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## Pest categorisation of *Gymnosporangium* spp. (non-EU)

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### Abstract

Following a request from the European Commission, the EFSA Panel on Plant Health performed a pest categorisation of *Gymnosporangium* spp. (non-EU), a well-defined and distinguishable group of fungal plant pathogens of the family Pucciniaceae affecting woody species. Many different *Gymnosporangium* species are recognised, of which at least 14 species are considered not to be native in the European Union. All the non-EU *Gymnosporangium* species are not known to be present in the EU and are regulated in Council Directive 2000/29/EC (Annex IAI) as harmful organisms whose introduction into the EU is banned. *Gymnosporangium* spp. are biotrophic obligate plant pathogens. These rust fungi are heteroecious as they require *Juniperus*, *Libocedrus*, *Callitropsis*, *Chamaecyparis* or *Cupressus* (telial hosts) and rosaceous plants of subfamily Pomoideae (aecial hosts) to complete their life cycle. The pathogens could enter the EU via host plants for planting (including artificially dwarfed woody plants) and cut branches. They could establish in the EU, as climatic conditions are favourable and hosts are common. They would be able to spread following establishment by movement of host plants for planting and cut branches, as well as by natural dispersal. Should *Gymnosporangium* spp. (non-EU) be introduced in the EU, impacts can be expected in orchards, ornamental trees and nurseries. On telial hosts, these pathogens cause galls on stems, twigs and branches, and fusiform swellings on stems. Foliar infections on aecial hosts may lead to severe defoliations. The main knowledge gap concerns the limited available information on the biology, distribution range and impact of several non-EU *Gymnosporangium* spp. The criteria assessed by the Panel for consideration of *Gymnosporangium* spp. (non-EU) as potential quarantine pests are met, while, for regulated non-quarantine pests, the criterion on the pest presence in the EU is not met.

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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<sup>1</sup> 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<sup>2</sup> 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<sup>3</sup>, 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, is 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.

<sup>1</sup> 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.

<sup>2</sup> 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.

<sup>3</sup> 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**

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

##### **(b) Bacteria**

Citrus variegated chlorosis	<i>Xanthomonas campestris</i> pv. <i>oryzae</i> (Ishiyama)
<i>Erwinia stewartii</i> (Smith) Dye	Dye and pv. <i>oryzicola</i> (Fang, et al.) Dye

##### **(c) Fungi**

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

##### **(d) Virus and virus-like organisms**

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

#### **Annex IIB**

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

<i>Anthonomus grandis</i> (Boh.)	<i>Ips cembrae</i> Heer
<i>Cephalcia lariciphila</i> (Klug)	<i>Ips duplicatus</i> Sahlberg
<i>Dendroctonus micans</i> Kugelán	<i>Ips sexdentatus</i> Börner
<i>Gilpinia hercyniae</i> (Hartig)	<i>Ips typographus</i> Heer
<i>Gonipterus scutellatus</i> Gyll.	<i>Sternochetus mangiferae</i> Fabricius
<i>Ips amitinus</i> Eichhof	

**(b) Bacteria**

*Curtobacterium flaccumfaciens* pv. *flaccumfaciens*  
(Hedges) Collins and Jones

**(c) Fungi**

*Glomerella gossypii* Edgerton

*Hypoxyton mammatum* (Wahl.) J. Miller

*Gremmeniella abietina* (Lag.) Morelet

**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) <i>Carneocephala fulgida</i> Nottingham | 3) <i>Graphocephala atropunctata</i> (Signoret) |
| 2) <i>Draeculacephala minerva</i> Ball     |   |

Group of Tephritidae (non-EU) such as:

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

**(c) Viruses and virus-like organisms**

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

- |                                  |  |
|----------------------------------|--|
| 1) Andean potato latent virus    | 4) Potato black ringspot virus   |
| 2) Andean potato mottle virus    | 5) Potato virus T  |
| 3) Arracacha virus B, oca strain | 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       | 8) Peach yellows mycoplasma  |
| 2) Cherry rasp leaf virus (American) | 9) Plum line pattern virus (American)  |
| 3) Peach mosaic virus (American)     | 10) Raspberry leaf curl virus (American)   |
| 4) Peach phony rickettsia            | 11) Strawberry witches' broom mycoplasma   |
| 5) Peach rosette mosaic virus        | 12) Non-EU viruses and virus-like organisms of <i>Cydonia</i> Mill., <i>Fragaria</i> L., <i>Malus</i> Mill., <i>Prunus</i> L., <i>Pyrus</i> L., <i>Ribes</i> L., <i>Rubus</i> L. and <i>Vitis</i> L. |
| 6) Peach rosette mycoplasma          |  |
| 7) Peach X-disease mycoplasma        |  |

## 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

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

### (b) Fungi

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

### (c) Viruses and virus-like organisms

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

### (d) Parasitic plants

*Arceuthobium* spp. (non-EU)

## **Annex I A I I**

### **(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**

*Gymnosporangium* spp. (non-EU) 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.

The term 'non-EU' is interpreted to refer to those *Gymnosporangium* spp. native outside of the EU and, if introduced in the EU, with restricted distribution and under official control. Therefore, the European native *Gymnosporangium* species *Gymnosporangium amelanchieris*, *Gymnosporangium clavariiforme*, *Gymnosporangium confusum*, *Gymnosporangium cornutum*, *Gymnosporangium fuscum*, *Gymnosporangium fusisporum*, *Gymnosporangium minus*, *Gymnosporangium orientale*, *Gymnosporangium sabinae*, *Gymnosporangium torminali-juniperum* and *Gymnosporangium tremelloides* (Helfer, 2005; Lāce, 2017; Fernández, 2018), although in some cases reported from outside the EU (EPPO, 2006), are not considered non-EU and are not part of this pest categorisation. Likewise, *Gymnosporangium atlanticum*, which has been reported from Morocco, Spain and China (Fernández et al., 2016; Fernández, 2018), is not considered to be non-EU (as Spain is likely part of the native range of that species) and is not part of this pest categorisation.

## **2. Data and methodologies**

### **2.1. Data**

#### **2.1.1. Literature search**

A literature search on *Gymnosporangium* spp. was conducted at the beginning of the categorisation in the ISI Web of Science bibliographic database, using the scientific name of the pest as search term. 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 Plant 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 SANTÉ) 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 *Gymnosporangium* spp. (non-EU) following guiding principles and steps presented in the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018) and as defined in the International Standard for Phytosanitary Measures No 11 (FAO, 2013) and No 21 (FAO, 2004).

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.

**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
<b>Identity of the pest (Section 3.1)</b>	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?
<b>Absence/presence of the pest in the EU territory (Section 3.2)</b>	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)

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
<b>Regulatory status (Section 3.3)</b>	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?
<b>Pest potential for entry, establishment and spread in the EU territory (Section 3.4)</b>	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!
<b>Potential for consequences in the EU territory (Section 3.5)</b>	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?
<b>Available measures (Section 3.6)</b>	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?
<b>Conclusion of pest categorisation (Section 4)</b>	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**, the identity of the pest is established.

*Gymnosporangium* spp. are fungi of the family Pucciniaceae.

Based on the results of a phylogenetic study, the split of *Gymnosporangium* species from the genus *Ravenelia* occurred at the Eocene epoch of the Palaeogene period in the Cenozoic era, approximately 51.7–44.3 million years ago (Zhao et al., 2016). Many different *Gymnosporangium* species are now recognised (Table 2). Index fungorum (<http://www.indexfungorum.org/names/names.asp>) lists 66 accepted species (accessed September 2018).

Eighteen *Gymnosporangium* species are listed in the EPPO Global Database (EPPO, 2018; accessed September 2018). Considering the information provided by EPPO (2018) (Table 2), at least 14 *Gymnosporangium* species are non-EU. Five of these non-EU species were recommended for regulation in the EPPO region: *Gymnosporangium asiaticum* (EPPO, 1997a), *Gymnosporangium clavipes* (EPPO, 1997b), *Gymnosporangium globosum* (EPPO, 1997c), *Gymnosporangium juniperi-virginianae* (EPPO, 1997d) and *Gymnosporangium yamadae* (EPPO, 1997e). Some other non-EU *Gymnosporangium* species have been reported in North America (Aldwinckle, 1990): *Gymnosporangium kernianum*, *Gymnosporangium libocedri* and *Gymnosporangium nelsonii*, (EPPO, 2006). For many more *Gymnosporangium* species that have been reported from outside the EU, there are no available reports from the EU (Table 2).

Two new species of *Gymnosporangium* have been described from South Korea: *Gymnosporangium monticola* and *Gymnosporangium unicorne* (Yun et al., 2009; EPPO, 2013). In addition, the following new species were described from China: *Gymnosporangium huanglongense* (Cao et al., 2016) and *Gymnosporangium przewalskii* (Cao et al., 2017). *Gymnosporangium corniforme* and *Gymnosporangium nitakayamense* sp. nov. have been reported in Taiwan (Shen et al., 2018).

