis japonica Ckll.
Listronotus bonariensis (Kuschel)
Numonia pyrivorella (Matsumura)
Oligonychus perditus Pritchard and Baker
Pissodes spp. (non-EU)
Scirtothrips aurantii Faure
Scirtothrips citri (Moultex)
Scolytidae spp. (non-EU)
Scrobipalpopsis solanivora Povolny
Tachypterellus quadrigibbus Say
Toxoptera citricida Kirk.
Unaspis citri Comstock

(b) Bacteria

Citrus variegated chlorosis
Erwinia stewartii (Smith) Dye
Xanthomonas campestris pv. *oryzae* (Ishiyama) Dye and pv. *oryzicola* (Fang. et al.) Dye

(c) Fungi

Alternaria alternata (Fr.) Keissler (non-EU pathogenic isolates)
Anisogramma anomala (Peck) E. Müller
Apiosporina morbosa (Schwein.) v. Arx
Ceratocystis virescens (Davidson) Moreau
Cercoseptoria pini-densiflorae (Hori and Nambu) Deighton
Cercospora angolensis Carv. and Mendes
Elsinoe spp. Bitanc. and Jenk. Mendes
Fusarium oxysporum f. sp. *albedinis* (Kilian and Maire) Gordon
Guignardia piricola (Nosa) Yamamoto
Puccinia pittieriana Hennings
Stegophora ulmea (Schweinitz: Fries) Sydow & Sydow
Venturia nashicola Tanaka and Yamamoto

(d) Virus and virus-like organisms

Beet curly top virus (non-EU isolates)
Black raspberry latent virus
Blight and blight-like
Cadang-Cadang viroid
Citrus tristeza virus (non-EU isolates)
Leprosis
Little cherry pathogen (non- EU isolates)
Naturally spreading psorosis
Palm lethal yellowing mycoplasm
Satsuma dwarf virus
Tatter leaf virus
Witches' broom (MLO)

Annex IIB

(a) Insect mites and nematodes, at all stages of their development

Anthonomus grandis (Boh.)
Cephalcia lariciphila (Klug)
Dendroctonus micans Kugelan
Gilphinia hercyniae (Hartig)
Gonipterus scutellatus Gyll.
Ips amitinus Eichhof
Ips cembrae Heer
Ips duplicatus Sahlberg
Ips sexdentatus Börner
Ips typographus Heer
Sternochetus mangiferae Fabricius

(b) Bacteria

Curtobacterium flaccumfaciens pv. flaccumfaciens (Hedges) Collins and Jones

(c) Fungi

Glomerella gossypii Edgerton
Gremmeniella abietina (Lag.) Morelet
Hypoxylon mammatum (Wahl.) J. Miller

1.1.2.2. Terms of Reference: Appendix 2

List of harmful organisms for which pest categorisation is requested per group. The list below follows the categorisation included in the annexes of Directive 2000/29/EC.

Annex IAI

(a) Insects, mites and nematodes, at all stages of their development

Group of Cicadellidae (non-EU) known to be vector of Pierce's disease (caused by *Xylella fastidiosa*), such as:

1) *Carneocephala fulgida* Nottingham
2) *Draeculacephala minerva* Ball
3) *Graphocephala atropunctata* (Signoret)

Group of Tephritidae (non-EU) such as:

1) *Anastrepha fraterculus* (Wiedemann)
2) *Anastrepha ludens* (Loew)
3) *Anastrepha obliqua* Macquart
4) *Anastrepha suspensa* (Loew)
5) *Dacus ciliatus* Loew
6) *Dacus curcurbitae* Coquillet
7) *Dacus dorsalis* Hendel
8) *Dacus tryoni* (Froggatt)
9) *Dacus tsuneonis* Miyake
10) *Dacus zonatus* Saund.
11) *Epochra canadensis* (Loew)
12) *Pardalaspis cyanescens* Bezzi
13) *Pardalaspis quinaria* Bezzi
14) *Pterandrus rosa* (Karsch)
15) *Rhacochlaena japonica* Ito
16) *Rhagoletis completa* Cresson
17) *Rhagoletis fausta* (Osten-Sacken)
18) *Rhagoletis indifferens* Curran
19) *Rhagoletis mendax* Curran
20) *Rhagoletis pomonella* Walsh
21) *Rhagoletis suavis* (Loew)

(c) Viruses and virus-like organisms

Group of potato viruses and virus-like organisms such as:

1) Andean potato latent virus
2) Andean potato mottle virus
3) Arracacha virus B, oca strain
4) Potato black ringspot virus
5) Potato virus T
6) non-EU isolates of potato viruses A, M, S, V, X and Y (including Yo, Yn and Yc) and Potato leafroll virus

Group of viruses and virus-like organisms of *Cydonia* Mill., *Fragaria* L., *Malus* Mill., *Prunus* L., *Pyrus* L., *Ribes* L., *Rubus* L. and *Vitis* L., such as:

1) Blueberry leaf mottle virus
2) Cherry rasp leaf virus (American)
3) Peach mosaic virus (American)
4) Peach phony rickettsia
5) Peach rosette mosaic virus
6) Peach rosette mycoplasm
7) Peach X-disease mycoplasm
8) Peach yellows mycoplasm
9) Plum line pattern virus (American)
10) Raspberry leaf curl virus (American)
11) Strawberry witches' broom mycoplasma
12) Non-EU viruses and virus-like organisms of *Cydonia* Mill., *Fragaria* L., *Malus* Mill., *Prunus* L., *Pyrus* L., *Ribes* L., *Rubus* L. and *Vitis* L.

Annex IIAI

(a) Insects, mites and nematodes, at all stages of their development

Group of *Margarodes* (non-EU species) such as:

1) *Margarodes vitis* (Phillipi)
2) *Margarodes vredendalensis* de Klerk
3) *Margarodes prieskaensis* Jakubski

1.1.2.3. Terms of Reference: Appendix 3

List of harmful organisms for which pest categorisation is requested. The list below follows the annexes of Directive 2000/29/EC.

Annex IAI

(a) Insects, mites and nematodes, at all stages of their development

Acleris spp. (non-EU)
Amauromyza maculosa (Malloch)
Anomala orientalis Waterhouse
Arrhenodes minutus Drury
Choristoneura spp. (non-EU)
Conotrachelus nenuphar (Herbst)
Dendrolimus sibiricus Tschetverikov
Diabrotica barberi Smith and Lawrence
Diabrotica undecimpunctata howardi Barber
Diabrotica undecimpunctata undecimpunctata Mannerheim
Diabrotica virgifera zeae Krysan & Smith
Diaphorina citri Kuway
Heliothis zea (Boddie)
Hirschmanniella spp., other than *Hirschmanniella gracilis* (de Man) Luc and Goodey
Liriomyza sativae Blanchard
Longidorus diadecturus Eveleigh and Allen
Monochamus spp. (non-EU)
Myndus crudus Van Duzee
Nacobbus aberrans (Thorne) Thorne and Allen
Naupactus leucoloma Boheman
Premnotrypes spp. (non-EU)
Pseudopityophthorus minutissimus (Zimmermann)
Pseudopityophthorus pruinosus (Eichhoff)
Scaphoideus luteolus (Van Duzee)
Spodoptera eridania (Cramer)
Spodoptera frugiperda (Smith)
Spodoptera litura (Fabricus)
Thrips palmi Karny
Xiphinema americanum Cobb sensu lato (non-EU populations)
Xiphinema californicum Lamberti and Bleve-Zacheo

(b) Fungi

Ceratocystis fagacearum (Bretz) Hunt
Chrysomyxa arctostaphyli Dietel
Cronartium spp. (non-EU)
Endocronartium spp. (non-EU)
Guignardia laricina (Saw.) Yamamoto and Ito
Gymnosporangium spp. (non-EU)
Inonotus weirii (Murril) Kotlaba and Pouzar
Melampsora farlowii (Arthur) Davis
Mycosphaerella larici-leptolepis Ito et al.
Mycosphaerella populorum G. E. Thompson
Phoma andina Turkensteen
Phyllosticta solitaria Ell. and Ev.
Septoria lycopersici Speg. var. *malagutii* Ciccarone and Boerema
Thecaphora solani Barrus
Trechispora brinkmannii (Bresad.) Rogers

(c) Viruses and virus-like organisms

Tobacco ringspot virus
Tomato ringspot virus
Bean golden mosaic virus
Cowpea mild mottle virus
Lettuce infectious yellows virus
Pepper mild tigré virus
Squash leaf curl virus
Euphorbia mosaic virus
Florida tomato virus

(d) Parasitic plants

Arceuthobium spp. (non-EU)

Annex IAII

(a) Insects, mites and nematodes, at all stages of their development

Meloidogyne fallax Karssen
Rhizoecus hibisci Kawai and Takagi
Popillia japonica Newman

(b) Bacteria

Clavibacter michiganensis (Smith) Davis et al. ssp. *sepedonicus* (Spieckermann and Kotthoff) Davis et al.
Ralstonia solanacearum (Smith) Yabuuchi et al.