##### 3.1.2. Biology of the pest

*Gymnosporangium* spp. are biotrophic obligate plant pathogens. These rust fungi are heteroecious as they require plants of either *Juniperus* or *Libocedrus* as telial hosts and rosaceous plants of subfamily Pomoideae as aecial hosts to complete their life cycle (Kern, 1973b; EPPO, 2006). The genus *Gymnosporangium* had long been supposed to lack the uredinial stage; however that stage was later described for some species of the genus (e.g. *Gymnosporangium gaeumannii*, *Gymnosporangium nootkatense*) (Kern, 1970 and references therein).

As a general rule, telia are produced on twigs and branches of the telial host in the spring. In moist conditions, the telia germinate *in situ* and produce basidiospores which are dispersed and are able to infect leaves of nearby alternate host plants. After infection of the aecial host, spermatogonia develop on the upper surface of leaves or occasionally on fruits; they are visible from late spring to early summer. The most favourable conditions for infection have been reported for some of the species. For instance for *G. clavipes*, an extended wetting period (over 48 h) with a mean temperature over 10°C between the tight cluster and late pink bud stages is deemed favourable for infections to occur (Aldwinckle, 1990; EPPO, 1997b). Later, aeciospores are produced inside tubular protective sheaths (peridia) on the underside of leaves. The wind-borne aeciospores are released and dispersed over long distances. After germinating on the telial host, an overwintering latent mycelium is produced. The pathogen does not persist in the aecial host once the infected leaves or fruits have fallen.

Depending on the pathogen species, infections on the telial host may be either annual or known to be persistent for more than one year. In the former case the pathogen produces only one batch of teliospores, thus implying that fresh infections of the host are needed every year for the life cycle to be maintained (Peterson, 1967; EPPO, 1997d). In the latter case, the pathogen may be able to release basidiospores over many years (Aldwinckle, 1990; EPPO, 1997a). Infections can be latent during winter (EPPO, 1997a–e). In addition, infection may also have remained latent on the plants in the previous growing season (EPPO, 1997a–e).

**Table 2:** List of currently recognised *Gymnosporangium* species compiled from Index Fungorum ([www.indexfungorum.org/names/names.asp](http://www.indexfungorum.org/names/names.asp)), EPPO Global Database (EPPO, 2018), and other sources. 'X' in the EPPO Global Database column implies presence in that database. '-' implies no information available

Accepted species name in Index Fungorum	EPPO GD	Presence in the EU	Origin and/or distribution according to EPPO GD	Origin and/or distribution according to other sources
<i>Gymnosporangium amelanchieris</i> E. Fisch. ex F. Kern	-	Yes	-	Europe, Asia, North Africa (Helfer, 2005), Spain (Vila et al., 2004), Turkey (Bahcecioglu, 2001)
<i>Gymnosporangium asiaticum</i> Miyabe ex G. Yamada <sup>(a)</sup>	X	No	China, Japan, North and South Korea, Russia, USA	-
<i>Gymnosporangium atlanticum</i> Guyot & Malençon	-	Yes	-	China, Morocco, Spain (Tarragona, Zarazoga and Huesca) (Fernández et al., 2016; Fernández, 2018)
<i>Gymnosporangium aurantiacum</i> Syd. & P. Syd.	-	-	-	-
<i>Gymnosporangium bermudianum</i> Earle	-	-	-	Alabama (Stone, 1909), Bermuda Islands and Mississippi, US (Underwood and Earle, 1896)
<i>Gymnosporangium bethelii</i> F. Kern	-	-	-	Alberta, Canada (Brandt, 1995); Rocky Mountains, US (Peterson, 1967)
<i>Gymnosporangium biseptatum</i> Ellis	-	-	-	New Hampshire (Baldwin, 1961); Maine, US (Bessette et al., 2001)
<i>Gymnosporangium clavariiforme</i> (Wulfen) DC. <sup>(b)</sup>	X	Yes	Europe, Middle East, Asia, Canada, USA	-
<i>Gymnosporangium clavipes</i> Cooke & Peck	X	No	Canada, Guatemala, Mexico, USA	-
<i>Gymnosporangium confusum</i> Plowr.	X	Yes	Europe, Asia, USA	Europe, Africa, Asia (Helfer, 2005; Fernández, 2018)
<i>Gymnosporangium connersii</i> Parmelee	-	-	-	Canada (Parmelee, 1965)
<i>Gymnosporangium corniculans</i> F. Kern	-	-	-	Canada (McDowall et al., 1967)
<i>Gymnosporangium corniforme</i> Sawada	-	No	-	Taiwan (Shen et al., 2018)
<i>Gymnosporangium cornutum</i> Arthur ex F. Kern	X	Yes	Europe, Asia (areas of Archangel to Kamchatka), western China, Japan and North America	Europe, Africa, Asia and North America (Helfer, 2005)
<i>Gymnosporangium cunninghamianum</i> Barclay	-	-	-	Guatemala, Mexico, USA (Peterson, 1982), Nepal (Balfour-Browne, 1968)
<i>Gymnosporangium cupressi</i> Long & Goodd.	-	-	-	Arizona and California, US (Long and Goodding, 1940; Peterson, 1968)
<i>Gymnosporangium davisii</i> F. Kern	-	-	-	Maine and Wisconsin, US (Kern, 1908)
<i>Gymnosporangium dobrozrakovae</i> Mitrof.	-	-	-	Turkey (Dervis et al., 2010)
<i>Gymnosporangium effusum</i> F. Kern	-	-	-	Washington, D.C., USA (Long, 1945)
<i>Gymnosporangium ellisii</i> (Berk.) Berk.	-	-	-	North America (Kreisel, 1973)

Accepted species name in Index Fungorum	EPPO GD	Presence in the EU	Origin and/or distribution according to EPPO GD	Origin and/or distribution according to other sources
<i>Gymnosporangium exiguum</i> F. Kern	–	–	–	Texas (Kern, 1908)
<i>Gymnosporangium exterum</i> Arthur & F. Kern	–	–	–	Kentucky, US (Arthur and Kern, 1908)
<i>Gymnosporangium floriforme</i> Thaxt.	–	–	–	Alabama and Arkansas, US (Kern, 1908)
<i>Gymnosporangium formosanum</i> Hirats. f. & Hashioka	–	–	–	Taiwan (Hiratsuka and Hashioka, 1935), Japan (Hiratsuka, 1937)
<i>Gymnosporangium fraternum</i> F. Kern	–	–	–	New Jersey, US (Dodge, 1915)
<i>Gymnosporangium fusisporum</i> E. Fisch.	–	Yes	–	Africa, Moldova, Switzerland, Ukraine (Helfer, 2005), China (Xu et al., 2013) and France (Fernández, 2018)
<i>Gymnosporangium gaeumannii</i> H. Zogg	–	Yes	–	Alberta, Canada (Parmelee, 1969), China (Xu et al., 2013), Switzerland (Zogg, 1949), Austria, Bulgaria and France (Fernández, 2018)
<i>Gymnosporangium gjaerumii</i> Korbonsk. & Azbukina	–	–	–	Tajikistan (Azbukina, 1997)
<i>Gymnosporangium globosum</i> (Farl.) Farl.	X	No	Canada, Mexico, USA	–
<i>Gymnosporangium gracile</i> Pat.	–	Yes	–	Northern Africa, Southern North America, Europe (Bulgaria, France, Greece, Italy, Spain) (Helfer, 2005)
<i>Gymnosporangium gracilens</i> (Peck) F. Kern & Bethel	–	–	–	New Mexico, US (Standley, 1916)
<i>Gymnosporangium harknessianum</i> F. Kern ex Arthur	–	–	–	Rocky Mountains, US (Peterson, 1967)
<i>Gymnosporangium hemisphaericum</i> Hara	–	–	–	Japan (Hiratsuka, 1937)
<i>Gymnosporangium huanglongense</i> Y.M. Liang & B. Cao	–	No	–	China (Cao et al., 2016)
<i>Gymnosporangium hyalinum</i> (Cooke) F. Kern	–	–	–	Florida and South Carolina (Kern and West, 1947)
<i>Gymnosporangium inconspicuum</i> F. Kern	–	–	–	Rocky Mountains, US (Peterson, 1967)
<i>Gymnosporangium juniperi-virginianae</i> Schwein.	X	No	Canada, USA	–
<i>Gymnosporangium kernianum</i> Bethel <sup>(c)</sup>	X	No	USA	–
<i>Gymnosporangium libocedri</i> (Henn.) F. Kern	X	No	USA <sup>(d)</sup>	–
<i>Gymnosporangium meridissimum</i> Crowell	–	–	–	Guatemala (Wagener, 1948)
<i>Gymnosporangium mespili</i> F. Kern <sup>(c)</sup>	–	–	–	–