(c) Fungi

Melampsora medusae Thümen
Synchytrium endobioticum (Schilbersky) Percival

Annex I B

(a) Insects, mites and nematodes, at all stages of their development

Leptinotarsa decemlineata Say
Liriomyza bryoniae (Kaltenbach)

(b) Viruses and virus-like organisms

Beet necrotic yellow vein virus

1.2. Interpretation of the Terms of Reference

Melampsora medusae is one of a number of pests listed in the Appendices to the Terms of Reference (ToR) to be subject to pest categorisation to determine whether it fulfils the criteria of a quarantine pest or those of a regulated non-quarantine pest (RNQP) for the area of the EU.

2. Data and methodologies

2.1. Data

2.1.1. Literature search

A literature search on *M. medusae* was conducted at the beginning of the categorisation in the ISI Web of Science bibliographic database, using the scientific name of the pest as well as its synonyms, as search terms. Relevant papers were reviewed and further references and information were obtained from experts, as well as from citations within the references and grey literature.

2.1.2. Database search

Pest information, on host(s) and distribution, was retrieved from the European and Mediterranean Plan Protection Organization (EPPO) Global Database (EPPO, 2018) and relevant publications.

Data about the import of commodity types that could potentially provide a pathway for the pest to enter the EU and about the area of hosts grown in the EU were obtained from EUROSTAT (Statistical Office of the European Communities).

The Europhyt database was consulted for pest-specific notifications on interceptions and outbreaks. Europhyt is a web-based network run by the Directorate General for Health and Food Safety (DG SANTE) of the European Commission, and is a subproject of PHYSAN (Phyto-Sanitary Controls) specifically concerned with plant health information. The Europhyt database manages notifications of interceptions of plants or plant products that do not comply with EU legislation, as well as notifications of plant pests detected in the territory of the Member States (MS) and the phytosanitary measures taken to eradicate or avoid their spread.

2.2. Methodologies

The Panel performed the pest categorisation for *M. medusae* following guiding principles and steps presented in the EFSA guidance on the harmonised framework for pest risk assessment (EFSA PLH Panel, 2010) and as defined in the International Standard for Phytosanitary Measures No 11 (FAO, 2013) and No 21 (FAO, 2004).

In accordance with the guidance on a harmonised framework for pest risk assessment in the EU (EFSA PLH Panel, 2010), this work was started following an evaluation of the EU plant health regime. Therefore, to facilitate the decision-making process, in the conclusions of the pest categorisation, the Panel addresses explicitly each criterion for a Union quarantine pest and for a Union RNQP in accordance with Regulation (EU) 2016/2031 on protective measures against pests of plants, and includes additional information required in accordance with the specific terms of reference received by the European Commission. In addition, for each conclusion, the Panel provides a short description of its associated uncertainty.

Table 1 presents the Regulation (EU) 2016/2031 pest categorisation criteria on which the Panel bases its conclusions. All relevant criteria have to be met for the pest to potentially qualify either as a quarantine pest or as a RNQP. If one of the criteria is not met, the pest will not qualify. A pest that does not qualify as a quarantine pest may still qualify as a RNQP that needs to be addressed in the opinion. For the pests regulated in the protected zones only, the scope of the categorisation is the territory of the protected zone; thus, the criteria refer to the protected zone instead of the EU territory.

It should be noted that the Panel's conclusions are formulated respecting its remit and particularly with regard to the principle of separation between risk assessment and risk management (EFSA founding regulation (EU) No 178/2002); therefore, instead of determining whether the pest is likely to have an unacceptable impact, the Panel will present a summary of the observed pest impacts. Economic impacts are expressed in terms of yield and quality losses and not in monetary terms, whereas addressing social impacts is outside the remit of the Panel, in agreement with the EFSA guidance on a harmonised framework for pest risk assessment (EFSA PLH Panel, 2010).

Table 1: Pest categorisation criteria under evaluation, as defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column)

Criterion of pest categorisation	Criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest	Criterion in Regulation (EU) 2016/2031 regarding protected zone quarantine pest (articles 32–35)	Criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest
Identity of the pest (Section 3.1)	Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?	Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?	Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?
Absence/ presence of the pest in the EU territory (Section 3.2)	Is the pest present in the EU territory? If present, is the pest widely distributed within the EU? Describe the pest distribution briefly!	Is the pest present in the EU territory? If not, it cannot be a protected zone quarantine organism	Is the pest present in the EU territory? If not, it cannot be a RNQP. (A RNQP must be present in the risk assessment area)
Regulatory status (Section 3.3)	If the pest is present in the EU but not widely distributed in the risk assessment area, it should be under official control or expected to be under official control in the near future	The protected zone system aligns with the pest free area system under the International Plant Protection Convention (IPPC) The pest satisfies the IPPC definition of a quarantine pest that is not present in the risk assessment area (i.e. protected zone)	Is the pest regulated as a quarantine pest? If currently regulated as a quarantine pest, are there grounds to consider its status could be revoked?

Criterion of pest categorisation	Criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest	Criterion in Regulation (EU) 2016/2031 regarding protected zone quarantine pest (articles 32–35)	Criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest
Pest potential for entry, establishment and spread in the EU territory (Section 3.4)	Is the pest able to enter into, become established in, and spread within, the EU territory? If yes, briefly list the pathways!	Is the pest able to enter into, become established in, and spread within, the protected zone areas? Is entry by natural spread from EU areas where the pest is present possible?	Is spread mainly via specific plants for planting, rather than via natural spread or via movement of plant products or other objects? Clearly state if plants for planting is the main pathway!
Potential for consequences in the EU territory (Section 3.5)	Would the pests' introduction have an economic or environmental impact on the EU territory?	Would the pests' introduction have an economic or environmental impact on the protected zone areas?	Does the presence of the pest on plants for planting have an economic impact, as regards the intended use of those plants for planting?
Available measures (Section 3.6)	Are there measures available to prevent the entry into, establishment within or spread of the pest within the EU such that the risk becomes mitigated?	Are there measures available to prevent the entry into, establishment within or spread of the pest within the protected zone areas such that the risk becomes mitigated? Is it possible to eradicate the pest in a restricted area within 24 months (or a period longer than 24 months where the biology of the organism so justifies) after the presence of the pest was confirmed in the protected zone?	Are there measures available to prevent pest presence on plants for planting such that the risk becomes mitigated?
Conclusion of pest categorisation (Section 4)	A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential quarantine pest were met and (2) if not, which one (s) were not met	A statement as to whether (1) all criteria assessed by EFSA above for consideration as potential protected zone quarantine pest were met, and (2) if not, which one(s) were not met	A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential RNQP were met, and (2) if not, which one(s) were not met

The Panel will not indicate in its conclusions of the pest categorisation whether to continue the risk assessment process, but following the agreed two-step approach, will continue only if requested by the risk managers. However, during the categorisation process, experts may identify key elements and knowledge gaps that could contribute significant uncertainty to a future assessment of risk. It would be useful to identify and highlight such gaps so that potential future requests can specifically target the major elements of uncertainty, perhaps suggesting specific scenarios to examine.

3. Pest categorisation

3.1. Identity and biology of the pest

3.1.1. Identity and taxonomy

Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?