Accepted species name in Index Fungorum	EPPO GD	Presence in the EU	Origin and/or distribution according to EPPO GD	Origin and/or distribution according to other sources
<i>Gymnosporangium minus</i> Crowell	–	Yes	–	Greece (Crowell, 1940; Helfer, 2005)
<i>Gymnosporangium miyabei</i> G. Yamada & I. Miyake	–	–	–	Japan (Hiratsuka, 1937)
<i>Gymnosporangium monticola</i> H.Y. Yun	X	No	South Korea	–
<i>Gymnosporangium multiporum</i> F. Kern	–	–	–	Colorado, US (Kern, 1909)
<i>Gymnosporangium nelsonii</i> Arthur	X	No	USA <sup>(d)</sup>	–
<i>Gymnosporangium nidus-avis</i> Thaxt.	–	–	–	Nevada, US (Peterson, 1967)
<i>Gymnosporangium niitakayamense</i> Y. M. Shen	–	No	–	Taiwan (Shen et al., 2018)
<i>Gymnosporangium nootkatense</i> (Trel.) Arthur	–	–	–	Alaska, US (Hennon, 1990)
<i>Gymnosporangium orientale</i> P. Syd. & Syd.	–	Yes	–	Greece (Simtems and Bornmüller, 1891)
<i>Gymnosporangium padmarensense</i> Balf.-Browne	–	–	–	Nepal (Balfour-Browne, 1968)
<i>Gymnosporangium paraphysatum</i> Vienn.-Bourg.	–	–	–	Vietnam (Viennot-Bourgin, 1960)
<i>Gymnosporangium przewalskii</i> Y.M. Liang & B. Cao	–	No	–	China (Cao et al., 2017)
<i>Gymnosporangium sabinae</i> (Dicks.) G. Winter	X	Yes	Europe, Asia and North Africa	–
<i>Gymnosporangium shiraianum</i> Hara	X <sup>(e)</sup>	–	–	Japan (Hara, 1919; cited in Hiratsuka, 1937)
<i>Gymnosporangium sorbi</i> (Arthur) F. Kern	–	–	–	–
<i>Gymnosporangium speciosum</i> Peck	–	–	–	Colorado (Bethel, 1911), Nevada, US (Peterson, 1967)
<i>Gymnosporangium taianum</i> F. Kern	–	–	–	China (Kern, 1964)
<i>Gymnosporangium tianschanicum</i> Z.Y. Zhao & J.Y. Zhuang	–	–	–	China (Zhao and Zhuang, 2007)
<i>Gymnosporangium torminali-juniperini</i> E. Fisch. <sup>(f)</sup>	–	Yes	–	Europe (Austria, Britain, France, Germany, Greece, Hungary, Italy, Portugal, Russia, Spain, Sweden, Switzerland), North Africa (Helfer, 2005; Fernández, 2018)
<i>Gymnosporangium trachysorum</i> F. Kern	–	–	–	Alabama, North Carolina and Louisiana, US (Arthur, 1910)
<i>Gymnosporangium tremelloides</i> R. Hartig	X	Yes	Europe, North-west Africa, China and western North America	–
<i>Gymnosporangium tsingchenense</i> C.T. Wei	–	–	–	–

Accepted species name in Index Fungorum	EPPO GD	Presence in the EU	Origin and/or distribution according to EPPO GD	Origin and/or distribution according to other sources
<i>Gymnosporangium turkestanicum</i> Tranzschel	–	–	–	China (Xu et al., 2013)
<i>Gymnosporangium unicolorne</i> H.Y. Yun	X	No	Republic of Korea	Taiwan (Shen et al., 2018)
<i>Gymnosporangium vauqueliniae</i> Long & Goodd.	–	–	–	Arizona, US (Goodding, 1935)
<i>Gymnosporangium yamadae</i> Miyabe ex G. Yamada	X	No	China, Japan, North and South Korea, USA	In addition: Canada, Russian Far East and Taiwan (CABI, 2018)

(a): EPPO (2018) lists *Gymnosporangium haraeaeum* separately, but Index Fungorum reports it as a synonym of *G. asiaticum*.

(b): EPPO (2018) lists *Gymnosporangium juniperinum* separately, but Index Fungorum reports it as a synonym of *G. clavariiforme*.

(c): Reported as synonym of *G. confusum* in EPPO (2018).

(d): EPPO, 2006.

(e): Reported in EPPO (2017) as formerly *G. shiraianum*.

(f): Reported as *Gymnosporangium torminalis-juniperum* by Fernández (2018).

### 3.1.3. Intraspecific diversity

For most of the non-EU *Gymnosporangium* species there is little information on the degree of intraspecific diversity. Sakuma (1992) described two races of *G. asiaticum*, differentiated by their behaviour on cultivars of *Pyrus pyrifolia*; *Pyrus communis* cv. 'Bartlett' gave a resistant reaction to both. A *forma specialis* of *G. asiaticum* (f. sp. *crataegicola*) was described in China on *Crataegus* (Wang et al., 1993). However, it is not clear whether strict specificity to *Crataegus* has been confirmed (EPPO, 1997a). Low genetic diversity was detected based on microsatellite markers in populations of *G. yamadae* in China (Tao et al., 2018). Races of *G. juniperi-virginianae* that vary in virulence to various apple cultivars are known, but no comparable information is available regarding the reactions of juniper hosts (Sinclair and Lyon, 2005).

### 3.1.4. Detection and identification of the pest

Are detection and identification methods available for the pest?

**Yes**, detection and identification methods are available for some (but not all) *Gymnosporangium* spp.

A diagnostic standard for the detection and identification of non-EU *Gymnosporangium* species *G. asiaticum*, *G. clavipes*, *G. globosum*, *G. juniperi-virginianae* and *G. yamadae*, based on spore morphology and symptoms on telial and aecial hosts, is available (EPPO, 2006).

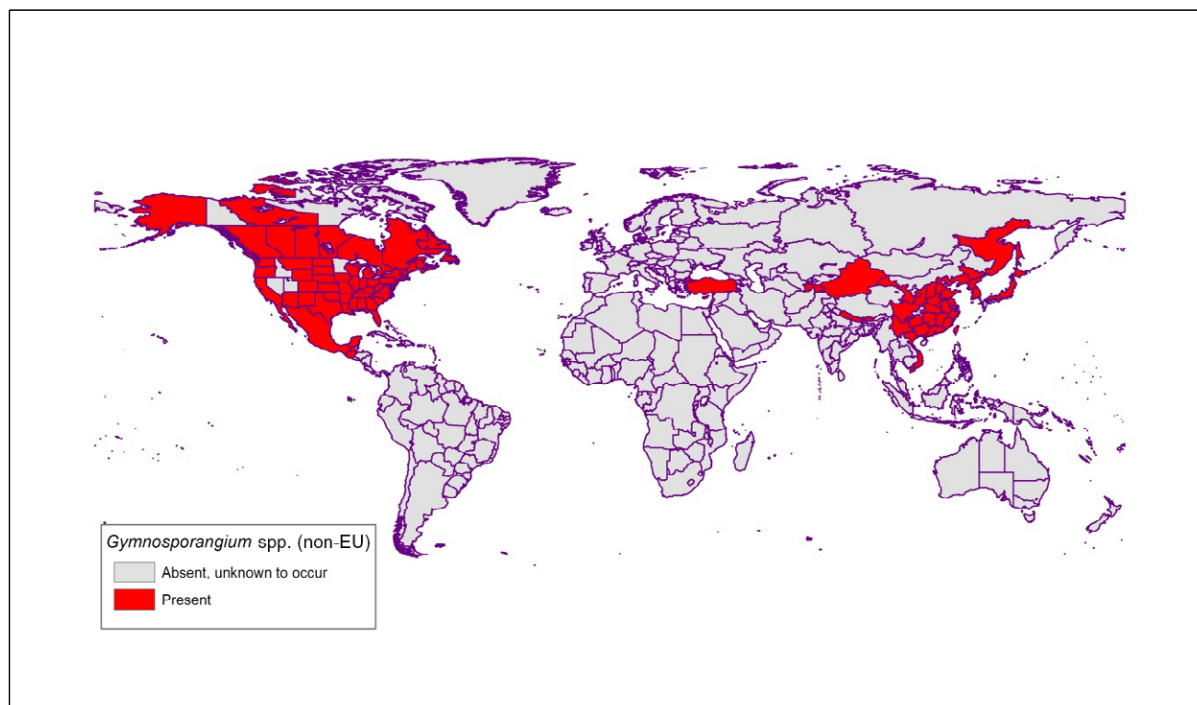
Descriptions of other non-EU *Gymnosporangium* species useful for diagnostics purposes are also available (e.g. Cao et al., 2016, 2017; Shen et al., 2018). The non-EU *Gymnosporangium* species can be confused with the European *Gymnosporangium* species *G. fuscum*, *G. clavariiforme*, *G. confusum*, *G. cornutum* and *G. tremelloides* (EPPO, 2006). This increases the uncertainty of the geographical distribution of the various *Gymnosporangium* species. However, identification keys for the *Gymnosporangium* species present in Europe are available (Fernández, 2018).

Little information on molecular markers for diagnostic purposes of *Gymnosporangium* spp. has been reported (EPPO, 2006; Fernández et al., 2016; Tao et al., 2018). However, a phylogenetic tree of *Gymnosporangium* spp. using the internal transcribed spacers (ITS) and the large subunit (LSU) rRNA partial gene has been published (Cao et al., 2017).

### 3.2. Pest distribution

#### 3.2.1. Pest distribution outside the EU

*Gymnosporangium* spp. (non-EU) are present in North and Central America and Asia (Table 2; EPPO, 2018). The known distribution of *Gymnosporangium* spp. (non-EU) outside the EU is shown in Figure 1.



**Figure 1:** Global distribution map for *Gymnosporangium* spp. (based on Table 2 and 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?*

**No**, *Gymnosporangium* spp. (non-EU) are not reported to be present in the EU.

*G. asiaticum* is reported as absent in the Netherlands (confirmed by survey, 2018) and in France (intercepted only, 1992) (EPPO, 2018). *G. clavipes*, *G. globosum*, *G. juniperi-virginianae* and *G. yamadae* are reported as absent in Slovenia (no pest record, 2017) and in the Netherlands (confirmed by survey, 2018) (EPPO, 2018). The UK (Plant Health Risk Register, accessed September 2018, <https://secure.fera.defra.gov.uk/phiw/riskRegister/>) reports the absence of *G. asiaticum*, *G. clavipes*, *G. globosum*, *G. juniperi-virginianae*, *G. libocedri*, *G. monticola* and *G. tremelloides*. With the exception of the Netherlands, there are no reports of absence confirmed by survey available to the Panel.

### 3.3. Regulatory status

#### 3.3.1. Council Directive 2000/29/EC

*Gymnosporangium* spp. (non-EU) are listed in Council Directive 2000/29/EC. Details are presented in Tables 3 and 4.



**Table 3:** *Gymnosporangium* spp. (non-EU) in Council Directive 2000/29/EC

<b>Annex I, Part A</b>	<b>Harmful organisms whose introduction into, and spread within, all Member States shall be banned</b>
<b>Section I</b>	<b>Harmful organisms not known to occur in any part of the community and relevant for the entire Community</b>
(c)	Fungi
	Species
6.	<i>Gymnosporangium</i> spp. (non-European)

### 3.3.2. Legislation addressing the hosts of *Gymnosporangium* spp. (non-EU)

**Table 4:** Regulated hosts and commodities that may involve *Gymnosporangium* spp. (non-EU) in Annexes III, IV and V of Council Directive 2000/29/EC

<b>Annex III, Part A</b>	<b>Plants, plant products and other objects the introduction of which shall be prohibited in all Member States</b>	
	Description	Country of origin
1.	Plants of <i>Abies</i> Mill., <i>Cedrus</i> Trew, <i>Chamaecyparis</i> Spach, <i>Juniperus</i> L., <i>Larix</i> Mill., <i>Picea</i> A. Dietr., <i>Pinus</i> L., <i>Pseudotsuga</i> Carr. and <i>Tsuga</i> Carr., other than fruit and seeds	Non-European countries
9.	Plants of <i>Chaenomeles</i> Ldl., <i>Cydonia</i> Mill., <i>Crataegus</i> L., <i>Malus</i> Mill., <i>Prunus</i> L., <i>Pyrus</i> L., and <i>Rosa</i> L., intended for planting, other than dormant plants free from leaves, flowers and fruit	Non-European countries
18.	Plants of <i>Cydonia</i> Mill., <i>Malus</i> Mill., <i>Prunus</i> L. and <i>Pyrus</i> L. and their hybrids, [...], intended for planting, other than seeds	Without prejudice to the prohibitions applicable to the plants listed in Annex III A (9), where appropriate, non-European countries, other than Mediterranean countries, Australia, New Zealand, Canada, the continental states of the USA
<b>Annex V</b>	<b>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</b>	
<b>Part A</b>	Plants, plant products and other objects originating in the Community	
<b>Section I</b>	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	
1.1.	Plants, intended for planting, other than seeds, of <i>Amelanchier</i> Med., <i>Chaenomeles</i> Lindl., <i>Cotoneaster</i> Ehrh., <i>Crataegus</i> L., <i>Cydonia</i> Mill., <i>Eriobotrya</i> Lindl., <i>Malus</i> Mill., <i>Mespilus</i> L., <i>Photinia davidiana</i> (Dcne.) Cardot, <i>Prunus</i> L., other than <i>Prunus laurocerasus</i> L. and <i>Prunus lusitanica</i> L., <i>Pyracantha</i> Roem., <i>Pyrus</i> L. and <i>Sorbus</i> L.	

## 3.4. Entry, establishment and spread in the EU

### 3.4.1. Host range

The host range of *Gymnosporangium* spp. (non-EU) includes genera in the family Cupressaceae (telial hosts) and rosaceous plants of the subfamily Pomoideae (aecial hosts) (Kern, 1973a; EPPO, 2006).

The list of telial hosts of *Gymnosporangium* spp. (non-EU) includes the following (Aldwinckle, 1990; EPPO, 2006, 2018; Yun et al., 2009; Cao et al., 2016, 2017): *Juniperus* spp., *Juniperus chinensis*, *Juniperus communis*, *Juniperus occidentalis*, *Juniperus pachyphlea*, *Juniperus przewalskii*, *Juniperus rigida*, *Juniperus scopulorum*, *Juniperus utahensis*, *Juniperus virginiana*. The telial host of *G. libocedri* is *Libocedrus decurrens*. Cupressus species are reported as hosts of *Gymnosporangium cunninghamianum*, *Gymnosporangium cupressi* and *Gymnosporangium taianum* (Peterson, 1968, 1982). Telial hosts of non-EU *Gymnosporangium* spp. also include *Chamaecyparis* spp. and *Callitropsis* spp. (Novick, 2008).

The list of aecial hosts rated as major hosts includes (EPPO, 2018): *Crataegus* spp., *Cydonia oblonga*, *Malus domestica* and *Pyrus pyrifolia*.

EPPO (2018) lists as minor aecial hosts: *Malus* spp., *Malus baccata*, *Malus halliana*, *Malus prunifolia*, *Malus pumila* and *Malus toringa*.

Other incidental aecial hosts or known aecial hosts not rated for their susceptibility include (Aldwinckle, 1990; Helfer, 2005; EPPO, 2006, 2018; Yun et al., 2009; Xu et al., 2013; Cao et al., 2016, 2017; Shen et al., 2018): *Amelanchier* spp., *Aronia* spp., *Chaenomeles* spp., *Cotoneaster* spp., *Malus sylvestris*, *Mespilus* spp., *Photinia* spp., *Photinia niitakayamensis*, *Pyrus* spp., *Pyrus calleryana*, *P. communis*, *Pyrus ussuriensis*, *Sorbus* spp., *Sorbus alnifolia* and *Sorbus koehneana*.

*Gymnosporangium* spp. (non-EU) (i.e. *G. asiaticum*) have also been observed, and reported as interceptions, on *Pseudocydonia* spp. and *Pyracantha* spp. (see Section 3.4.2).

For some *Gymnosporangium* species (i.e. *G. unicorne*), the aecial stage was not observed in nature, however several rosaceous hosts (*Crataegus pinnatifida*, *Chaenomeles speciosa*, *Pseudocydonia sinensis*, *Pyrus pyrifolia* var. *culta*, *P. ussuriensis*) could produce the aecial stage after artificial inoculation with teliospores (Yun et al., 2009). Likewise, *Sorbus randaiensis* was demonstrated to be an aecial host of *G. corniforme* based on molecular analyses and inoculation experiments (Shen et al., 2018).

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? If yes, identify and list the pathways!*

**Yes**, *Gymnosporangium* spp. (non-EU) could enter the EU on host plants for planting and cut branches.

The main pathways of entry (EPPO, 2018) are:

- plants for planting (including artificially dwarfed plants)
- and cut branches

of host species, including *Chaenomeles* spp., *Crataegus* spp., *Cydonia oblonga*, *Juniperus* spp., *Malus* spp., *Pyrus* spp., *Sorbus* spp. (for both plants for planting and cut branches) and *Photinia* spp. (plants for planting).

In international trade, telial hosts plants, and especially artificially dwarfed plants (see below), may carry the disease. *Gymnosporangium* spp. can be latent during winter (the probable importing period) and may not be detectable at pre-export phytosanitary certification. Infection may also have remained latent on the plants in the previous growing season. It is unlikely that infection from the telial stage could be carried on packing materials, at least for some non-EU *Gymnosporangium* spp. (EPPO, 1997d).

Introduction of *Gymnosporangium* spp. (non-EU) on commercial imports of aecial host plants is unlikely for the following reasons: infected leaves are not persistent in the dormant stage of host plants, and fruits are either not infected or it is very unlikely that infected fruits would be harvested or meet quality standards for export (EPPO, 1997a–e).