Yes

Melampsora medusae Thüm. is a fungus of the family Melampsoraceae. Species synonyms listed for *M. medusae* are: *Melampsora albertensis*, *Melampsora populina* subsp. *medusae*, and *Uredo medusae* (Index Fungorum, http://www.indexfungorum.org/names/names.asp; Vialle et al., 2011), the last referring to the uredinial state of the fungus (EPPO, 1997). In addition, the Latin binomial *Caeoma faulliana* was used for the aecial state (EPPO, 1997).

3.1.2. Biology of the pest

M. medusae is a heteroecious rust fungus having *Populus* spp. as primary hosts producing telia and uredinia and various conifers as secondary hosts producing spermagonia and aecia, though in mild climates the fungus may overwinter as uredinial mycelium in buds and bark of poplars without the need for an alternate host (EPPO, 1997; Sinclair and Lyon, 2005) (Figure 1). In the heteroecious cycle, the fungus overwinters as telia, arising beneath the epidermis of poplar leaves (Sinclair and Lyon, 2005), and releasing basidiospores in the spring. Thus, infections of aecial hosts occur in the spring through basidiospores on young current-year needles. Spermagonia and aecia develop within about two weeks on the undersides of slightly chlorotic portions of needles (Sinclair and Lyon, 2005).

Aeciospores may be carried over long distances in the wind; they are unable to reinfect the secondary host, but they infect leaves of susceptible *Populus* spp. in the summer (EPPO, 1997). Golden-yellow uredinia producing urediniospores appear on both sides of yellow leaf spots within two more weeks (Sinclair and Lyon, 2005). The urediniospores produced on *Populus* spp. can also be carried over long distances by wind, and they may reinfect the primary host species (Sinclair and Lyon, 2005). Trans-Tasmanian wind currents were responsible for the spread of the fungus from Australia to New Zealand (Wilkinson and Spiers, 1976; Spiers, 1998), which supports a wide dispersal range of the pathogen. The number of uredinia increases throughout the summer during humid or wet weather as urediniospores reinfect poplar (Sinclair and Lyon, 2005). *M. medusae* is a biotrophic, obligate parasite infecting poplar leaves by penetrating through stomata. Other details on the infection biology and patterns of host colonisation have been previously described (Spiers and Hopcroft, 1988).

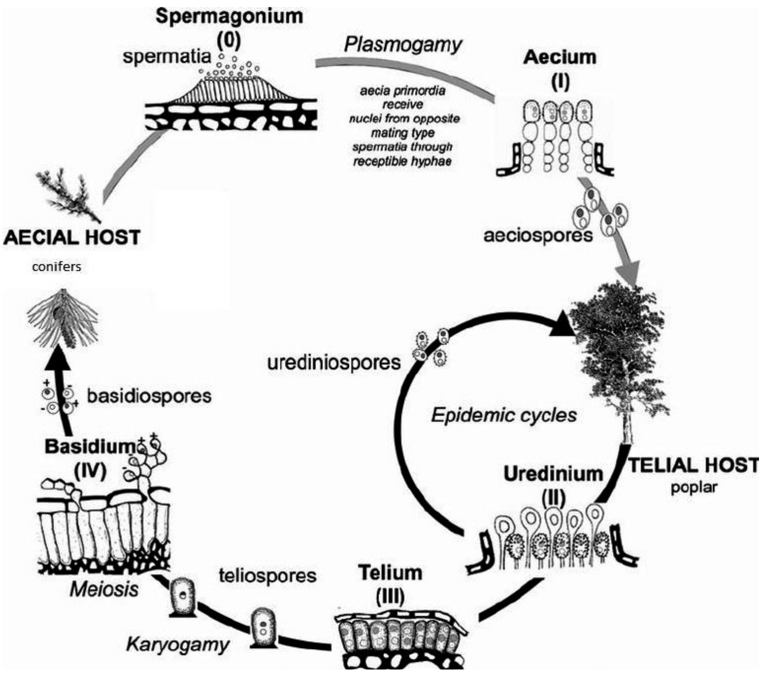

Figure 1: Typical life cycle of heteroecious *Melampsora* spp., adapted to the *M. medusae* case, where the aecial hosts are conifer species (modified from Vialle et al., 2011)

Wet, warm and humid weather conditions favour rapid spread of the disease (EPPO, 1997). Mild wet weather favours infection of both the telial and aecial hosts. At 18°C, more than 24 h with free moisture on needles are necessary for infection of larch needles by basidiospores, and more than 48 h are needed for maximum infection (Sinclair and Lyon, 2005). Production of urediniospores on telial hosts is favoured by humid weather and temperatures of 15–20°C (Sinclair and Lyon, 2005).

Based on experimental evidence, increased levels of CO_2 and O_3 are likely to predispose plants to increased infection by the rust pathogen (Karnosky et al., 2002). Furthermore, disease expression of *M. medusae* isolates from six locations across the eastern USA was mainly influenced by temperature (Prakash and Thielges, 1989). Simulation models of climate change for France resulted in a predicted expansion of favourable zones for *M. medusae* inward from the coasts, but with the expected relative frequency remaining low in most areas (Desprez-Loustau et al., 2007).

3.1.3. Intraspecific diversity

Based on experimental evidence, isolates collected from natural stands of *Populus deltoides* along the lower Mississippi River Valley from a northern latitude (37°N) were more aggressive than isolates sampled at a more southern latitude (34–36°N) (Prakash and Thielges, 1987).

Two formae speciales *M. medusae* f. sp. *deltoidae* and *M. medusae* f. sp. *tremuloides* were described based on the basis of their pathogenicity on *Populus* species from the section Aigeiros (e.g. *Populus deltoides*) or Populus (e.g. *Populus tremuloides*), respectively (Shain, 1988; Boutigny et al., 2013a).

According to EPPO (2009), only *M. medusae* f. sp. *deltoidae* has been reported in Europe.

Many races of *M. medusae* exist that vary in virulence patterns on poplar clones (Sinclair and Lyon, 2005).

3.1.4. Detection and identification of the pest

Are detection and identification methods available for the pest?
Yes

Symptoms similar to those caused on poplar by *M. medusae* may be caused by other *Melampsora* spp., which are widespread in Europe (e.g. *M. populnea*, *M. larici-populina*) (EPPO, 1997). However, diagnostic protocols for *M. medusae* based on both morphological traits and molecular assays are available (EPPO, 2009; Boutigny et al., 2013b; Husson et al., 2013).

3.2. Pest distribution

M. medusae is native to North America and has spread to other continents, including Europe (EPPO, 2018) (Figure 2).

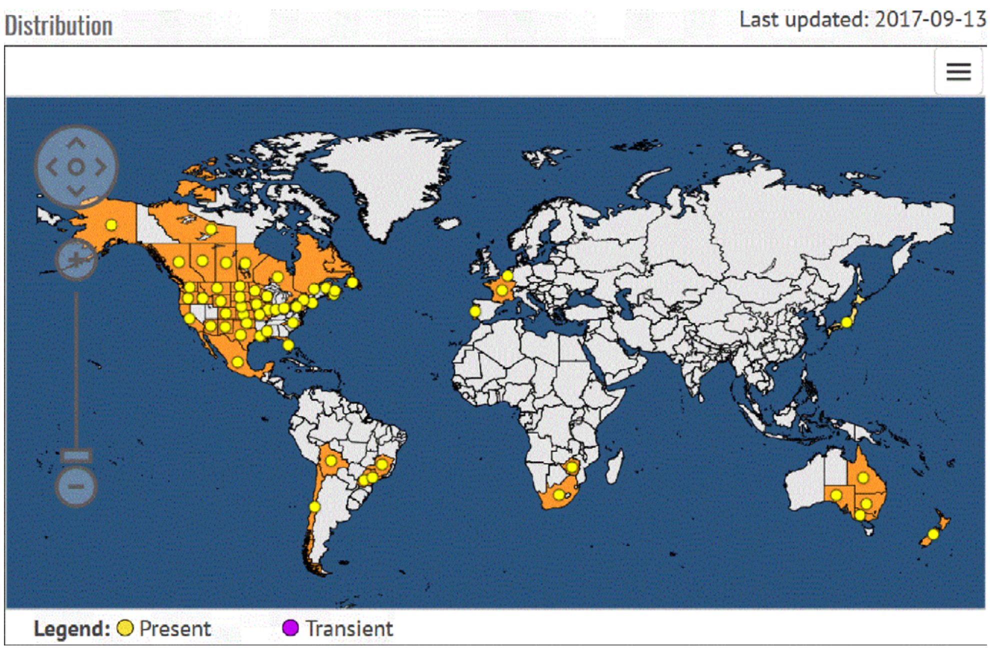

Figure 2: Global distribution map for *Melampsora medusae* (extracted from EPPO (2018), accessed March 2018)

3.2.1. Pest distribution outside the EU

In North America, *M. medusae* is widespread in Canada and the United States, while it is present with restricted distribution in Mexico. In South America, the fungus is present with no further details in Bolivia, Brazil and Chile, while the reports from Argentina and Uruguay were deemed unreliable. Therefore, the fungus is reported as absent in the last two countries (EPPO, 2018).