The *Juniperus* plant pathway is regulated by EU legislation banning the import from non-European countries (see Section 3.3.2; Matthews-Berry, 2014). There is also a ban on importing plants of *Chaenomeles*, *Crataegus*, *Malus* and *Pyrus*, but dormant plants without leaves of these genera are not banned (see Section 3.3.2).

Based on Matthews-Berry (2014), there were five interceptions at two UK nurseries in 2008 on Junipers brought in from Japan under the derogation for the import of naturally and artificially dwarfed plants. These plants all originated from the same nursery in Japan and these interceptions resulted in the destruction of all plants which had been imported into the UK from that nursery. *G. asiaticum* has been intercepted in the UK in 1974 and 1982 on dwarf bonsai juniper (*J. chinensis*) trees from Japan. There has also been an interception in France in 1988 and again on *J. chinensis* bonsai plants (EPPO, 1974, 1988).

Between January 2005 and August 2018, there were the following records of interception of *Gymnosporangium* spp. (non-EU) in the Europhyt database: one record of *G. asiaticum* on *J. chinensis* bonsai from Japan in 2008, four records and one record of *G. asiaticum* on *J. chinensis* and *J. rigida*

bonsai, respectively, from Japan in 2009, three records of *G. asiaticum* on *J. chinensis*, *Pseudocystodonia* sp. and *Pyracantha* sp. bonsai from the Republic of Korea in 2011, four records of *G. asiaticum* on *J. chinensis* bonsai from Japan in 2015 and one record of *G. asiaticum* on *Juniperus* sp. bonsai from Japan in 2016.

### 3.4.3. Establishment

*Is the pest able to become established in the EU territory?*

**Yes**, the pest could establish in the EU, as hosts are present and favourable climatic conditions are common.

#### 3.4.3.1. EU distribution of main host plants

The main telial and aecial host species of *Gymnosporangium* spp. (non-EU) (see Section 3.4.1) are common as native and/or cultivated plants, including ornamentals, in the EU. The most common telial native species *J. communis* is widespread throughout the EU, with the exception of the most south-western and southern areas (Figure 2).



**Figure 2:** Distribution map of *Juniperus communis*, from Caudullo et al. (2017)

Apples, which are major aecial hosts of *Gymnosporangium* spp. (non-EU), are widely grown in the EU (Table 5), as previously reported (EFSA PLH Panel et al., 2017).

**Table 5:** Area cultivated with apples in the EU between 2013 and 2017 (in 1,000 ha). Source: Eurostat (code: tag00120), data extracted in September 2018

EU Member States <sup>(a)</sup>	2013	2014	2015	2016	2017
EU28	538	524	538	524	524
Poland	162	163	180	165	163
Romania	60	56	56	56	56
Italy	53	52	52	56	57
France	51	50	50	50	50
Hungary	33	33	33	33	32
Germany	32	32	32	32	34
Spain	31	31	31	31	31
United Kingdom	20	16	16	17	17
Portugal	14	14	14	14	15
Greece	13	12	12	12	10
Lithuania	12	11	11	10	10

(a): Only Member States growing more than 10,000 ha are reported.

Apples are also grown, but to a lesser extent, in the Czech Republic, the Netherlands, Belgium, Austria, Croatia, Bulgaria, Slovakia, Latvia, Slovenia, Denmark, Sweden, Estonia, Cyprus, Ireland, Finland and Luxembourg (EFSA PLH Panel, 2017).

Over the period 2006–2010, the average area of production of *Cydonia oblonga* in the EU28 was about 3,700 ha (EFSA PLH Panel, 2014).

Starting from the 1990s, the cultivation of Asian pears has been promoted for commercial production and for ornamental purposes in the EU, as reported by EFSA PLH Panel (2017). There are, however, no data concerning the abundance and distribution of these host plants in the risk assessment area, although enterprises producing plants for planting and fresh fruit of Asian pears are currently present in the EU (EFSA PLH Panel, 2017).

### 3.4.3.2. Climatic conditions affecting establishment

The distribution of *Gymnosporangium* spp. (non-EU) in their native range covers a wide variety of climates, including those found throughout the EU regions with presence of hosts. Climate is thus assumed not to be a limiting factor for the establishment in the EU.

For the UK, Matthews-Berry (2014) scored the risk of establishment of *G. asiaticum* as moderately likely outdoors and likely under protection.

### 3.4.4. Spread

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

**Yes**, by movement of host plants for planting and cut branches, as well as dispersal of spores.

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

**No**, spread is not mainly via plants for planting, as it can also occur by movement of cut branches and by natural dispersal of spores.

Under natural conditions, spread of *Gymnosporangium* spp. (non-EU) occurs by means of basidiospores to rosaceous hosts, and by wind-borne aeciospores to the telial hosts. For *G. asiaticum*, it has been reported that aecial hosts within 100 m from telial hosts are at high risk of infection, and up to 1,000 m in windy situations (Unemoto et al., 1989).

Over long distances, telial hosts plants, and especially artificially dwarfed plants (see Section 3.4.2), may carry the disease. As pointed out in the Entry (Section 3.4.2), *Gymnosporangium* spp. can be latent during winter (the most probable importing period) and may not be detectable at pre-export phytosanitary certification. Infection may also have remained latent on the plants in the previous growing season.

### 3.5. Impacts

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

**Yes**, the introduction of *Gymnosporangium* spp. (non-EU) would have economic impacts in orchards, ornamentals and nurseries.

*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?<sup>4</sup>*

**Yes**, the presence of *Gymnosporangium* spp. (non-EU) would have an economic impact on their intended use.

*Gymnosporangium* spp. (non-EU) are responsible, on telial hosts and depending on the pathogen species, for the production of telia on leaves and green stems, of galls on stems, twigs and branches, and of fusiform swellings on stems (EPPO, 1997a–e). On aecial hosts, these pathogens develop spermagonia and aecia on leaves. Small yellow-orange lesions may appear on the upper surface of the leaves and petioles. Foliar infections on aecial hosts may lead to severe defoliations (EPPO, 1997a–e).

*G. juniperi-virginianae* is responsible for a serious disease on apples in North America, and has been reported as the most important of the North American *Gymnosporangium* spp. (Aldwinckle, 1990). The disease is one of the few to have triggered legislation for the purpose of disease suppression (Sinclair and Lyon, 2005). The disease has the potential to cause severe crop reduction through fruit infections and premature defoliation of trees (Sinclair and Lyon, 2005). It also causes problems on *Juniperus virginiana*, which is an important timber and amenity tree in North America (EPPO, 1997d) (Figure 3).

*G. asiaticum* is reported to be a serious pathogen of *Pyrus pyrifolia* and one of the most important pests of urban ornamentals (*J. chinensis*) in China (Zhang, 1990). In Japan, this pathogen is reported as causing one of the most important diseases affecting Japanese pear cultivation, with frequent outbreaks in some areas of Japan since 2008 due to the emergence of fungicide resistance (Kikuhara et al., 2019). However, it has been reported that there is no indication that *G. asiaticum* has any practical importance in North America, nor that it causes significant disease of any rosaceous host other than *P. pyrifolia* (EPPO, 1997a; Matthews-Berry, 2014).

*G. globosum* can lead to severe damage on *Crataegus* seedlings in nurseries. Nevertheless, Aldwinckle (1990) rates it as a minor pathogen of fruit crops, compared with *G. clavipes* and *G. juniperi-virginianae*. In a study of field susceptibility of apple cultivars to three *Gymnosporangium* spp. (Warner, 1990), *G. globosum* caused only minor leaf symptoms and was much less severe than *G. juniperi-virginianae* (EPPO, 1997d). Nevertheless, *G. globosum* has been reported to be able to cause problems on *Juniperus virginiana* (EPPO, 1997c).

On susceptible apple cultivars, *G. yamadae* has been reported to cause very severe defoliations (EPPO, 1997e).

Little information is available about the impact of other non-EU *Gymnosporangium* spp., with the exception of *G. libocedri*, which may cause premature drop of fruits, a disease occasionally reported as serious on pears in the western USA (Sinclair and Lyon, 2005; EPPO, 2006).

<sup>4</sup> See Section 2.1 on what falls outside EFSA's remit.



**Figure 3:** *Gymnosporangium juniperi-virginianae*, Smoky Mountains, North Carolina, US. Photo by Jason Hollinger. Available online: [https://commons.wikimedia.org/wiki/File:Gymnosporangium\\_juniperi-virginianae\\_-\\_Flickr\\_-\\_pellaea.jpg](https://commons.wikimedia.org/wiki/File:Gymnosporangium_juniperi-virginianae_-_Flickr_-_pellaea.jpg)

### 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**, see Sections 3.3 and 3.6.1.

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

**Yes**, production of host plants for planting in pest free areas and observation of the consignments in quarantine over the growing season are available measures to prevent pest presence on plants for planting (EPPO, 1997d). However, EPPO (1997d) recommends an import ban of this commodity. See Section 3.6.1.3 for latent infection as a limiting factor for these mitigation measures.