In Asia, the fungus is reported as present in Japan, with no further information (EPPO, 2018).

In Africa, the pathogen is reported as widespread in South Africa and present, with no further details, in Zimbabwe (EPPO, 2018).

In Oceania, *M. medusae* is reported as widespread in both Australia and New Zealand (EPPO, 2018).

3.2.2. Pest distribution in the EU

Is the pest present in the EU territory? If present, is the pest widely distributed within the EU?

Yes, the pest is present in the EU territory, but it is not widely distributed.

M. medusae is present, although not widespread, in the EU (Table 2). Only the telial state of *M. medusae* f. sp. *deltoidae* has been reported in Europe (EPPO, 2009). The pathogen is reported as present with few occurrences both in Belgium and France, and present with a restricted distribution in South Portugal (EPPO, 1997). A record from Spain was deemed unreliable, and thus the pathogen is reported as absent in that country (EPPO, 2018). Slovenia reported *M. medusae* as absent in 2017 (EPPO, 2018). The pathogen is reported as absent in the UK (UK Plant Health Portal, accessed March 2018). The pathogen is also reported as absent based on survey conducted in 2017 in the Netherlands (EPPO, 2018). With this exception, there are no reports of absence available to the Panel that have been confirmed by survey.

In France, an outbreak of *M. medusae* was detected in December 2013 on several clones of poplar grown in a nursery in the department of Gers (Aquitaine region, SW France). Surveys were carried out to delimit the extent of the disease (Anon, 2014). Within a previous survey of *Melampsora medusae* (1993–2003), systematic observations were conducted by the Service de la Protection des Végétaux in 311 nurseries in France, showing that the pathogen was still restricted to a small area in the South-West of France (Desprez-Loustau et al., 2007).

Table 2: Current status of *M. medusae* in the EU MS for which information is available, based on the EPPO Global Database (EPPO, 2018) and other sources if relevant

Country	EPPO Global Database Last update: 2017-9-13 Date accessed: 2018-3-20	Other sources
Belgium	Present, few occurrences	
France	Present, few occurrences	
Netherlands	Absent, confirmed by survey	
Portugal	Present, restricted distribution	EPPO (1997)
Slovenia	Absent, no pest record	
Spain	Absent, unreliable record	
United Kingdom	Absent, no pest record	UK Plant Health Portal (accessed March 2018)

3.3. Regulatory status

3.3.1. Council Directive 2000/29/EC

M. medusae is listed in Council Directive 2000/29/EC. Details are presented in Tables 3 and 4.

Table 3: *M. medusae* in Council Directive 2000/29/EC

Annex I, Part A	**Harmful organisms whose introduction into, and spread within, all Member States shall be banned**
Section I	**Harmful organisms not known to occur in any part of the community and relevant for the entire Community**
(c)	Fungi
1.	*Melampsora medusae* Thümen

3.3.2. Legislation addressing the hosts of *M. medusae*

Table 4: Regulated hosts and commodities that may involve *Melampsora medusae* in Annexes III and V of Council Directive 2000/29/EC

Annex III, Part A	**Plants, plant products and other objects the introduction of which shall be prohibited in all member states**
Description	Country of origin
1. Plants of *Abies* Mill., *Cedrus* Trew, *Chamaecyparis* Spach, *Juniperus* L., *Larix* Mill., *Picea* A. Dietr., *Pinus* L., *Pseudotsuga* Carr. and *Tsuga* Carr., other than fruit and seeds	Non-European countries
3. Plants of *Populus* L., with leaves, other than fruit and seeds	North American countries
8. Isolated bark of *Populus* L.	Countries of the American continent
Annex IV, Part A	**Special requirements which must be laid down by all Member States for the introduction and movement of plants, plant products and other objects into and within all Member States**
Section I	**Plants, plant products and other objects originating outside the Community**
10. Plants of *Abies* Mill., *Larix* Mill., *Picea* A. Dietr., *Pinus* L. *Pseudotsuga* Carr. and *Tsuga* Carr., intended for planting, other than seeds	Without prejudice to the provisions applicable to the plants listed in Annex III(A)(1), and Annex IV(A)(I)(8.1), (8.2) or (9), where appropriate, official statement that no symptoms of *Melampsora medusae* Thümen have been observed at the place of production or its immediate vicinity since the beginning of the last complete cycle of vegetation.
13.1. Plants of *Populus* L., intended for planting, other than seeds, originating in third countries	Without prejudice to the prohibitions applicable to the plants listed in Annex III(A)(3), official statement that no symptoms of *Melampsora medusae* Thümen have been observed at the place of production or its immediate vicinity since the beginning of the last complete cycle of vegetation.
Section II	**Plants, plant products and other objects originating in the Community**
5. Plants of *Abies* Mill., *Larix* Mill., *Picea* A. Dietr., *Pinus* L., *Pseudotsuga* Carr. and *Tsuga* Carr., intended for planting, other than seeds	Without prejudice to the requirements applicable to the plants listed in Annex IV(A)(II)(4), where appropriate, official statement that no symptoms of *Melampsora medusae* Thümen have been observed at the place of production or in its immediate vicinity since the beginning of the last complete cycle of vegetation.
6. Plants of *Populus* L., intended for planting, other than seeds	Official statement that no symptoms of *Melampsora medusae* Thümen have been observed at the place of production or in its immediate vicinity since the beginning of the last complete cycle of vegetation.
Annex V	**Plants, plant products and other objects which must be subject to a plant health inspection (at the place of production if originating in the Community, before being moved within the Community — in the country of origin or the consignor country, if originating outside the Community) before being permitted to enter the Community**
Part A	**Plants, plant products and other objects originating in the Community**

Section I	**Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community and which must be accompanied by a plant passport**
2.1.	Plants intended for planting, other than seeds, of the genus *Populus* L.
Section II	**Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for certain protected zones, and which must be accompanied by a plant passport valid for the appropriate zone when introduced into or moved within that zone**
1.1.	Plants of *Abies* Mill., *Larix* Mill., *Picea* A. Dietr., *Pinus* L. and *Pseudotsuga* Carr.
Part B	**Plants, plant products and other objects originating in territories, other than those territories referred to in part A**
Section I	**Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community**
2.	Parts of plants, other than fruits and seeds, of the genus *Populus* L.

3.4. Entry, establishment and spread in the EU

3.4.1. Host range

The major (i.e. highly susceptible) telial hosts for *M. medusae* are the North American *Populus balsamifera*, *P. deltoides* and *P. tremuloides*, and the European *P. nigra* (EPPO, 2018). There is some inconsistent information on the susceptibility level of *P. nigra* var. *italica* (EPPO, 1997), which is reported as susceptible in New Zealand (Spiers, 2009; see also Sinclair and Lyon, 2005). Hybrids and cultivars of the above poplar species are susceptible as well (EPPO, 1997). An overview of the susceptibility of various poplar cultivars planted in Europe is provided by Pinon and Valadon (1997) and Anon (2006). *P. yunnanensis* is reported as resistant (EPPO, 1997).

P. alba and *P. tremula*, both native in Europe, are reported to be resistant to infection by *M. medusae* (i.e. few lesions, no leaf necrosis) in New Zealand (Spiers, 2009). However, the infection of *P. alba* var. *hickeliana* by *M. medusae* has been reported (Sharma and Heather, 1977). Moreover, *Populus* as a genus is reported as a minor host of *M. medusae* by the UK Plant Health Portal (https://planthealthportal.defra.gov.uk/data/pests/362/data) The alternate aecial hosts for the pathogen are *Larix* spp., *Pinus* spp., especially young plants, and *Pseudotsuga menziesii* (Ziller, 1965, 1974; EPPO, 1997, 2018). The following are reported as incidental aecial hosts: *Abies* spp., *Picea* spp., and *Tsuga* spp. (EPPO, 2018). There are no reports of the aecial state in the EU (EPPO, 2009).

In Council Directive 2000/29/EC, the pest is not regulated on a particular host or commodity; its introduction into the EU is banned (Annex IAI).

3.4.2. Entry

Is the pest able to enter into the EU territory?

Yes, the pest has been reported from three EU MS. Further introductions into the EU could occur via movement of host plants for planting and cut branches.

M. medusae is already present in the EU territory, although not widely distributed and only represented by *M. medusae* f. sp. *deltoidae* (EPPO, 2009).

Host commodities which could provide a pathway of entry for the pathogen in additional EU countries are:

- plants for planting, and
- cut branches

of host species, both telial (*Populus* as a genus) and aecial hosts (see Section 3.4.1) (EPPO, 2018). Given the high dissemination potential of the fungus (see Section 3.4.4 Spread), *M. medusae* could also enter in other EU MSs via natural spread, although the forms of the pathogen present in Europe do not seem aggressive and have had no tendency to spread (EPPO, 1997).

The pathway plants for planting is closed for the aecial hosts due to Council Directive 2000/29/EC banning the import of plants of *Abies, Larix*, *Picea*, *Pinus*, *Pseudotsuga* and *Tsuga*, other than fruit and seeds (from non-European countries). However, the import into the EU of plants of *Populus* is only banned from North-American countries, whilst the pathogen is reported also from South America, Africa, Asia and Oceania. Moreover, according to EPPO (1997), aecia are occasionally produced on cones of conifers, which would imply that there is an additional pathway not covered by the legislation.

As of February 2018, there were no records of interception of *M. medusae* in the Europhyt database.

3.4.3. Establishment

Is the pest able to become established in the EU territory?
Yes, the pest is already established in three EU MS, although with few occurrences or restricted distribution.

3.4.3.1. EU distribution of main host plants

The fungus is already present and established in three EU MS (see Table 2). The main native telial host species *P. nigra* is widely distributed throughout the EU, with the exception of northern countries (Figure 3). *P. deltoides* and hybrids between *P. deltoides* and *P. nigra*, as well as other North American telial host species and their hybrids are cultivated in plantations throughout the EU.

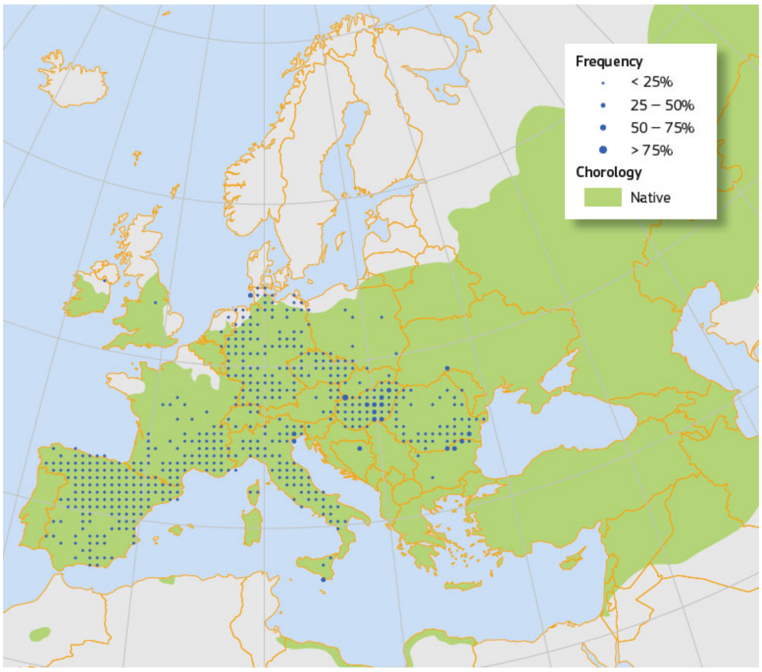

Figure 3: Plot distribution and simplified chorology map for *Populus nigra*. Frequency of *P. nigra* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *P. nigra* is derived from EUFORGEN (de Rigo et al., 2016b)

The alternate aecial hosts of *M. medusae* are also present and widely distributed in the EU. The natural distribution of the European larch *L. decidua* is mainly restricted to the Alps and the Carpathians, but the species has been planted elsewhere mostly in central and northern Europe (Figure 4). The genus *Pinus* is present in natural forest stands or plantations all over EU, although more abundantly in central and northern countries (Figure 5). The North American alternate host *P. menziesii* has been widely planted as a reforestation species in Western Europe (Da Ronch et al., 2016). In Europe, 80% of the *P. menziesii* area is to be found in three countries: France (half of the European area), Germany and the UK (Figure 6) (Da Ronch et al., 2016).

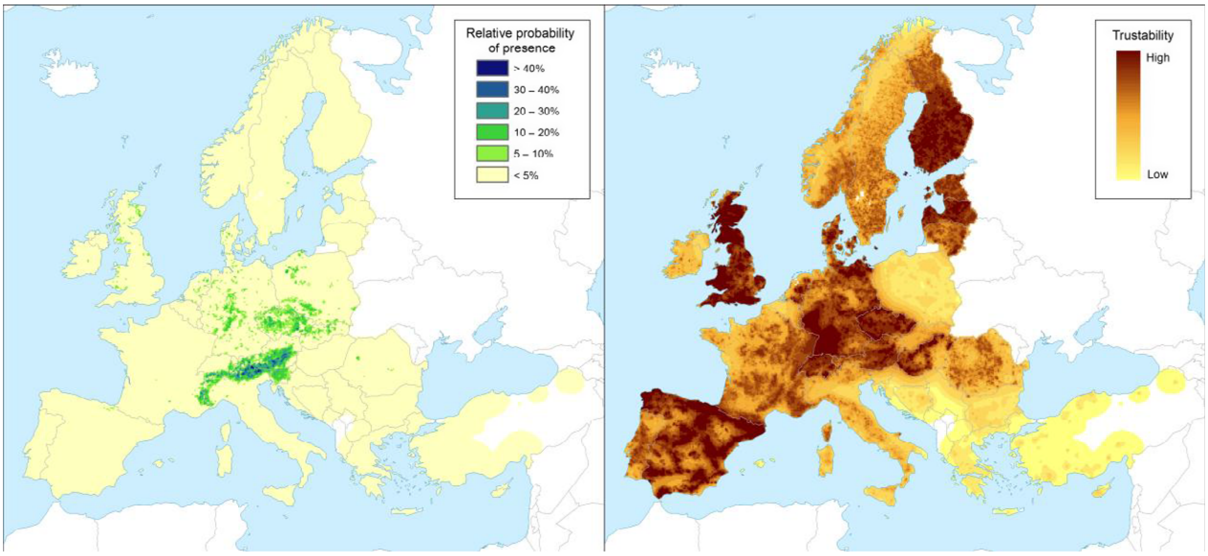

Figure 4: Left-hand panel: Relative probability of presence (RPP) of the genus *Larix* (based on data from the species: *L. decidua, L. kaempferi* and *L. sibirica*) in Europe, mapped at 100 km^2 resolution. The underlying data are from European-wide forest monitoring data sets and from national forestry inventories based on standard observation plots measuring in the order of hundreds m^2. RPP represents the probability of finding at least one individual of the taxon in a standard plot placed randomly within the grid cell. For details, see Appendix A (courtesy of JRC, 2017). Right-hand panel: Trustability of RPP. This metric expresses the strength of the underlying information in each grid cell and varies according to the spatial variability in forestry inventories. The colour scale of the trustability map is obtained by plotting the cumulative probabilities (0–1) of the underlying index (for details see Appendix A)