#### 3.6.1. Identification of additional measures

Phytosanitary measures (import ban) are currently applied to *Juniperus* plants (see Section 3.3.2). However, there are various other hosts on which non-EU *Gymnosporangium* spp. may be introduced into the EU (see Section 3.4.1).

##### 3.6.1.1. Additional control measures

Potential additional control measures are listed in Table 6.

**Table 6:** Selected control measures (a full list is available in EFSA PLH Panel, 2018) for pest entry/establishment/spread/impact in relation to currently unregulated hosts and pathways. Control measures are measures that have a direct effect on pest abundance

Information sheet title (with hyperlink to information sheet if available)	Control measure summary	Risk component (entry/establishment/spread/impact)
Chemical treatments on crops including reproductive material	Successful control may be possible with routine fungicide applications (e.g. dithiocarbamates, sterol-inhibiting fungicides) (EPPO, 1997a–e)	Establishment/Spread
Use of resistant and tolerant plant species/varieties	Varietal differences in susceptibility are known for non-EU <i>Gymnosporangium</i> spp. (Warner, 1990), and resistant cultivars exist (EPPO, 1997a–e).	Establishment/Spread
<a href="#">Roguing and pruning</a>	Suppression of the alternate host within a certain radius of orchards is recommended, but may be difficult as alternate hosts may be present in private gardens (EPPO, 1997a; CABI, 2018).	Spread/Impact
<a href="#">Crop rotation, associations and density, weed/volunteer control</a>	It is not recommended to plant telial hosts close to aecial hosts orchards, for the sake of either host (EPPO, 1997c).	Impact

### 3.6.1.2. Additional supporting measures

Potential additional supporting measures are listed in Table 7.

**Table 7:** Selected supporting measures (a full list is available in EFSA PLH Panel, 2018) in relation to currently unregulated hosts and pathways. Supporting measures are organisational measures or procedures supporting the choice of appropriate risk reduction options that do not directly affect pest abundance

Information sheet title (with hyperlink to information sheet if available)	Supporting measure summary	Risk component (entry/establishment/spread/impact)
<a href="#">Inspection and trapping</a>	Consignments from infested areas should be kept in quarantine over the growing season and found free from <i>Gymnosporangium</i> spp. (EPPO, 1997d)	Entry

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

- Based on symptoms, *Gymnosporangium* spp. (non-EU) may be confused with native European *Gymnosporangium* spp. (EPPO, 2006).
- Latent infections of telial hosts, with infections that may also have remained latent on the plants in the previous growing season, may hamper a prompt detection of the pest.

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

- Latent infections of telial hosts may hamper a prompt detection of the pest on infected plants for planting.
- The emergence of resistance for fungicides previously able to control Japanese pear rust has been reported for *G. asiaticum* in Japan (Kikuhara et al., 2019).

## 3.7. Uncertainty

- The area of origin and geographic distribution of most (non-EU and EU) *Gymnosporangium* spp. is uncertain.
- For most non-EU *Gymnosporangium* spp., there is limited information on their biology.

- Based on symptoms, *Gymnosporangium* spp. (non-EU) may be confused with native European *Gymnosporangium* spp. (EPPO, 2006).
- There is little information of the impact of several non-EU *Gymnosporangium* spp.

#### 4. Conclusions

*Gymnosporangium* species (non-EU) meet the criteria assessed by EFSA for consideration as potential quarantine pests (Table 8).

**Table 8:** 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
<b>Identity of the pest (Section 3.1)</b>	The identity of <i>Gymnosporangium</i> spp. (non-EU) as a group of species is clear	The identity of <i>Gymnosporangium</i> spp. (non-EU) as a group of species is clear	None
<b>Absence/presence of the pest in the EU territory (Section 3.2)</b>	The non-EU <i>Gymnosporangium</i> spp. are not reported to be present in the EU	The non-EU <i>Gymnosporangium</i> spp. are not reported to be present in the EU	The area of origin and geographic distribution of most non-EU <i>Gymnosporangium</i> spp. is uncertain
<b>Regulatory status (Section 3.3)</b>	<i>Gymnosporangium</i> spp. (non-EU) are regulated by Council Directive 2000/29/EC (Annex IAI) as harmful organisms whose introduction into, and spread within, all Member States shall be banned	<i>Gymnosporangium</i> spp. (non-EU) are regulated by Council Directive 2000/29/EC (Annex IAI) as harmful organisms whose introduction into, and spread within, all Member States shall be banned	None
<b>Pest potential for entry, establishment and spread in the EU territory (Section 3.4)</b>	Entry: the pest could enter the EU via host plants for planting and cut branches. Establishment: hosts are common and climatic conditions are favourable in the risk assessment area. Spread: the pest could spread following establishment by movement of host plants for planting and cut branches, as well as natural spread	Plants for planting are not the main pathway of spread, given the potential contribution of cut branches and natural spread	The area of origin and geographic distribution of most non-EU <i>Gymnosporangium</i> spp. is uncertain
<b>Potential for consequences in the EU territory (Section 3.5)</b>	The introduction of <i>Gymnosporangium</i> spp. (non-EU) would have economic and environmental impacts in orchards, ornamental trees and nurseries	The introduction of the pest could have an impact on the intended use of plants for planting	There is little information of the impact of several non-EU <i>Gymnosporangium</i> spp.
<b>Available measures (Section 3.6)</b>	Import prohibition of host plants, locating nurseries far away from infected stands, and selecting resistant host varieties are available measures	Production of plants for planting in pest free areas can prevent pest presence on plants for planting	None
<b>Conclusion on pest categorisation (Section 4)</b>	The criteria assessed by the Panel for consideration of <i>Gymnosporangium</i> spp. (non-EU) as potential quarantine pests are met	The criterion on the pest presence in the EU is not met	



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
Aspects of assessment to focus on/ scenarios to address in future if appropriate	The main knowledge gap is the limited available information on the biology, distribution range and impact of several non-EU <i>Gymnosporangium</i> species		

## References

- Aldwinckle HS, 1990. Rust diseases. In: Aldwinckle HS and Jones AL (eds.). Compendium of Apple and Pear Diseases. American Phytopathological Society, St. Paul, US. pp. 10–14.
- Arthur JC, 1910. Cultures of Uredineae in 1909. *Mycologia*, 2, 213–240.
- Arthur JC and Kern FD, 1908. Type of *Gymnosporangium exterum* Arthur & F.Kern [family Pucciniaceae]. The William and Lynda Steere Herbarium of the New York Botanical Garden, 1908/04/10. Available online: <https://plants.jstor.org/stable/10.5555/al.ap.specimen.ny00053746> [Accessed: September 2018]
- Azbukina ZM, 1997. A new species of genus *Gymnosporangium* (Uredinales) from Tadzhikistan. *Mikologiya i Fitopatologiya*, 31, 3–4.
- Bahcecioglu Z, 2001. New records of Pucciniaceae from Turkey. *Plant Disease Research*, 16, 17–22.
- Baldwin HI, 1961. Further notes on *Chamaecyparis thyoides* in New Hampshire. *Rhodora*, 63, 281–285.
- Balfour-Browne FL, 1968. Fungi of recent Nepal expeditions. *Bulletin of the British Museum (Natural History) Botany*, 4, 3, 97–141.
- Bessette AR, Bessette A and Neill WJ, 2001. *Mushrooms of Cape Cod and the national seashore*. Syracuse University Press, Syracuse, NY, USA.
- Bethel E, 1911. Notes on some species of *Gymnosporangium* in Colorado. *Mycologia*, 3, 156–160.
- Brandt JP, 1995. Forest insect and disease conditions in west-central Canada in 1994 and predictions for 1995. Canadian Forest Service, Northwest Region, Northern Forestry Centre. 57 pp. Available online: [http://www.cfs.nrcan.gc.ca/bookstore\\_pdfs/11635.pdf](http://www.cfs.nrcan.gc.ca/bookstore_pdfs/11635.pdf) [Accessed: September 2018]
- CABI (Commonwealth Agricultural Bureau International), 2018. *Gymnosporangium yamadae* (Japanese apple rust). CABI Invasive Species Compendium. Available online: <https://www.cabi.org/isc/datasheet/26238> [Accessed: September 2018]
- Cao B, Tian CM and Liang YM, 2016. *Gymnosporangium huanglongense* sp. nov. from western China. *Mycotaxon*, 131, 375–383.
- Cao B, Han FZ, Tian CM and Liang YM, 2017. *Gymnosporangium przewalskii* sp. nov. (Pucciniales, Basidiomycota) from China and its life cycle. *Phytotaxa*, 311, 67–76.
- Caudullo G, Welk E and San-Miguel-Ayanz J, 2017. Chorological maps for the main European woody species. *Data in Brief*, 12, 662–666. <https://doi.org/10.1016/j.dib.2017.05.007>
- Crowell IH, 1940. New species of *Gymnosporangium*. *Canadian Journal of Research*, 18, 10–12.
- Dervis S, Dixon L, Doğanlar M and Rossman A, 2010. Gall production on hawthorns caused by *Gymnosporangium* spp. in Hatay province, Turkey. *Phytoparasitica*, 38, 391–400.
- Dodge BO, 1915. The effect of the host on the morphology of certain species of *Gymnosporangium*. *Bulletin of the Torrey Botanical Club*, 42, 519–542.
- EFSA PLH Panel (EFSA Panel on Plant Health), 2014. Scientific Opinion on the pest categorisation of *Erwinia amylovora* (Burr.) Winsl. et al. *EFSA Journal* 2014;12(12):3922, 37 pp. <https://doi.org/10.2903/j.efsa.2014.3922>
- EFSA PLH Panel (EFSA Panel on Plant Health), Jeger M, Bragard C, Caffier D, Candresse T, Chatzivassiliou E, Dehnen-Schmutz K, Gilioli G, Gregoire J-C, Jaques Miret JA, MacLeod A, Navajas Navarro M, Niere B, Parnell S, Potting R, Rafoss T, Urek G, Van Bruggen A, Van der Werf W, West J, Winter S, Armengol Forti J, Vloutoglou I, Bottex B and Rossi V, 2017. Scientific Opinion on the pest categorisation of *Botryosphaeria kuwatsukai*. *EFSA Journal* 2017;15(11):5035, 26 pp. <https://doi.org/10.2903/j.efsa.2017.5035>
- EFSA PLH Panel (EFSA Panel on Plant Health), Jeger M, Bragard C, Caffier D, Candresse T, Chatzivassiliou E, Dehnen-Schmutz K, Gregoire J-C, 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, Hart A, Schans J, Schrader G, Suffert M, Kertesz V, Kozelska S, Mannino MR, Mosbach-Schulz O, Pautasso M, Stancanelli G, Tramontini S, Vos S and Gilioli G, 2018. Guidance on quantitative pest risk assessment. *EFSA Journal* 2018;16(8):5350, 86 pp. <https://doi.org/10.2903/j.efsa.2018.5350>