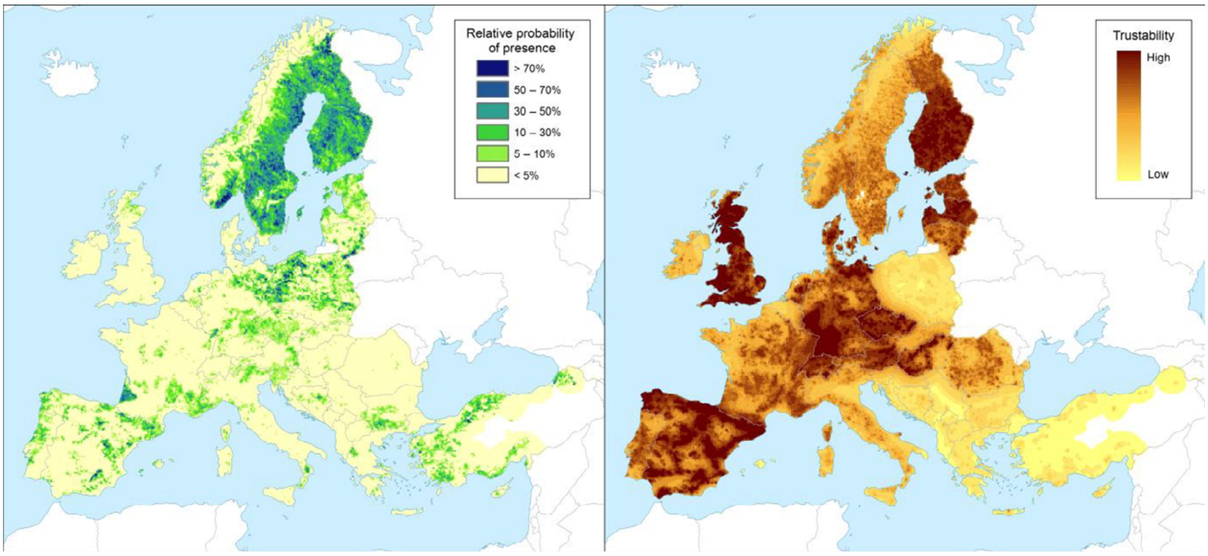

Figure 5: Left-hand panel: Relative probability of presence (RPP) of the genus *Pinus* (based on data from the species: *P. sylvestris*, *P. pinaster, P. halepensis, P. nigra, P. pinea, P. contorta, P. cembra, P. mugo, P. radiata, P. canariensis, P. strobus, P. brutia, P. banksiana, P. ponderosa, P. heldreichii, P. leucodermis, P. wallichiana*) in Europe, mapped at 100 km^2 resolution. The underlying data are from European-wide forest monitoring data sets and from national forestry inventories based on standard observation plots measuring in the order of hundreds m^2. RPP represents the probability of finding at least one individual of the taxon in a standard plot placed randomly within the grid cell. For details, see Appendix A (courtesy of JRC, 2017). Right-hand panel: Trustability of RPP. This metric expresses the strength of the underlying information in each grid cell and varies according to the spatial variability in the forestry inventories). The colour scale of the trustability map is obtained by plotting the cumulative probabilities (0–1) of the underlying index (for details see Appendix A)

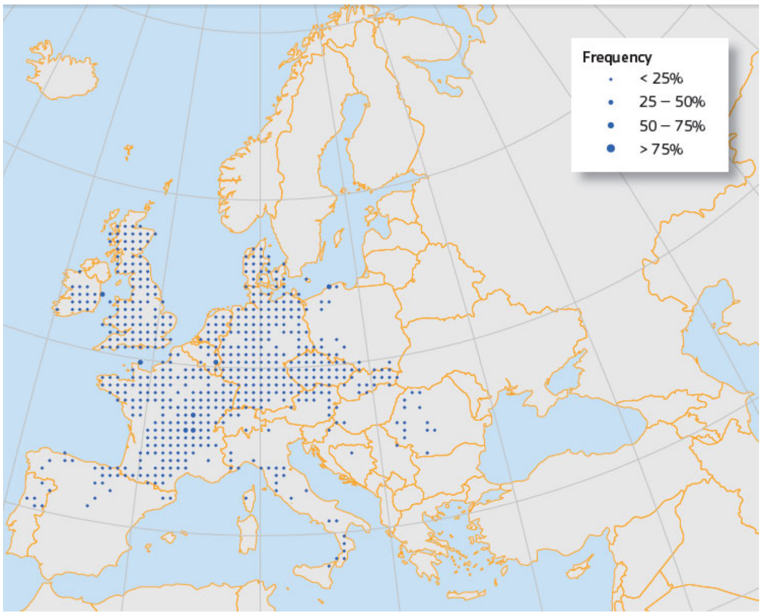

Figure 6: Plot distribution map for *P. menziesii*. Frequency of *P. menziesii* occurrences within the field observations as reported by the National Forest Inventories (Da Ronch et al., 2016)

The distribution ranges of telial and aecial hosts of *M. medusae* overlap to a large extent in the EU, except in the northern countries, where the main native telial host is absent.

3.4.3.2. Climatic conditions affecting establishment

The distribution of *M. medusae* in North America (Figure 2; Section 3.2.1) covers areas with a wide range of climate types which to a large extent overlap with the distribution of native and non-native telial and aecial hosts present in Europe. Therefore, climate is assumed not to be a limiting factor for the establishment of the pathogen in the EU.

However, the reported lower pathogenicity of populations present in France was attributed to environmental amongst other factors (Pinon, 1986).

3.4.4. Spread

Is the pest able to spread within the EU territory following establishment? How?

Yes, by natural dispersal and movement of infected plants for planting and cut branches.

RNQPs: Is spread mainly via specific plants for planting, rather than via natural spread or via movement of plant products or other objects?

No, plants for planting are just one of the means of spread of the pathogen.

M. medusae is characterised by a high dissemination potential. Urediniospores and aeciospores of the pathogen can be spread by wind over long distances. Successful airborne spread of *M. medusae* has been reported for the introduction of the pathogen into New Zealand from Australia in 1973 and later years (Spiers, 1998). The fungus spread 2,000 km by wind to the islands of New Zealand and high correlations were found between the wind patterns in this area and the newly detected infestation sites in New Zealand (Brown, 1984).

In Australia, *M. medusae* was first detected on 27 January 1972 on poplars near Sydney (Walker and Hartigan, 1972). Within 2 months, the rust had spread over a large area from Melbourne to south Queensland (Viljanen-Rollinson and Cromey, 2002).

In North America, there is genetic evidence that epidemics of *M. medusae* originate in regions of co-occurrence of telial and aecial hosts (where the rust can complete its life cycle), with annual recolonisation by the pathogen of areas without co-occurrence of telial and aecial hosts (Bourassa et al., 2007).

The pathogen can also be spread on infected planting material of the various hosts (EPPO, 1997).

3.5. Impacts

Would the pests' introduction have an economic or environmental impact on the EU territory?

Yes, if aggressive isolates of M. medusae were introduced into the EU.

RNQPs: Does the presence of the pest on plants for planting have an economic impact, as regards the intended use of those plants for planting?[4]

Yes, the presence of the pest on plants for planting would have an impact on their intended use.

M. medusae is the most widespread and important Melampsora rust in North America (Sinclair and Lyon, 2005). The pathogen can have impacts on both the telial and the aecial hosts. It causes the leaves of susceptible poplars to shrivel and fall prematurely, reducing growth (Figure 7). In one test involving natural infection, the average annual growth loss in terms of volume of wood of five clones was 31–42% and the volume loss in highly susceptible clones ranged up to 57% (Sinclair and Lyon, 2005). Premature leaf drop and loss of vigour may also be observed in *Larix* spp., *Pinus* spp. and *P. menziesii* (EPPO, 1997).

[4] See Section 2.1 on what falls outside EFSA's remit.

Figure 7: Symptoms of *Melampsora medusae* (telial state) on *Populus* spp. Photo courtesy of W. Cranshaw, Colorado State University, Bugwood.org. Available online at: https://www.forestryimages.org/browse/detail.cfm?imgnum=5369755

M. medusae is very damaging in both Australia and New Zealand, where *Populus* has been introduced into a new environment. In western Canada, where the rust is native, extensive damage has also been reported to conifers and *Populus* spp. in nurseries and plantations as well as in natural forests (EPPO, 1997).

The rust has been reported in France on poplar plantations and nurseries but it has remained with restricted distribution and without economic significance (EPPO, 1997; Desprez-Loustau et al., 2007). However, there is the potential for significant impacts on wood production and ecosystem services; in France, there are about 240,000 ha of poplar plantations (about 1.6% of the total forest area), which produce about 1.3 million m^3 of wood per year, i.e. ca. 25% of broadleaved wood production (Husson et al., 2013).

The reduced pathogenicity in Europe was ascribed to environmental factors which seem to limit its spread, because of overwintering problems, host alternation and ecological constraints (Pinon, 1986). According to EPPO (2009), *M. medusae* has not yet been found on any aecial host in the EPPO region. Other European *Melampsora* spp. cause very similar diseases on European *Populus* spp., and have been, up to now, of much greater significance (EPPO, 1997). On the basis of the evidence from France, the form of the pathogen reported in Europe would have little impact in other European countries. The introduction of aggressive isolates of *M. medusae* in the EU might cause serious losses, particularly in areas with a mild winter where no alternate host is required (EPPO, 1997).

Moreover, *M. medusae* has been shown to be able to hybridise with other *Melampsora* spp., thus leading to the emergence of new fungal pathogen species and novel host-pathogen associations (Spiers and Hopcroft, 1994; Newcombe et al., 2000; Wingfield et al., 2010).

3.6. Availability and limits of mitigation measures

Are there measures available to prevent the entry into, establishment within or spread of the pest within the EU such that the risk becomes mitigated?

Yes. Please see Section 3.6.2.

RNQPs: Are there measures available to prevent pest presence on plants for planting such that the risk becomes mitigated?

Yes, production of plants for planting in pest free areas can prevent pest presence on plants for planting.

3.6.1. Phytosanitary measures

Phytosanitary measures are currently applied to the host species of *M. medusae* (see Section 3.3.2). However, pathways exist also from countries not specified in the Directive 2000/29/EC for *Populus* plants (South America, Africa, Asia and Oceania) (see Section 3.4.1).

3.6.1.1. Biological or technical factors limiting the feasibility and effectiveness of measures to prevent the entry, establishment and spread of the pest

- Based on symptoms, *M. medusae* can be confused with other *Melampsora* spp. (EPPO, 1997).
- Urediniospores and aeciospores of *M. medusae* can be spread by wind over long distances (see Section 3.4.4).
- In areas with mild winters, no alternate host is required for the establishment and spread of the disease (EPPO, 1997; Sinclair and Lyon, 2005).
- The genetic uniformity of *Populus* plants for planting may facilitate the spread of the pathogen (EPPO, 1997).

3.6.1.2. Biological or technical factors limiting the ability to prevent the presence of the pest on plants for planting

- Long-distance dispersal may limit the ability to prevent the presence of the pest on plants for planting.

3.6.2. Pest control methods

- Some resistant *Populus* cultivars are available (Siwecky, 1974; EPPO, 1997).
- Increasing host genetic diversity can prevent disease impacts (Prakash and Thielges, 1989).
- Removing and destroying diseased leaves from the ground may help reduce infections (Anon, 2011).
- Wide spacing between trees may create a less favourable microclimate for spread and infection (Anon, 2011).
- Production of plants for planting in pest free areas and places of production can prevent pest presence on plants for planting.
- No information was found on chemical control methods in nurseries or plantations specific to *M. medusae*. Chemical control of generic poplar rusts in France is described in Anon (2006).

3.7. Uncertainty

There is uncertainty about which factors may be limiting the spread of *M. medusae* in the EU MS which have reported the pathogen (overwintering problems, host alternation or ecological constraints) (Pinon, 1986).

It is unclear if the low pathogenicity of the populations of *M. medusae* present in Europe may be due to a reduced life cycle and/or to the environmental factors listed above. There is uncertainty about the life cycle of the pathogen in Belgium, France and Portugal.

There is uncertainty about the level of susceptibility of the native *P. alba* and *P. tremula*.

4. Conclusions

M. medusae meets the criteria assessed by EFSA for consideration as a potential quarantine pest (Table 5).

Table 5: The Panel's conclusions on the pest categorisation criteria defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column)

Criterion of pest categorisation	Panel's conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest	Panel's conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest	Key uncertainties
Identity of the pest (Section 3.1)	The identity of the pest as a species is clear	The identity of the pest as a species is clear	None
Absence/ presence of the pest in the EU territory (Section 3.2)	*M. medusae* is present, although not widespread, in the EU (and only represented by *M. medusae* f. sp. *deltoidae*). It is reported as present with few occurrences both in Belgium and France, and present with a restricted distribution in South Portugal	*M. medusae* is present, although not widespread, in the EU (and only represented by *M. medusae* f. sp. *deltoidae*). It is reported as present with few occurrences both in Belgium and France, and present with a restricted distribution in South Portugal	None
Regulatory status (section 3.3)	*M. medusae* is regulated by Council Directive 2000/29/EC (Annex IAI) as a harmful organism whose introduction into, and spread within, all Member States shall be banned	*M. medusae* is regulated by Council Directive 2000/29/EC (Annex IAI) as a harmful organism whose introduction into, and spread within, all Member States shall be banned	None
Pest potential for entry, establishment and spread in the EU territory (Section 3.4)	Entry: the pest could enter the EU via host plants for planting and cut branches Establishment: hosts and favourable climatic conditions are widespread in the risk assessment area Spread: the pest would be able to spread following establishment by various means, i.e. host plants for planting, cut branches and spore dissemination	Plants for planting are not the main means of spread, as the pathogen can also spread via cut branches and aerial dissemination of spores	There is uncertainty about which factors are limiting the spread of *M. medusae* in the EU MS which have reported the pathogen (overwintering problems, host alternation or ecological constraints) There is uncertainty about the level of susceptibility of the native *P. alba* and *P. tremula*
Potential for consequences in the EU territory (Section 3.5)	The introduction into the EU of aggressive isolates of *M. medusae* (of both the already present *M. medusae* f. sp. *deltoidae* and the not known to occur *M. medusae* f. sp. *tremuloides*) would have economic and environmental impacts in woodlands, poplar plantations and nurseries	The introduction into the EU of aggressive isolates of *M. medusae* (of both the already present *M. medusae* f. sp. *deltoidae* and the not known to occur *M. medusae* f. sp. *tremuloides*) would have an impact on the intended use of plants for planting	It is unclear if low pathogenicity of populations of either f. sp. of *M. medusae* may be due to their reduced life cycle characteristics
Available measures (Section 3.6)	Import prohibition of host plants for planting is an available measure to reduce the risk of introduction. Some resistant *Populus* cultivars are available. Moreover, increasing host genetic diversity can prevent disease impacts	Production of plants for planting in pest free areas and places of production can prevent pest presence on plants for planting	The effectiveness of pest free areas for the production of clean nursery stock is uncertain, due to the long-distance dispersal potential of the rust

Criterion of pest categorisation	Panel's conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest	Panel's conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest	Key uncertainties
Conclusion on pest categorisation (Section 4)	The criteria assessed by the Panel for consideration as a potential quarantine pest are met. The pathogen is present in the EU but with a restricted distribution and is under official control	The criterion on plants for planting as the main pathway of spread is not met	None
Aspects of assessment to focus on/ scenarios to address in future if appropriate	The main knowledge gap concerns the factors responsible for the low aggressiveness of the populations of *M. medusae* present in Europe		

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Abbreviations

CLC	Corine Land Cover
C-SMFA	constrained spatial multi-scale frequency analysis
DG SANTE	Directorate General for Health and Food Safety
EPPO	European and Mediterranean Plant Protection Organization
EUFGIS	European Information System on Forest Genetic Resources
FAO	Food and Agriculture Organization
GD^2	Georeferenced Data on Genetic Diversity
IPPC	International Plant Protection Convention
MS	Member State
PLH	EFSA Panel on Plant Health
RNQP	Regulated non-quarantine pest
RPP	relative probability of presence
TFEU	Treaty on the Functioning of the European Union
ToR	Terms of Reference

Appendix A – Methodological notes on Figures 3 and 4

The relative probability of presence (RPP) reported here for *Larix* spp. and *Pinus* spp. in Figures 3 and 4 and in the European Atlas of Forest Tree Species (de Rigo et al., 2016a; San-Miguel-Ayanz et al., 2016) is the probability of that genus to occur in a given spatial unit (de Rigo et al., 2017). In forestry, such a probability for a single taxon is called 'relative'. The maps of RPP are produced by means of the constrained spatial multi-scale frequency analysis (C-SMFA) (de Rigo et al., 2014, 2017) of species presence data reported in geo-located plots by different forest inventories.