- EPPO (European and Mediterranean Plant Protection Organization), 1974. EPPO Reporting Service no.01-1974. Available online: <https://gd.eppo.int/reporting/Rse-1974-01> [Accessed: September 2018]
- EPPO (European and Mediterranean Plant Protection Organization), 1988. EPPO Reporting Service no.06-1988. Available online: <https://gd.eppo.int/reporting/Rse-1988-06> [Accessed: September 2018]
- EPPO (European and Mediterranean Plant Protection Organization), 1997a. Data sheets on quarantine pests: *Gymnosporangium asiaticum*. In: Smith IM, McNamara DG, Scott PR and Holderness M (eds.). Quarantine Pests for Europe, 2nd Edition. CABI/EPPO, Wallingford. 1425 pp.
- EPPO (European and Mediterranean Plant Protection Organization), 1997b. Data sheets on quarantine pests: *Gymnosporangium clavipes*. In: Smith IM, McNamara DG, Scott PR and Holderness M (eds.). Quarantine Pests for Europe, 2nd Edition. CABI/EPPO, Wallingford. 1425 pp.
- EPPO (European and Mediterranean Plant Protection Organization), 1997c. Data sheets on quarantine pests: *Gymnosporangium globosum*. In: Smith IM, McNamara DG, Scott PR and Holderness M (eds.). Quarantine Pests for Europe, 2nd Edition. CABI/EPPO, Wallingford. 1425 pp.
- EPPO (European and Mediterranean Plant Protection Organization), 1997d. Data sheets on quarantine pests: *Gymnosporangium juniper-virginianae*. In: Smith IM, McNamara DG, Scott PR, Holderness M (eds.). Quarantine Pests for Europe, 2nd Edition. CABI/EPPO, Wallingford. 1425 pp.
- EPPO (European and Mediterranean Plant Protection Organization), 1997e. Data sheets on quarantine pests: *Gymnosporangium yamadae*. In: Smith IM, McNamara DG, Scott PR and Holderness M (eds.). Quarantine Pests for Europe, 2nd Edition. CABI/EPPO, Wallingford. 1425 pp.
- EPPO (European and Mediterranean Plant Protection Organization), 2006. *Gymnosporangium* spp. (non-European). PM 7/73 (1). EPPO Bulletin, 36, 441-446.
- EPPO (European and Mediterranean Plant Protection Organization), 2013. New data on quarantine pests and pests of the EPPO Alert List. EPPO Reporting Service no. 02-2013. Available online: <https://gd.eppo.int/reporting/article-2503> [Accessed: September 2018]
- EPPO (European and Mediterranean Plant Protection Organization), 2017. EPPO A1 and A2 lists of pests recommended for regulation as quarantine pests. EPPO Standards PM 1/2(26). Available online: <https://gd.eppo.int/download/standard/2/pm1-002-26-en.pdf> [Accessed: September 2018]
- EPPO (European and Mediterranean Plant Protection Organization), 2018. EPPO Global Database. Available online: <https://gd.eppo.int> [Accessed: September 2018]
- FAO (Food and Agriculture Organization of the United Nations), 1995. ISPM (International standards for phytosanitary measures) No 4. Requirements for the establishment of pest free areas. Available online: <https://www.ippc.int/en/publications/614/>
- FAO (Food and Agriculture Organization of the United Nations), 2004. ISPM (International Standards for Phytosanitary Measures) 21—Pest risk analysis of regulated non-quarantine pests. FAO, Rome, 30 pp. Available online: [https://www.ippc.int/sites/default/files/documents/1323945746\\_ISPM\\_21\\_2004\\_En\\_2011-11-29\\_Refor.pdf](https://www.ippc.int/sites/default/files/documents/1323945746_ISPM_21_2004_En_2011-11-29_Refor.pdf)
- FAO (Food and Agriculture Organization of the United Nations), 2013. ISPM (International Standards for Phytosanitary Measures) 11—Pest risk analysis for quarantine pests. FAO, Rome, 36 pp. Available online: [https://www.ippc.int/sites/default/files/documents/20140512/isp\\_m\\_11\\_2013\\_en\\_2014-04-30\\_201405121523-494.65%20KB.pdf](https://www.ippc.int/sites/default/files/documents/20140512/isp_m_11_2013_en_2014-04-30_201405121523-494.65%20KB.pdf)
- FAO (Food and Agriculture Organization of the United Nations), 2017. ISPM (International standards for phytosanitary measures) No 5. Glossary of phytosanitary terms. Available online: <https://www.ippc.int/en/publications/622/>
- Fernández JL, 2018. Claves de identificación de *Gymnosporangium* en España y Europa. Boletín de la Sociedad Micológica de Madrid, 42, 79–90.
- Fernández JL, Llorens I and Alvarado P, 2016. Evidence for *Gymnosporangium atlanticum* in Europe. Mycotaxon, 131, 357–366.
- Goodding LN, 1935. Isotype of *Gymnosporangium vauquelinae* Long & Goodding [family Pucciniaceae]. Arthur Herbarium Purdue University, 1935/11/01. Available online: <https://plants.jstor.org/stable/10.5555/al.ap.specimen.pur000126> [Accessed: September 2018]
- Hara K, 1919. Studies on "Mikata-Akahoshiyo" of pear caused by *Gymnosporangium shiraianum*. Journal of Plant Protection, 6, 681–687 and 751–756.
- Helfer S, 2005. Overview of the rust fungi (Uredinales) occurring on Rosaceae in Europe. Nova Hedwigia, 81, 325–370.
- Hennon PE, 1990. Fungi on *Chamaecyparis nootkatensis*. Mycologia, 82, 59–66.
- Hiratsuka N, 1937. *Gymnosporangium* of Japan. V. The Botanical Magazine, 51, 1–8.
- Hiratsuka N and Hashioka Y, 1935. Uredinales Collected in Formosa III. The Botanical Magazine, 49, 19–26.
- Kern FD, 1908. Studies in the genus *Gymnosporangium*. Bulletin of the Torrey Botanical Club, 35, 499–511.
- Kern FD, 1909. A notable species of *Gymnosporangium* from Colorado. Mycologia, 1, 208–210.
- Kern FD, 1964. Lists and keys of the cedar rusts of the world. Memoirs of the New York Botanical Garden, 10, 305–326.
- Kern FD, 1970. The uredial stage in *Gymnosporangium*. Bulletin of the Torrey Botanical Club, 97, 159–161.
- Kern FD, 1973a. A host survey of *Gymnosporangium*. Mycopathologia et Mycologia Applicata, 51, 99–101.
- Kern FD, 1973b. A revised taxonomic account of *Gymnosporangium*. Pennsylvania State University Press, University Park, PA, USA.
- Kern FD and West E, 1947. Another gymnosporangial connection. Mycologia, 39, 120–125.