A.1. Geolocated plot databases

The RPP models rely on five geodatabases that provide presence/absence data for tree species and genera: four European-wide forest monitoring data sets and a harmonised collection of records from national forest inventories (de Rigo et al., 2014, 2016a, 2017). The databases report observations made inside geolocalised sample plots positioned in a forested area, but do not provide information about the plot size or consistent quantitative information about the recorded species beyond presence/absence.

The harmonisation of these data sets was performed within the research project at the origin of the European Atlas of Forest Tree Species (de Rigo et al., 2016a; San-Miguel-Ayanz, 2016; San-Miguel-Ayanz et al., 2016). Given the heterogeneity of strategies of field sampling design and establishment of sampling plots in the various national forest inventories (Chirici et al., 2011a,b), and also given legal constraints, the information from the original data sources was harmonised to refer to an INSPIRE compliant geospatial grid, with a spatial resolution of 1 km^2 pixel size, using the ETRS89 Lambert Azimuthal Equal-Area as geospatial projection (EPSG: 3035, http://spatialreference.org/ref/epsg/etrs89-etrs-laea/).

A.1.1. European National Forestry Inventories database

This data set was derived from National Forest Inventory data and provides information on the presence/absence of forest tree species in approximately 375,000 sample points with a spatial resolution of 1 km^2/pixel, covering 21 European countries (de Rigo et al., 2014, 2016a,b).

A.1.2. Forest Focus/Monitoring data set

This project is a Community scheme for harmonised long-term monitoring of air pollution effects in European forest ecosystems, normed by EC Regulation No 2152/2003[5]. Under this scheme, the monitoring is carried out by participating countries on the basis of a systematic network of observation points (Level I) and a network of observation plots for intensive and continuous monitoring (Level II). For managing the data, the JRC implemented a Forest Focus Monitoring Database System, from which the data used in this project were taken (Hiederer et al., 2007; Houston Durrant and Hiederer, 2009). The complete Forest Focus data set covers 30 European Countries with more than 8,600 sample points.

A.1.3. BioSoil data set

This data set was produced by one of a number of demonstration studies performed in response to the 'Forest Focus' Regulation (EC) No 2152/2003 mentioned above. The aim of the BioSoil project was to provide harmonised soil and forest biodiversity data. It comprised two modules: a Soil Module (Hiederer et al., 2011) and a Biodiversity Module (Houston Durrant et al., 2011). The data set used in the C-SMFA RPP model came from the Biodiversity module, in which plant species from both the tree layer and the ground vegetation layer were recorded for more than 3,300 sample points in 19 European Countries.

[5] Council of the European Union, 2003. Regulation (EC) No 2152/2003 of the European Parliament and of the Council of 17 November 2003 concerning monitoring of forests and environmental interactions in the Community (Forest Focus). Official Journal of the European Union, 46, L 324, pp. 1–8.

A.1.4. European Information System on Forest Genetic Resources (EUFGIS)

EUFGIS (http://portal.eufgis.org) is a smaller geodatabase providing information on tree species composition in over 3,200 forest plots in 34 European countries. The plots are part of a network of forest stands managed for the genetic conservation of one or more target tree species. Hence, the plots represent the natural environment to which the target tree species are adapted.

A.1.5. Georeferenced Data on Genetic Diversity (GD^2)

GD^2 (http://gd2.pierroton.inra.fr) provides information about 63 species of interest for genetic conservation. The database covers 6,254 forest plots located in stands of natural populations that are traditionally analysed in genetic surveys. While this database covers fewer species than the others, it covers 66 countries in Europe, North Africa, and the Middle East, making it the data set with the largest geographic extent.

A.2. Modelling methodology

For modelling, the data were harmonised in order to have the same spatial resolution (1 km^2) and filtered to a study area comprising 36 countries in the European continent. The density of field observations varies greatly throughout the study area and large areas are poorly covered by the plot databases. A low density of field plots is particularly problematic in heterogeneous landscapes, such as mountainous regions and areas with many different land use and cover types, where a plot in one location is not representative of many nearby locations (de Rigo et al., 2014). To account for the spatial variation in plot density, the model used here (C-SMFA) considers multiple spatial scales when estimating RPP. Furthermore, statistical resampling is systematically applied to mitigate the cumulated data-driven uncertainty.

The presence or absence of a given forest tree species then refers to an idealised standard field sample of negligible size compared with the 1 km^2 pixel size of the harmonised grid. The modelling methodology considered these presence/absence measures as if they were random samples of a binary quantity (the punctual presence/absence, not the pixel one). This binary quantity is a random variable having its own probability distribution which is a function of the unknown average probability of finding the given tree species within a plot of negligible area belonging to the considered 1 km^2 pixel (de Rigo et al., 2014). This unknown statistic is denoted hereinafter with the name of 'probability of presence'.

C-SMFA performs spatial frequency analysis of the geolocated plot data to create preliminary RPP maps (de Rigo et al., 2014). For each 1 km^2 grid cell, the model estimates kernel densities over a range of kernel sizes to estimate the probability that a given species is present in that cell. The entire array of multi-scale spatial kernels is aggregated with adaptive weights based on the local pattern of data density. Thus, in areas where plot data are scarce or inconsistent, the method tends to put weight on larger kernels. Wherever denser local data are available, they are privileged ensuring a more detailed local RPP estimation. Therefore, a smooth multi-scale aggregation of the entire arrays of kernels and data sets is applied instead of selecting a local 'best performing' one and discarding the remaining information. This array-based processing, and the entire data harmonisation procedure, are made possible thanks to the semantic modularisation which defines the Semantic Array Programming modelling paradigm (de Rigo, 2012).

The probability to find a single species (e.g. a particular coniferous tree species) in a 1 km^2 grid cell cannot be higher than the probability of presence of all the coniferous species combined. The same logical constraints applied to the case of single broadleaved species with respect to the probability of presence of all the broadleaved species combined. Thus, to improve the accuracy of the maps, the preliminary RPP values were constrained so as not to exceed the local forest-type cover fraction with an iterative refinement (de Rigo et al., 2014). The forest-type cover fraction was estimated from the classes of the Corine Land Cover (CLC) maps which contain a component of forest trees (Bossard et al., 2000; Büttner et al. 2012).

The resulting probability of presence is relative to the specific tree taxon, irrespective of the potential co-occurrence of other tree taxa with the measured plots, and should not be confused with the absolute abundance or proportion of each taxon in the plots. RPP represents the probability of finding at least one individual of the taxon in a plot placed randomly within the grid cell, assuming that the plot has negligible area compared with the cell. As a consequence, the sum of the RPP associated with different taxa in the same area is not constrained to be 100%. For example, in a forest with two co-dominant tree species which are homogeneously mixed, the RPP of both may be 100% (see e.g. the Glossary in San-Miguel-Ayanz et al. (2016), http://forest.jrc.ec.europa.eu/media/atlas/Glossary.pdf).

The robustness of RPP maps depends strongly on sample plot density, as areas with few field observations are mapped with greater uncertainty. This uncertainty is shown qualitatively in maps of 'RPP trustability'. RPP trustability is computed on the basis of the aggregated equivalent number of sample plots in each grid cell (equivalent local density of plot data). The trustability map scale is relative, ranging from 0 to 1, as it is based on the quantiles of the local plot density map obtained using all field observations for the species. Thus, trustability maps may vary among species based on the number of databases that report a particular species (de Rigo et al., 2014, 2016a,b).

The RPP and relative trustability range from 0 to 1 and are mapped at a 1 km spatial resolution. To improve visualisation, these maps can be aggregated to coarser scales (i.e. 10 $\times$ 10 pixels or 25 $\times$ 25 pixels, respectively summarising the information for aggregated spatial cells of 100 and 625 km^2) by averaging the values in larger grid cells.