- Kikuhara K, Iiyama K, Matsumoto M and Furuya N, 2019. First report on DMI fungicide resistance in *Gymnosporangium asiaticum*, the causal agent of Japanese pear rust, in Japan. *Journal of General Plant Pathology*, in press. <https://doi.org/10.1007/s10327-018-0820-5>
- Kreisel H, 1973. *Bibliographie der Verbreitungskarten von Pilzen II. Hemi-und Phragmobasidiomyceten 1917–1971*. Feddes Repertorium, 83, 741–755.
- Lāce B, 2017. *Gymnosporangium* species – an important issue of plant protection. *Proceedings of the Latvian Academy of Sciences B*, 71, 95–102.
- Long WH, 1945. Notes on four eastern species of *Gymnosporangium*. *Journal of the Washington Academy of Sciences*, 35, 182–188.
- Long WH and Goodding LN, 1940. Notes on *Gymnosporangium cupressi*. *Mycologia*, 32, 489–492.
- Matthews-Berry S, 2014. Rapid pest risk analysis for *Gymnosporangium asiaticum*. The Food & Environment Research Agency, UK. Available online: <https://secure.fera.defra.gov.uk/phiw/riskRegister/downloadExternalPra.cfm?id=3833> [Accessed: September 2018]
- McDowall LL, Campbell AE, Mortensen KL, Arthurs JW, Tidsbury RC, Devlin RJ, McLeod BB, Crawford WB, Rentz CL, Still GN and Homann MJ, 1967. Annual district reports - forest insect and disease survey - Manitoba-Saskatchewan region 1966. Forest Research Station, Winnipeg, Manitoba, Canada. Available online: <http://www.cfs.nrcan.gc.ca/pubwarehouse/pdfs/23234.pdf> [Accessed: September 2018]
- Novick RS, 2008. Phylogeny, taxonomy, and life cycle evolution in the cedar rust fungi (*Gymnosporangium*). PhD Dissertation, Yale University, New Haven, USA.
- Parmelee JA, 1965. The genus *Gymnosporangium* in eastern Canada. *Canadian Journal of Botany*, 43, 239–267.
- Parmelee JA, 1969. *Gymnosporangium gaeumannii* in North America. *Mycologia*, 61, 401–404.
- Peterson RS, 1967. Studies of juniper rusts in the West. *Madrono*, 19, 79–91.
- Peterson RS, 1968. The life cycle of *Gymnosporangium cupressi*. *The Southwestern Naturalist*, 13, 102–103.
- Peterson RS, 1982. Rust fungi (Uredinales) on Cupressaceae. *Mycologia*, 74, 903–910.
- Sakuma T, 1992. Pathogenic races of *Gymnosporangium asiaticum* on Japanese pear and pathogenicity to some species in genus *Pyrus*. *Bulletin of the Fruit Tree Research Station*, 22, 67–78.
- Shen YM, Chung WH, Huang TC, Rodeva R and Hung TH, 2018. Unveiling *Gymnosporangium corniforme*, *G. unicorne*, and *G. nitakayamense* sp. nov. in Taiwan. *Mycoscience*, 59, 218–228.
- Simtens P and Bornmüller J, 1891. Isotype of *Gymnosporangium orientale* Syd. [family Pucciniaceae]. Arthur Herbarium Purdue University, 1891/08/01. Available online: <https://plants.jstor.org/stable/10.5555/al.ap.specimen.pur000125> [Accessed: September 2018]
- Sinclair WA and Lyon HH, 2005. *Diseases of Trees and Shrubs*, 2nd edition. Cornell University Press, Ithaca, NY. p. 660.
- Standley PC, 1916. Fungi of New Mexico. *Mycologia*, 8, 142–177.
- Stone RE, 1909. Species of *Gymnosporangium* in southern Alabama. *Torreyia*, 9, 114–117.
- Tao SQ, Cao B, Tian CM and Liang YM, 2018. Development and characterization of novel genic-SSR markers in apple-juniper rust pathogen *Gymnosporangium yamadae* (Pucciniales: Pucciniaceae) using next-generation sequencing. *International Journal of Molecular Sciences*, 19, 1178.
- Underwood LM and Earle FS, 1896. The distribution of the species of *Gymnosporangium* in the South. *Botanical Gazette*, 22, 255–258.
- Unemoto S, Murata A and Nagai Y, 1989. Dispersal of Japanese pear rust fungus, *Gymnosporangium asiaticum* Miyabe ex Yamada. *Annals of the Phytopathological Society of Japan*, 55, 250–253.
- Viennot-Bourgin G, 1960. *Gymnosporangium paraphysatum* sp. nov. sur le *Heyderia macrolepis* au Viet-Nam. *Revue de Mycologie*, 25, 293–305.
- Vila J, Llimona X, Cortés C, Hoyo P and Alentorn RM, 2004. Els fongs de la vall d'Alinyà (primeres dades). In: Germain J (ed.). *Els sistemes naturals de la vall d'Alinyà*. Institució Catalana d'Història Natural, Barcelona, Spain. *Treballs de la Institució Catalana d'Història Natural*, 14, 167–196. Available online: [https://ichn.iec.cat/pdf/Alinyà/06\\_Fongs.pdf](https://ichn.iec.cat/pdf/Alinyà/06_Fongs.pdf) [Accessed: September 2018]
- Wagner WW, 1948. Diseases of cypresses. *Aliso: A Journal of Systematic and Evolutionary Botany*, 1, 255–321. Available online: <http://scholarship.claremont.edu/aliso/vol1/iss1/3> [Accessed: September 2018]
- Wang K, Bai JK, Li DH and Deng GY, 1993. Identification and biological characteristics of *Gymnosporangium asiaticum* Miyabe ex Yamada f. sp. *crataegicola* infecting hawthorn. *Acta Phytopathologica Sinica*, 23, 187–192.
- Warner J, 1990. Field susceptibility of scab-resistant apple cultivars and selections to cedar apple rust, quince rust and hawthorn rust. *Fruit Varieties Journal*, 44, 216–224.
- Xu B, Zhao ZY and Zhuang JY, 2013. Rust fungi hitherto known from Xinjiang (Sinkiang), northwestern China. *Mycosystema*, 32, 170–189.
- Yun HY, Hong SG, Rossman AY, Lee SK, Lee KJ and Bae KS, 2009. The rust fungus *Gymnosporangium* in Korea including two new species, *G. monticola* and *G. unicorne*. *Mycologia*, 101, 790–809.
- Zhang NT, 1990. Report of a national survey on diseases of urban ornamental plants. *Forest Pest and Disease*, 1, 44–46.
- Zhao Z and Zhuang J, 2007. A new species of *Gymnosporangium* (Uredinales) occurring upon *Sabina vulgaris* Antoine (Cupressaceae). *Mycosystema*, 26, 321–323.
- Zhao P, Liu F, Li YM and Cai L, 2016. Inferring phylogeny and speciation of *Gymnosporangium* species, and their coevolution with host plants. *Scientific Reports*, 6, 29339.

Zogg E, 1949. On a new, uredo-forming *Gymnosporangium*: *Gymnosporangium gaeumanni* n. sp. Berichte der Schweizerischen Botanischen Gesellschaft, 59, 421–426.

## Glossary

Containment (of a pest)	Application of phytosanitary measures in and around an infested area to prevent spread of a pest (FAO, 1995, 2017)
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO, 1995, 2017)
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO, 2017)
Eradication (of a pest)	Application of phytosanitary measures to eliminate a pest from an area (FAO, 2017)
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2017)
Impact (of a pest)	The impact of the pest on the crop output and quality and on the environment in the occupied spatial units
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO, 2017)
Measures	Control (of a pest) is defined in ISPM 5 (FAO 2017) as "Suppression, containment or eradication of a pest population" (FAO, 1995). Control measures are measures that have a direct effect on pest abundance. Supporting measures are organisational measures or procedures supporting the choice of appropriate Risk Reduction Options that do not directly affect pest abundance.
Pathway	Any means that allows the entry or spread of a pest (FAO, 2017)
Phytosanitary measures	Any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO, 2017)
Protected zones (PZ)	A Protected zone is an area recognised at EU level to be free from a harmful organism, which is established in one or more other parts of the Union.
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2017)
Regulated non-quarantine pest	A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party (FAO, 2017)
Risk reduction option (RRO)	A measure acting on pest introduction and/or pest spread and/or the magnitude of the biological impact of the pest should the pest be present. A RRO may become a phytosanitary measure, action or procedure according to the decision of the risk manager
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO, 2017)

## Abbreviations

DG SANTÉ	Directorate General for Health and Food Safety
EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization
IPPC	International Plant Protection Convention
ISPM	International Standards for Phytosanitary Measures
ITS	internal transcribed spacers
LSU	large subunit
MS	Member State
PLH	EFSA Panel on Plant Health
PZ	Protected Zone
ToR	Terms of Reference